The ASP is pleased to announce that abstract proposals for our 2014 Annual Meeting are welcome in support of the categories below. Along with our E/PO friends and colleagues, we look forward to Celebrating Science: Putting Education Best Practices to Work through:

- Supporting the Next Generation Science Standards (NGSS)
- Engaging with 21st Century Media and Technology
- Enhancing Science Communication Skills and Practices
- Evaluating, Assessing, and Documenting E/PO Impacts
- Promoting Multicultural Diversity and Gender Equity
- Using Authentic Science and Citizen Science
- Improving Our Professional Practice

We are also pleased to announce preliminary details about the 2014 Annual Meeting plenaries, panels and workshops:

- Confirmed featured plenary speaker, Dennis Bartels, Executive Director of the Exploratorium, will address connections across formal and informal STEM learning.
- Next Generation Science Standards (NGSS) plenary will address implications for schools, school districts, teacher professional development providers, and others. Linda Shore, new Executive Director of the ASP and recently Director of the Teacher Institute at the Exploratorium, will moderate. NGSS-oriented hands-on workshops will follow.
- A plenary panel will examine enhancing the science communication skills of research scientists, with panel moderator Dennis Schatz, Pacific Science Center, who will also follow with a hands-on workshop.
- Other plenaries and concurrent sessions will explore NASA E/PO impacts and metrics, public science literacy, “big science,” and amateur astronomers’ impact on research and outreach.
- Abstracts related to any of these plenary ideas and conference threads are now welcome. Please note that this year we invite a new category of abstracts: 2-hour special sessions.

Abstracts are due May 4.

Please visit www.astrosociety.org/meeting for abstract submission instructions, continual event updates, and helpful destination information.

We look forward to seeing you in charming Burlingame, CA August 4, 5 and 6!
Project ASTRO: 20 Years and Flourishing

For 20 years, Project ASTRO has brought the excitement of scientific discovery through astronomy to students.

What Makes a Project ASTRO Partnership Successful?

Successful teacher/astronomer partnerships seem to have five common characteristics.

Project ASTRO: Evolving to Remain Relevant

The implementation of the Next Generation Science Standards in K-12 classrooms will be a challenging endeavor.

Astronomy in the News

A 'perfect' solar storm, the Kepler mission announces a planet bonanza, and a spiral galaxy spills blood and guts — these are some of the discoveries that recently made news in the astronomical community.
Do You Cosmos?

I’m not a huge fan of commercial television, but lately I’ve been tuning into FOX every Sunday evening. You probably know why.

Have you also been following Cosmos: A Spacetime Odyssey? I’m writing this partway through the series, so I don’t know how it ends, but after some initial misgivings, I’m enjoying this new journey.

When I watched the first episode, I didn’t much care for it. The problem was, I kept comparing my warm memory of Carl Sagan, fuzzy though it was, with the new host — Neil deGrasse Tyson. And Neil kept coming in second. Perhaps it was because Tyson’s delivery seemed stiff. I’ve been to a couple of his live talks, and he’s a fabulous speaker.

So the next night I watched it again. And this time, it clicked. It wasn’t that I’d banished Sagan; rather, I’d accepted Tyson. He has his own style and mannerisms — he’s not Sagan and doesn’t claim to be.

I also noticed that the series began the same, but different. The new Cosmos followed the same overarching storylines as the original — at least for the first three episodes — though the examples and vignettes Tyson used were different. With episode four, Cosmos: A Spacetime Odyssey took on a life of its own, and I expect that new arc to continue.

But perhaps what tickles me the most is the show’s location: on FOX (and the National Geographic Channel) instead of PBS. Of course there’s nothing wrong with PBS, and I’m hoping the new Cosmos (sans commercials) will eventually appear on PBS. But Cosmos on PBS is essentially “preaching to the choir.” Those who already tune in to Nova and other PBS science shows would watch; those who don’t wouldn’t.

Tyson, executive producer Seth MacFarlane, and Ann Druyan (Sagan’s widow) wanted the show to be viewed by those who normally wouldn’t click to PBS. They felt that on a big, commercial broadcast network, Cosmos could reach those who usually wouldn’t watch a science show. On FOX, they certainly achieved their goal.

Paul Deans
Editor, Mercury
I am thrilled to greet you as the new Executive Director of the Astronomy Society of the Pacific and honored to help spearhead the ASP’s mission to support astronomy educators, professionals, and enthusiasts. During my career, I have been particularly passionate about helping people understand and appreciate science (astronomy in particular) and giving them the tools they need to share their knowledge and excitement with others. In my experience, the only thing better than learning astronomy is the chance to teach it to someone else.

My first encounter with the ASP was as an astronomy graduate student at San Francisco State University. I was asked to teach an introductory astronomy course for non-science majors, and I was desperate to find astronomy slides that would help my students visualize the wonders of the universe and increase their appreciation for scientific discovery. My career in astronomy teaching began a decade before the advent of the “World Wide Web,” so I couldn’t just conduct an Internet search and download files from a portfolio of amazing Hubble images. At the time, using a 35mm slide projector to display photographs taken by the world’s largest ground-based telescopes was the only way to bring the magnificence of the planets, the beauty of nebulae, and the majesty of galaxies into the classroom.

Fortunately, the university was located just a mile from the headquarters of the ASP, where I made numerous visits to get help. Had it not been for the ASP’s support, teaching resources, and incredible collections of 35mm slide images (with accompanying explanations by Andrew Fraknoi), I would not have become a successful astronomy lecturer. Without having this early success as a novice astronomy teacher, I am convinced that I would not have pursued a career in science education. I would have never conducted research on astronomy preconceptions at the Harvard-Smithsonian Center for Astrophysics, written a dissertation on the impact that professional development has on improving the astronomy knowledge of elementary school teachers, or caught the attention of the Exploratorium where I served as the Director of the Exploratorium Teacher Institute for more than 20 years. Ultimately, I would not have ended up as the first woman to become Executive Director of the ASP — the very organization that got me started down this road in the first place.

Never underestimate the power of the ASP to change lives!
Somewhere right now, there is a high school student looking at the ASP’s Facebook page and “liking” the announcement of the discovery of a new and unusual exoplanet. There is a family reading a past issue of *Mercury* magazine and discussing an article on Comet ISON. A graduate astronomy student is reading a *PASP* article on active galaxies as she prepares ideas for her dissertation. An amateur astronomer is thinking about hosting a star party for an elementary school and is searching the NASA “Night Sky Network” web portal for astronomy activities developed by the ASP. A park ranger is using ASP materials to prepare an evening stargazing event for visitors. Literally thousands of people make use of ASP materials each year to learn astronomy or to teach it to someone else.

So let me thank you sincerely for the support you have given to the ASP and its mission. Your membership is absolutely critical to sustaining the work we do. In the coming months, I will be working with the staff to expand our existing programs and develop new ones. We plan to create new opportunities for amateur astronomers to share their expertise and knowledge — to not only mentor the next generation of amateurs but also to work more closely with schools and the public. We will also expand our existing teacher professional development programs and help science teachers use astronomy as a vehicle for exciting students, increasing their scientific literacy, and developing their abilities to think critically.

To quote my favorite ASP bumper sticker that has always been near my desk as a reminder of what the organization did for my career, “Astronomy Is Looking Up.”

**LINDA SHORE** is the new Executive Director of the Astronomical Society of the Pacific.
When a famous scientist makes a statement of a profound nature, it often sets the course of future studies. Areas of inquiry that once seemed promising are relegated to the dustbin, forcing researchers to pursue another paradigm. Often this lasts for years — or even a whole generation — until it is finally realized that the sage wisdom of that famous scientist was wrong.

The history of astronomy and physics is littered with errors, but some of them were so horrible that they adversely affected the progress of science. This was usually because a confluence of misinterpreted data, coming from the pen of the most respected scientist of the age, became the new “reality.” Here is a look at a few of those classic errors.

1. In 1847, J. P. Nichol, Professor of Astronomy at Glasgow University, denied the existence of nebulae. “Every shred of that evidence which induced us to accept as a reality, accumulations in the heavens of matter not stellar, is forever and hopelessly destroyed.” This was based on the mistaken observations by William Parsons and Lord Rosse that they were able to resolve the Orion Nebula (Messier 42) into stars. Of course they were hopelessly wrong. It cannot be resolved into stars, because it is composed of widely dispersed gas, as proven by William Huggins in 1864 when he used spectroscopy to study M42. There are billions of nebulae in the universe. Yes Virginia, nebulae do exist!

2. The most-quoted howler of all time comes from Lord Kelvin in the late 1890s. “There is nothing new to be discovered in Physics now. All that remains is more and more precise measurement.” It is said that this dissuaded many young people from studying physics. Why spend years in university and devote a lifetime of study to a science where there was nothing left to learn? Einstein’s theory of relativity soon shattered the complacency of Kelvin’s physics and set science on its present course.

3. Despite his great contributions to knowledge, Lord Kelvin mud-died the waters of other sciences, too. In 1897, knowing that Earth’s interior was still giving up heat but not aware of radioactivity, Lord Kelvin proclaimed that the planet could not be older than 40 million years — much to the annoyance of geologists and Darwinians. If Earth were any older, he argued (based on a naïve conduction model), its heat of formation would already have radiated away. Even though Antoine Becquerel had discovered radioactivity in 1896, it was several years before scientists realized it powered both the Sun and (in part, at least) the heat of Earth’s interior.

4. It seems that 1897 was a great year for classic errors. Following on the heels of Lord Kelvin, the great Austrian physicist Ernst Mach said that atoms are just things of thought. “I don’t believe that atoms exist!” he proclaimed after a meeting of the Imperial Academy of Science in Vienna. Einstein got his Nobel Prize not for relativity, but...
for his explanation of “Brownian motion.” To explain why tiny objects on the surface of water are in constant motion, Einstein assumed the existence of atoms and showed mathematically that this assumption explained the phenomenon. That was in 1903. The first picture of an atom was taken in 1980. Today we can move atoms and even build things from them. What would Mach say about that?

5. Agnes Clerke, the famous historian of astronomy, wrote in 1890, and repeated in 1905, that the Milky Way was the only galaxy in the universe. “No competent thinker, with the whole of the available evidence before him, can now, it is safe to say, maintain any single nebula to be a star system of coordinate rank with the Milky Way.” We now know that 27 of Messier’s 110 objects, which were known in the 1700s, are spiral galaxies like the Milky Way, and there countless billions more in the universe — a universe that no one in 1905 had any real concept even existed.

Of course, it also goes the other way. The most recent example of perseverance against the “experts” is Peter Higgs. Very few scientists in 1964 thought the new particle he predicted actually existed. We now know the entire universe is pervaded by the “Higgs field.” Higgs won the Nobel Prize in 2013.

The lessons for young scientists are obvious but scary. What do you do when the leading scientists in your field of study, maybe even a person who has won a Nobel Prize, seem to be wrong? Perhaps being told “there is no such thing” is a good place to start looking for it. And if you eventually find it, maybe that Nobel Prize will be yours.

CLIFFORD CUNNINGHAM was recently seen chatting with Bob Woodward and Carl Bernstein on the 40th anniversary of Watergate.

Lithium Giants, GC Pulsars, and Blue Stragglers — Oh My!

Several recent papers highlight challenges to our understanding of the finer points of stellar evolution.

As a star leaves the main sequence, its evolution is largely determined by its mass. At least, that is the case for single stars. Stars in binary systems evolve in ways that depend on their mass as well as the configuration of the binary orbit and the nature of the companion. While we have verified the general evolutionary paths of stars, there are some peculiar stars that challenge our models.

Let’s begin with the 25-year-old puzzle of lithium giants. Roughly one percent of all giant stars are Li-rich, showing enhanced lithium abundances at their surface. Surface lithium in evolved giants is expected to be destroyed as convective mixing carries it down to the hotter interior. Several mechanisms have been proposed to explain the observed Li enhancement, which is expected to occur when the star is on the asymptotic giant branch. Unfortunately, the precise ages of previously observed Li-rich giants make it difficult to discriminate between the various mechanisms.

Recent observations revealed the existence of the first known...
Li-rich giant that is fusing helium in its core. This places the star on the horizontal giant branch. The precise evolutionary age of the star was established using spectroscopy and asteroseismology: the star just recently underwent a helium flash to begin fusing helium in its core. Surface lithium is expected to be depleted as the star evolves toward the asymptotic giant branch, so this new discovery should prove extremely useful in constraining stellar evolution models.

Galactic Center (GC) pulsars present another challenge to stellar evolution theory. Within the central parsec of the GC resides an abundant population of massive O, B, and Wolf-Rayet stars, and an unusually large population of x-ray binaries. As a result, theorists posit that some 100-1000 pulsars should exist within the central parsec of the GC. Despite several deep radio surveys over the last decade, no pulsars have been detected in the central parsec. However, one lone magnetar (a highly magnetized neutron star) was discovered.

Jason Dexter and Ryan O’Leary argue that the failure to detect ordinary pulsars in the GC constitutes a “missing pulsar problem.” The dearth of pulsars cannot be explained by low-detection efficiency. At birth, neutron stars receive a large “kick” with velocities reaching up to 1000km/s, so perhaps the vast majority of pulsars in the GC escape the central parsec? Dexter and O’Leary point out that globular clusters have much higher escape velocities and exhibit large pulsar populations, so natal “kicks” are not a viable solution.

Instead O’Leary and Dexter argue that peculiar star and pulsar formation processes occur at the Galactic Center. The unexpected detection of the single magnetar in the GC is indicative of a high efficiency for the formation of magnetars. They suggest that rather than forming regular pulsars, massive stars in the central parsec of the GC are predisposed to forming short-lived magnetars. This indicates that neutron star formation and evolution is significantly altered in high-density environments like the GC.

Finally, blue straggler stars (BSSs) have been a mystery for more than a half-century. BSSs were originally named stragglers because they seemed to “lag” behind the group of stars with which they formed — appearing bluer and more luminous, and therefore younger. General formation scenarios range from stellar mergers to mass transfer.

One in every four stars in the open cluster NGC 188 is a BSS. Most of these are in binary systems. Thirteen of the 16 BSSs have orbital periods that indicate the companion star is a white dwarf. The presence of a white dwarf companion to a BSS star supports the mass transfer mechanism for BSS formation. Using Hubble Space Telescope data, a team of astronomers found three systems in which the white dwarf companions to BSSs are hot and young. They determined that the mass transfer ended less than 300 million years ago, providing the first direct evidence of the mass transfer formation mechanism!

JENNIFER BIRRIEL is an Associate Professor of Physics in the Department of Mathematics, Computer Science & Physics at Morehead State University in Morehead KY. Her current research interests include measurements of night sky brightness and stellar spectroscopy.
Blackout

We’re running out of power to explore the outer solar system.

Planetary exploration is in the midst of an energy crisis. The lights are about to go out on our ability to explore the dark depths of our solar system, and we’re out of light bulbs.

Nuclear power is essential to planetary exploration. While the Sun is an excellent power source in the inner solar system (and on Earth, for that matter), once beyond Jupiter it fades to just a particularly bright star. In that dark, what powers our spacecraft is nuclear radiation. Specifically, Plutonium-238.

This kind of plutonium produces a lot of heat as it decays, and that heat can be harnessed to produce electricity using a system called a radioisotope thermoelectric generator (RTG). RTGs have a huge advantage over the other obvious power source, chemical batteries. These batteries are recharged by solar power captured by a spacecraft’s solar panels. But when the Sun is distant and dim, solar panels and batteries are not effective.

On the other hand, RTGs are remarkably durable and have been used since the earliest days of spaceflight. There are a few on the Moon from the Apollo missions — and they are still working. Voyager 1, launched in 1977, has traveled more than 17.5 light-hours from the Sun (Voyager 2 is now 14.5 light-hours away). All are powered by RTGs. In more recent years, the Cassini mission to Saturn, the New Horizons probe currently en route to Pluto, and the Curiosity rover, among others, have carried plutonium cores.

During the nuclear arms race, Pu-238 was relatively plentiful. While essentially useless as a weapon, its “grandparent” isotope is neptunium-237, which is found in spent fuel rods from nuclear reactors. When the neptunium is irradiated, it decays to Pu-238.

Unfortunately, the United States stopped producing Pu-238 in 1988, and the stockpile quickly ran low. For every deep-space mission after 1993, we’ve purchased our power supply from Russia, and they stopped exporting the isotope in 2009. We have (theoretically)
enough to fuel our spacecraft through 2020 or so, but anything after that is limited to where the Sun is bright enough to use. We’ll essentially be confined to within the asteroid belt.

After the Russian supply dried up, NASA and the US Department of Energy came up with a plan to restart American production. Atomic energy law requires the Department of Energy to do the actual making, so they wanted to split the cost 50/50 with NASA, with the space agency being the main recipient of the created material.

In 2011, Congress finally allocated some money, but only fulfilled NASA’s request. With half of the needed funding, a tiny quantity of Pu-238 has been produced in a facility in Tennessee. If they can get up to full capacity, there will be about three pounds produced every year. (The unit powering Curiosity has eight pounds of plutonium.) If all goes well, we might have enough for an RTG by 2016.

All of our outer solar system missions will have either run out of power, run into a planet (the end game for Cassini, but that’s another story), or completed their missions by 2017. Currently, no replacement craft are either on their way or in production. Because of (among other things) the plutonium shortage, NASA is not accepting any new proposals that require nuclear power. The time from a proposed mission being accepted and actually being launched is usually five to 10 years, and the journey to the outer planets takes approximately a decade. Right now, the absolute earliest we’ll have new eyes out there is 2025. That’s a long time in the dark.

EMILY JOSEPH is a Research Assistant, with an emphasis on Mars studies, at the Planetary Science Institute. You can find her on Twitter @EmExAstris.

Cosmic Inflation Discovered…Sort of, Maybe
Is it evidence of inflationary theory or just inflationary hype?

The news spread through the physics and astronomy world perhaps as fast as the Big Bang inflationary period itself. A tiny telescope down at the South Pole called BICEP2 has claimed the first direct evidence of gravitational waves from the Big Bang.

The BICEP2 team said its finding is “the strongest confirmation yet” of cosmic inflation, the theory that the universe needed to expand trillions of times its size in a trillionth of a second after the Big Bang in order to have all the matter and energy we see today.

The result garnered at least six press releases, one from the Harvard-Smithsonian Center for Astrophysics, home to BICEP2 leader John Kovac. One came from a rival experiment called POLARBEAR, whose team was taken by surprise…particularly because these folks published similar results a week prior, on March 10, 2014.

And thus, many scientists and at least some reporters started wondering: Is this evidence of cosmic inflation or just PR inflation?

First, the result. BICEP2, funded by the National Science Foundation,
claims to have detected B-mode polarization in the afterglow light of the Big Bang, called the cosmic microwave background (CMB). The swirly B-mode pattern is a unique signature of gravitational waves, as it reveals the impact of those waves twisting space.

In short, we perhaps are seeing the imprint that the Big Bang and inflation made on space. If you really want to understand this fascinating stuff, I suggest reading the blog entry by Caltech astronomer Sean Carroll. But note the word of caution with nearly every quote you read about this in the popular press — something along the lines of “If this is true, it’s really big.”

Carroll finds the BICEP2 work impressive but doesn’t plan to pay up on the $100 bet he made with MIT cosmologist Max Tegmark until the space-based Planck mission confirms the results. “Overall, an amazing result — if it holds up,” he said on his blog.

Neil Turuk, director of the Perimeter Institute for Theoretical Physics in Waterloo, Ontario, threw in a double-if: “If, and it’s a big if, this is true,” it would be resounding evidence for inflationary theory, he said. Why the doubt? Two reasons. First, scientists were not expecting the B-mode polarization to be strong enough to detect in such detail with the current generation of ground-based missions. Turuk said that some serious tweaking to the standard model of cosmology would be needed to explain the strong detection of this polarization.

The other reason is that we’ve been here before, with balloon-based experiments such as BOOMERanG attempting to trump cosmology results from the space-based WMAP a decade ago.

Charles Bennett of Johns Hopkins University was the principal investigator for the landmark WMAP mission, and he is part of a team building a telescope near the Llano de Chajnantor Observatory along Cerro Toco in northern Chile to probe inflation. Bennett remains as optimistic about the BICEP2 results as other astronomers, however cautious. “Looking back, those initial BOOMERanG results were actually significantly in error when checked against WMAP,” he said. “There was a spectral measurement that ‘scooped’ John Mather’s [Nobel-prize-winning] COBE experiment. It was later seen to be wrong,” Bennett added.

Bennett explained the cycle of progress, with ground-based and balloon-based experiments accelerating during periods in which space-based projects are being built. Each such mission or project has the potential to feed the next one.

So, a prime question to ask is whether the BICEP2 result will win MIT’s Alan Guth the Nobel Prize, as the CERN Higgs experiments got the prize for Peter Higgs and François Englert? Guth is one of the primary names associated with inflationary theory, along with Demosthenes Kazanas (now at NASA Goddard) and Andrei Linde (now at Stanford University).

I wouldn’t bet on it. “All important results require independent confirmation,” Bennett said. “In this case even more is desired because there are at least two questions. Is this result correct; and since this result requires a modification to the standard model of cosmology, what is the right modification to make?”

Look for much more to come.

Gravitational waves from inflation generate a faint but distinctive twisting pattern in the polarization of the CMB, known as a “curl” or B-mode pattern. Shown here is the actual B-mode pattern observed with the BICEP2 telescope, with the line segments showing the polarization from different spots on the sky. (The BICEP2 Collaboration.)
Gender Segregation

Do we need to separate boys and girls so each learns to their potential?

Countless articles scattered throughout the educational literature have described gender issues. If Jane and John are in the same science classroom, John will take over discussions and experiments, possibly resulting in Jane learning less. Gender stereotyping in Jane’s school or home may have resulted in Jane thinking that she “cannot do science.” And as Sheila Tobias pointed out in They’re Not Dumb, They’re Different, some students do not perform well in science classes owing to their perception of an absence of community; this social aspect of education seems to affect women more than men.

Alex Rudolph (Cal Poly Pomona) and his colleagues conducted a national survey of Astro 101 classes and looked at the learning gains and student demographics. They found that, of the ascribed characteristics (gender, ethnicity, family income, language, and father’s education), only gender showed a relationship to learning gain; men had a learning gain nine percentage points higher than women.

If there is a difference between genders in social behaviors and expectations in the classroom that leads to disparity in learning, is there something we can do as instructors to change these results? Some K–12 schools have gone so far as to separate students by gender into separate classrooms, and a few dozen gender-specific colleges also exist. I have wondered whether gender-separation might be worth exploring in the college Astro 101 course.

The reasoning is that learning is affected by social biases: e.g., males tend to dominate frequency of speaking in speaking, language use (type of conversation), or biological issues (one advocate suggests that different genders learn better with different room temperatures). Removing gender-related distractions should, thus, improve the educational experience for all students.

Leonard Sax, a clinical psychologist and author of Why Gender Matters, Boys Adrift, and Girls on the Edge, is a leading advocate of same-sex education. He believes that there are distinct, biological differences between the female and male brain and that these differences require different educational approaches.

But Lise Eliot, a neuroscientist at Rosalind Franklin University, states in Pink Brain, Blue Brain that there is no significant biological difference between male and female brains. No biological reasons exist for why men are risk takers and why some women are more empathic. Any gender differences in learning are due to nurture, not nature. (See also the MRI studies by Rhosel Lenroot.)

If learning is, thus, socially driven, doesn’t that still imply that same-sex learning groups should be better? A recent study by Janet Hyde, a University of Wisconsin psychologist, and her colleagues Erin Pahlke and Carlie Allison shows that there is little to gain from single-sex classrooms. Their meta-study looked at 184 studies of 1.6 million K–12 math and science students. Fifty-seven of the studies
corrected for parental education and economics; from these demographically “corrected” studies, they find that there is no educational benefit from same-sex classrooms.

Improvement in the self-esteem of young women is often touted as one benefit of same-sex education. But studies show that this “conclusion” is unwarranted; there is no significant difference between the academic motivation of young women in same-sex and mixed-sex schools.

As is typical in our society today, the pseudoscience of Sax and his colleagues outshouts the careful science of educational researchers and is often promulgated by the public media. Thus, recommendations of same-sex classrooms are often more often heard than the contrary, real evidence. In fact, there may be some evidence that same-sex classrooms actually add to psychological harm by unintentionally highlighting gender and prompting students to infer performance connections for students that should not exist.

In opposition to what I first proposed, we should strive to diversify our groups. Not only does it better prepare our students for their future in a mixed-gender workplace, it provides them with an opportunity to sample a broad spectrum of learning styles and patterns.

As Rudolph and his colleagues point out in their demographic study, interactive learning methods equally benefit men and women, regardless of academic ability or previous science coursework. Increase in learning gains: that is something I think we can all agree is worth pursuing, and Rudolph et al.’s results are not sexism posing as scientific research.

Finally, there are gender-neutral behaviors we can employ in the classroom to obviate gender inferences; see the WEEA Equity Resource Center guide Promoting Gender Equity in the Science Classroom.

DAVID BRUNING teaches astronomy at a Midwestern state university. He believes it is important to not reinforce stereotypes unintentionally in our attempts to address past educational problems and tries to maintain mixed-gender work groups for his in-class activities.

A Winning Telescope

A telescope was raffled off at the ASP’s 2013 annual meeting. Here’s where it went.

The 2013 ASP conference in San Jose was the first meeting I’d ever been to, and I normally don’t buy raffle tickets. However, this time was different for some reason — I had really enjoyed the meeting, wanted to support the ASP, and the telescope (Explore Scientific’s AR127 Air-Spaced Doublet with Twilight I Alt-Azimuth Mount) looked quite beautiful. So, I figured I’d buy a few raffle tickets, even though I had little hope of actually winning. You can imagine my amazement when I found out this telescope was soon to be mine! I was in dire need of a good telescope (my old one just wasn’t cutting it anymore), so this was perfect!
As soon as it arrived at my house in Ohio, my boyfriend and I took it out for a spin in a nearby park and were rewarded with beautiful, clear views of Saturn and the Moon. However, the weather in Columbus isn’t particularly conducive to observing, so while we’ve taken it out ourselves a couple of times, most of our attempts to use the telescope for public outreach were thwarted by clouds and/or other bad weather. However, we have managed to carry out a couple of stargazing events during the past several months, and looking through this particular telescope was one of the highlights for our visitors.

The telescope made its public debut at the grand opening celebration of our newly renovated Ohio State Planetarium on campus (I’m privileged to be its Director). After a day filled with planetarium shows, we opened roof access to the public for stargazing. We had 800–900 people show up to the event altogether, so the telescope got a lot of use that evening! People were particularly impressed with the telescope’s ability to show off lunar features — the Moon’s craters and mountains appear exceptionally clear and vivid. We even had a look at the fuzzball-like Andromeda galaxy.

We also took the telescope to an event for elementary school children in March, and miraculously, the weather cooperated and gave us a gorgeous clear evening of stargazing. The kids were so excited to see all of the craters on the Moon and the moons of Jupiter. Two or three of the kids stayed out there for the entire hour looking through the telescope, and even many of the parents came by and wanted to take a look as they picked up their kids at the end. It was quite a hit; we were told that we were the best activity of the night!

We have more stargazing nights planned during the next few months, and hopefully as the weather gets warmer we will have more chances to take the telescope out and observe. However, even with our cloudy Columbus weather, this fabulous telescope has already been able to help us in our efforts to share our love astronomy with the public and to inspire young (and even old) minds along the way.

CATHERINE GRIER is a recent PhD from The Ohio State University (OSU). She currently serves as the Director of the OSU Planetarium and is engaged in postdoctoral research on the broad line region in active galactic nuclei.
The Night Sky Network is a community of more than 420 astronomy clubs. Since its inception in 2004, more than 25,000 events have been logged and 2.5 million people reached through the efforts of members utilizing the Network’s tools and educational resources. This poster paper, presented at the ASP’s 2013 annual meeting, reports our discoveries regarding the scale of outreach efforts during the past nine years.

Methods
Materials are constantly updated with feedback from amateur and professional astronomers, aiding development of educational resources for members to promote astronomy at both star parties and classroom settings.

Feedback is gathered via testing programs, Facebook, Twitter, email, and face-to-face meetings with fellow members of the Network. Materials are then updated as we are able, with attention paid to the need of our funders as well as the needs of astronomers and the public. Results and usage are recorded in logs kept on the Night Sky Network by participating clubs. Prizes, additional ToolKits, and telecons are provided as incentives to continue to use the Network.

Results
As more clubs adopt the Night Sky Network, more members of the general public are reached with help from the Network’s resources. Educational ToolKits have allowed greater outreach to the public in settings that have traditionally not been in the realm of astronomers, such as daytime settings at camps and schools, as well as certain urban and suburban locales.

In total, 25,000 events have been recorded by the 30,000 members of the 420 participating clubs, reaching more than 2.5 million people and counting (including 600,000 children). Another trend of note is that more than 100,000 resources have been downloaded since 2008.

The graphs (on the next page) are drawn from log files created by members of the Night Sky Network. All demographics entered were done so at the members’ discretion, but all show a general upward trend starting in 2004 and continuing through to 2013.

Quotes
Arkansas/Oklahoma Astronomical Society, founded 1985:
“Joining and being a continuing part of NSN is the most worthwhile endeavor our club has ever undertaken. Thank you!”
Texas: “(Our club) was created to take astronomy into the inner city and to serve the underserved areas of our community. We want to show young people that they have options when it comes to career fields.”

Chuck Kunesh, Lehigh Valley Amateur Astronomical Society Inc., PA: “Since we began to make Night Sky Network presentations a part of our club’s monthly public star parties, our attendance has skyrocketed to the point where we can no longer fit all the folks who come into our planetarium…."

Conclusions
The educational ToolKits and additional resources have allowed amateur astronomers from across the United States to reach greater amounts of the general public. In general there has been an increase every year in the amount of people of all groups reached and educated about various aspects of space science. The Night Sky Network is an invaluable tool for astronomy outreach and education.

Partners and Acknowledgments
The primary Night Sky Network partners are the Astronomical Society of the Pacific (ASP) and the NASA Exoplanet Exploration Program. Additional partners include:

• The NASA Origins Forum
• The Structure and Evolution of the Universe Education Forum
• The NASA Solar System Education Forum
• NASA’s Kepler Discovery Mission (NASA Grant NAG-2-6066 to SETI Institute)
• Multiverse at the UC Berkeley Space Sciences Laboratory
• NASA Science Mission Directorate under EPOESS Grant Number NNX10AE71G
• Virtual Planet Laboratory
• Space Science Institute for Interactive Learning
• NASA’s Wide-field Infrared Survey Explorer
• NASA Solar System Exploration
• Space Telescope Science Institute
• NASA Education and Public Outreach at Sonoma State University: GLAST, Swift and XMM-Newton
• Suzaku Mission E/PO Program at NASA/GSFC

In addition, NSF has provided approximately $3 million in grant support for specific NSN initiatives including research into club culture and for certain toolkits outside of NASA funding.

DAVID PROSPER is a self-described professional amateur astronomy nerd who is the Night Sky Network Communications Specialist for the ASP. VIVIAN WHITE is an ASP Astronomy Educator who creates hands-on activities and demonstrations for use by amateur astronomers doing public outreach.
Project ASTRO: 20 Years and Flourishing

By Andrew Fraknoi, Brian Kruse, Rommel J. Miranda, Theresa Moody, and Wil van der Veen.

Volunteer outreach astronomer Brandon Lawton and educator Victoria Mathew work together to cook up a comet at a Project ASTRO professional development meeting. Courtesy Rommel Miranda.
The Astronomical Society of the Pacific (ASP) has had many educational and outreach activities during the years, but Project ASTRO remains the flagship in our fleet of programs. It was the first project for which the Society received federal funding; the first to feature formal, professional evaluation; and the first one to engage three different segments of the Society’s membership — professional scientists, amateur astronomers, and teachers. And it’s still the program whose training and materials have had the most lasting impact nationwide. In this issue, you will read about Project ASTRO from several perspectives. Here, I’d like to introduce the program and tell you a little bit about its history and evolution.

What’s it All About?

Project ASTRO links professional and amateur astronomers with 3rd- to 9th-grade teachers in their communities. After the teacher-astronomer partners are trained together at two-day workshops, each volunteer astronomer “adopts” a class and makes at least four visits during the year. The main focus of the project is hands-on, inquiry-based activities that puts students in the position of acting...
like scientists and helps them reach a deeper understanding of the universe (and science in general) at their own level.

Note that Project ASTRO is not a curriculum in astronomy. There are no prescribed activities or topics to cover. Each partnership draws on its own strengths and interests to plan the astronomy being taught — what happens during each astronomer visit fits with the partners’ own vision of what might be best for the children. As part of the training, the ASP provides each partner with a practical How-to Manual, and with a rich notebook of activities and teaching resources called The Universe at Your Fingertips. Partners can select among the materials therein, or draw from their own work or experience as a source of inspiration.

During the Project ASTRO workshop, astronomers and teachers focus on classroom-tested activities that don’t just convey information but get the students to ask questions, formulate hypotheses, and make observations. Examples of our more popular activities are investigating the phases of the Moon (with models and journals), calculating and walking off a scale model of the solar system (unrolling toilet paper squares as your unit of measurement, to the delight of the students), or organizing and classifying beautiful color images of galaxies. Of course, we also encourage the visiting astronomers to talk about their own work and background in science.

With the help of the Institute for Learning Innovation (our evaluators), we learned a lot from observing the first hundred or so partners in action in the classroom, and refined the program based on the first few years of observations. The sidebar (on the next page) shows you some of the characteristics of successful partnerships, and to no one’s surprise, the lessons learned are very similar to what

Though perhaps not as delightful as the toilet paper solar system activity, using a roll of paper tape to illustrate the vast distances between the planets is just as helpful. (ASP/Brian Kruse)
Some Key Lessons from Project ASTRO (and their Similarity to Relationships!)

- Students learn best when they are actively engaged (especially using hands-on, inquiry-based activities).
- There’s no need to reinvent the wheel: good classroom activities/materials already exist.
- Not all topics in astronomy are equal (or, at least, not of equal interest at the K–12 level).
- Finding and matching astronomer and teacher partners turns out to be a more complex and time-consuming experience than we anticipated (all matchmakers know this).
- It’s good to put expectations and commitments into writing (like a pre-nuptial agreement).
- Astronomers and teachers work together best when they are treated as equal partners.
- The success of a visit is generally proportional to the time spent planning it.
- Visiting the same classroom several times (instead of different classrooms each only once or twice) was a more satisfying and effective experience for astronomers and students (one night stands are rarely better than ongoing relationships).
- Ongoing feedback and support is important for both partners (as it is in any relationship).
- For a Project ASTRO site to work in a sustained way, the leadership must want to do the project, not have it imposed on them from a higher authority.
- Everything in the K-12 classroom (and perhaps life itself) takes more time than you anticipate.

most of us take away from successful dating!

In the early days a substantial number of our volunteer partners were amateur astronomers, and there was some concern about whether they would have enough background in astronomy to be effective partners in the classroom. But our evaluators found that after Project ASTRO training, amateurs (as well as graduate students) were every bit as effective in the classroom as research scientists. After all, at the fifth grade level, it is rarely important to explain the detailed physics of black hole accretion-disk mechanisms or model stellar atmospheres. Indeed, it turned out that amateurs were often more ready to clarify some basic issue in observational astronomy, such as when will Venus be visible or what kind of telescope might my family buy, than very specialized professionals.

For an astronomer getting ready to face 30 pairs of 12-year-old eyes for the first time, the concern is rarely “Do I know enough about astronomy?” and much more often, “Can I present astronomy in ways the kids will understand and enjoy?” And not knowing an answer to a question is a wonderful opportunity to get the students to think about how to find that answer for themselves.

While Project ASTRO began with a pilot project run by the ASP in California, today there are regional ASTRO training sites around the US. Each site is managed by a lead institution, which appoints a local Project ASTRO coordinator. Many sites rely on a coalition of local scientific and educational organizations to help the lead institution share the work, find financial and in-kind support for the project, identify new partners, and put on regional workshops and follow-up programs for the partners.

A Little History

I should mention that, while I had the pleasure and privilege of founding and leading Project ASTRO, its success should be credited...
to a whole team of creative people. Foremost among them is Dennis Schatz, an astronomy educator from the Pacific Science Center in Seattle (later the first informal-science educator elected President of the ASP), who helped us brainstorm many of the key aspects of the project and create many of its most successful hands-on activities. Michael Bennett, a planetarium educator, college astronomy teacher, and (later) ASP Executive Director, was instrumental in helping us understand the level of support needed by partners some distance away from a training site.

And throughout the project, we had help organizing the complex logistics and “hand-holding” required to create and sustain a national organization from a series of Project ASTRO coordinators, each of whom added their personal stamp and many hours of work beyond the job's announced requirements. So a big “Thank You” to Jessica Richter (1993-96), Shannon Lalor (1996-2000), Erica Howson (2000-02), Dan Zevin (2002-07), and Brian Kruse (2009 to the present).

Project ASTRO emerged from a confluence of programs the ASP was pursuing in the 1980s, including national workshops for K-12 teachers and programs to get amateur astronomers more engaged in public education. I have recently described some of this early history in an article on the ASP’s website, so I will not repeat it here.

<table>
<thead>
<tr>
<th>Project ASTRO Regional Sites, and Their Lead Institutions, Through the Years</th>
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<tbody>
<tr>
<td><strong>Austin, TX:</strong> University of Texas</td>
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<tr>
<td><strong>Baltimore, MD:</strong> Towson University and the Maryland Science Center</td>
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<tr>
<td><strong>Boston, MA:</strong> Harvard-Smithsonian Center for Astrophysics and the Boston Museum of Science</td>
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<tr>
<td><strong>Boulder, CO:</strong> U of C Boulder Lab for Atmospheric and Space Physics</td>
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<tr>
<td><strong>Chicago, IL:</strong> Adler Planetarium and Astronomy Museum</td>
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<tr>
<td><strong>Cincinnati, OH:</strong> Cincinnati Observatory</td>
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<tr>
<td><strong>Cleveland, OH:</strong> Cleveland Museum of Natural History</td>
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<tr>
<td><strong>Connecticut (the whole state):</strong> Wesleyan University Astronomy Department</td>
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<tr>
<td><strong>Eugene, OR:</strong> University of Oregon</td>
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<tr>
<td><strong>Garden City, NY:</strong> Cradle of Aviation Museum</td>
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<td><strong>Hawaii (the Big Island):</strong> Gemini Observatory (emphasis on Family ASTRO)</td>
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<tr>
<td><strong>New Jersey:</strong> Astronomy Center at Raritan Valley Community College</td>
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<tr>
<td><strong>New Mexico (several areas throughout the state):</strong> Space Center, Alamogordo</td>
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<tr>
<td><strong>Northwestern MI:</strong> Northwestern Michigan College</td>
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<td><strong>Pullman, WA:</strong> Washington State University</td>
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<td><strong>Reno and Carson City, NV:</strong> Space Science for Schools</td>
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<td><strong>San Francisco Bay Area, CA:</strong> The Astronomical Society of the Pacific</td>
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<td><strong>San Diego, CA:</strong> San Diego State University</td>
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<td><strong>Salt Lake City, UT:</strong> Hansen Planetarium</td>
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<td><strong>Seattle, WA:</strong> University of Washington Astronomy Department</td>
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<td><strong>Tucson, AZ:</strong> National Optical Astronomy Observatory</td>
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<td><strong>West Chester, PA:</strong> West Chester University</td>
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Suffice it to say that our pilot project in Northern and Southern California, supported by the National Science Foundation from 1993 to 1995, went well enough that the NSF then gave us additional funding to expand Project ASTRO nationwide. One interesting byproduct of the first few years were three satellite projects, where astronomer partners who had become especially excited by their role in Project ASTRO had asked our permission to set up some mini-training for a small number of astronomer-teacher partners at their own institutions (in Stockton, Santa Barbara, and Sacramento, California.) This gave us a bit of a preview of how the program might be replicated away from “ASTRO Headquarters.”

In 1996, we put out a call to find astronomy and astronomy education organizations that might want to start their own regional ASTRO training site and found considerable interest around the country. The first two expansion sites were located in Chicago, Illinois (at the Adler Planetarium), and Tucson, Arizona (at the National Optical Astronomy Observatories). Since then, many other regional sites have joined the program; some for a short while, others on a more permanent basis.

By 1999, about a dozen active sites were training some 200 partners a year, and the total number of students impacted by the program since its inception was rising toward 100,000. As funding from NSF ran out, each site was required to find its own financial support locally, either from the lead institution or from their local coalition of supporters. This proved quite a challenge, but many sites managed the transition from federal to local funding with imaginative solutions, including getting local businesses involved, charging school districts for the workshops, finding wealthy donors, and enlisting help from other educational programs (including NASA projects and missions).

**Family ASTRO**

In the meantime, we were noticing that one of the unintended (but intriguing) consequences of Project ASTRO was additional involvement (in many schools) by the students’ families. For example, when local amateur clubs held an evening star party for the Project ASTRO class, even parents who rarely participated in school-parent events were excited enough to come look through the telescopes. Many teachers sent Project ASTRO activities home and encouraged students to share them with their parents and siblings, generating much positive response.

From observing these family interactions, we were inspired to begin a new Program, Family ASTRO, specifically targeted at helping family members enjoy astronomical exploration together. We received a third NSF grant to develop activities, kits, and games that families could do in unison, and to train Project ASTRO site leaders and individual partners on how to use these materials during family evenings or weekend programs.
Eventually, we were also “adopted” by a professional game company, called ImaginEngine, which helped us produce several family-oriented, educational games that were significantly more sophisticated than what a group of astronomy educators could have created by themselves. (The games are still available through the ASP’s AstroShop.)

I remember one of the board games, called Moon Mission, especially fondly, because the only way to win was for family members to cooperate instead of compete. This went so much against the grain of what kids are taught in our culture (in games and sports) from a very young age, that all of us had to get used to a new mindset in playing and teaching the game. But once the families in our test groups became familiar with the idea, they had a great time working together to be victorious on the Moon.

**A Gateway to Science**

As more and more sites across the country decided to join us, communication between the sites (and with the national office at the ASP) became more complex, but ever more necessary. To help each other, encourage the development of new sites, and foster cooperation with other astronomy education programs across the US, the regional site directors and coordinators formed a national network in 2000, which meets annually and keeps in touch through e-mail and teleconferences. Because the members of the network have access to a national pool of interested teachers, students, and volunteer astronomers, the network is an excellent partner for any astronomy education or outreach project that is developing new educational materials, trying innovative approaches to astronomy teaching, or seeking some training for its graduate students or educational staff on hands-on techniques. People from many programs have observed Project ASTRO training workshops, and several astronomy education projects have put funding aside to use the network to test and use their materials.

In 2001, we began to work seriously on a project that we had been merely experimenting with earlier — translating the activities and materials from Project ASTRO into Spanish for use in other countries and with bilingual populations in the US. For example, the Tucson ASTRO site had a satellite branch in Chile, where some of the NOAO observatories were located, and they were eager to have at least the most popular activities translated into the local language. By 2002, with a little extra help from NSF, we had translated the most popular materials in the project and published *El Universo a sus Pies*, a compilation that is still in use in many Spanish-speaking parts of the world.

Today, our program is as diverse in its approach as the regions it covers. The regional sites are disseminating Project ASTRO to inner-city schools, rural settings (including Native American reservations), as well as home-school groups. Some sites focus on Project ASTRO in schools, others (such as Hawaii) are doing wide-ranging family programs, while still others are integrating our astronomy activities and approaches into education and outreach programs with a broader focus.
As the years passed, many of our teachers went on to champion astronomy in their schools and districts, and a number of our astronomers have found their calling in education. Noted “graduates” of Project ASTRO include Yale professor and world-renowned planet hunter Debra Fischer; Gibor Basri, an expert on brown dwarfs and the Vice Chancellor for Equity and Inclusion at the University of California, Berkeley; planetary astronomer (and frequent media personality) Heidi Hammel; dwarf-planet discoverer extraordinary Michael Brown (of Caltech); and Isabel Hawkins of the Exploratorium, who recently won the ASP’s Klumpke-Roberts Prize for her national work in education and outreach.

Each time the national science standards and frameworks in the US are revised, we all tremble as we gauge how much or how little astronomy teachers and students will be expected to know. But ultimately, as Project ASTRO enters its third decade of operation, we remain confident that the inherent interest of our subject matter, and the nifty hands-on activities we train our partners to use, will continue to make us one of the most effective gateways to the joys of science for students of all ages.

If you’d like to learn even more, please visit our Project ASTRO webpage. ✉️

ANDREW FRAKNOI was the ASP’s Executive Director from 1978 to 1992 and founded Project ASTRO and Family ASTRO. Currently, he is Chair of the Astronomy Department at Foothill College, Vice-president of the Lick Observatory Council, and a member of the SETI Institute Board of Trustees. In 2013, the National Science Teachers Association gave him the Michael Faraday Award for Science Communication.
What Makes a Project ASTRO Partnership Successful?

Successful teacher/astronomer partnerships seem to have five common characteristics.

by Theresa Moody and Brian Kruse

You are about to embark on a rewarding and sometimes challenging partnership to improve science education. These words, from the Project ASTRO How-To Manual for Teachers and Astronomers, encapsulate what it means to be a Project ASTRO partner.

For the past 20 years, the Astronomical Society of the Pacific’s Project ASTRO has partnered educators with volunteer astronomers with the goal of enriching students’ astronomy experiences. Historically, the vast majority of participating educators have been teachers of grade 3-8 students, though all K-12 educators, including those in after-school and community settings, are welcome to participate.

Astronomers have come from various backgrounds. Many are professional astronomers and university faculty, or they are post-doctoral, graduate, or undergraduate students. About half the astronomer partners are amateurs active in their local clubs. Even with this varied background in education and outreach experience, astronomers come to Project ASTRO with a common love of sharing students in Megan Gover’s second grade class built simple spectrographs using aluminum foil, toilet paper tubes, index cards, small pieces of diffraction grating, and tape. The students were encouraged to look at the fluorescent lights through their diffraction grating material before installing it in their spectrographs. [Courtesy Megan Gover and Susan Benecchi.]
their knowledge and skills at bringing the wonders of the universe to others.

Getting a partnership started, and keeping it going, is not always easy. A few Project ASTRO partnerships never do get off the ground, and many of them last only a year or two. Some are more enduring, continuing to work together for several years. Others have stood the test of time, with partners who carry on working together even after more than a decade has passed since their initial partnering. Regardless, a successful partnership is not necessarily defined by the length of time they endure, but rather by the lasting impact the partnership has had on the students, teacher, and astronomer.

To gain a better sense of these lasting impacts, we asked teachers and astronomers involved in Project ASTRO to write a short description of their partnership, and describe what made their partnership successful. We received many replies, and have selected one of them for you to read (see page 31). From these responses, several attributes of successful partnerships emerged: Friendship and Respect, Communication and Planning, Personal and Professional Benefits, Joy, and a Ripple Effect into Additional Outreach.

**Friendship and Respect**

Astronomers and teachers from successful partnerships described how their working relationship has developed over time into a friendship and how the partners have genuine respect for the skills each brings to the table. Teachers and astronomers used words like “chemistry,” “camaraderie,” and “mutual respect,” and described how much they enjoy spending time talking, planning, and reflecting with each other.

“We get along very well, so I really enjoy working with Rennie [Watson]. She has a science background, so she’s very aware of where I’m coming from. She’s very flexible and does a fantastic job of helping me find topics that I’m comfortable with teaching and passionate about sharing, but also fit into her curriculum…. We also have good communication. At lunch or the end of the day we dissect what worked and what didn’t, and I make notes so I can tweak the lesson for the next year. Then over the summer we meet, review the previous year, and talk about what we want to do for the next year. It’s really nice to be partnered with someone you enjoy having a coffee with!” — Matthew Knight (Astronomer).

**Communication and Planning**

Other common attributes described by Project ASTRO teachers and astronomers were the importance of trust, communication, planning new things, and developing a routine together. Partners spoke of how important it is to regularly communicate, be flexible and accommodating, give feedback, take notes, and meet to plan new sessions. They enjoy the thrill of tweaking classic activities to...
improve them and also being adventurous enough to try new things together. There is a need for trust that each partner will come prepared to fulfill their role in the investigation, always with the students’ best interests in mind.

There is also an aspect of trust. We are each so busy that when a plan has been made to meet at a certain time and accomplish some task, each has to trust that the other will be there, prepared for the task at hand. Finally, we each have a sense of adventure. We have found activities that work, but we are always ready to try something new. We both have an adventurous spirit, and our natural curiosity promotes creative thinking and innovative lessons. Tom Krause (Astronomer) and Trish Stadler (Teacher).

Personal and Professional Benefits
It was clear in every partnership that the teacher and the astronomer felt they received both personal and professional benefits. Astronomers most frequently commented on how their Project ASTRO experience gave them a chance to see and remember their own enthusiasm for astronomy, a chance to share their own passion and knowledge, and a reminder that science is fun. They described the thrill of being back in the classroom, how rewarding it is, and the little moments when they know the effort has been worthwhile.

It’s quite a bit of work for me before each class: Going over the lesson to make sure it’s pitched to the right level, that it will last an appropriate amount of time, coming up with contingency plans if it goes too fast/slow, buying supplies and prepping them so the kids don’t waste too much time, etc. Throw in commuting… and a full day teaching, and each class visit really takes two full days of my time. Multiply that by three or four class visits over a month and this is a big hit to my productivity each winter.

As I don’t yet have a permanent position in astronomy, I am under a lot of pressure to publish and write proposals. So every year the pressure from the amount of missed research time builds up inside and I think, “Is this really what I should be doing with my time?” Then I teach, and I completely forget all of the things I was worrying about! For a whole day I am reminded of how much fun science is. I leave at the end of the day exhausted but flying high. Matthew Knight (Astronomer).
One thing of which I have been made acutely aware is this: In the second grade everybody wants to be a scientist. A few years ago I was sitting in a doctor’s waiting room, and a young boy kept staring at me. I was a bit curious until finally his mother came over and said: “You helped him build a telescope.” Oh! Did that feel good! So I talked with him about the telescope and about Ms. Trish’s class. And I left with the feeling, “Wow! I guess it is all worthwhile!” Tom Krause (Astronomer).

Teachers most frequently commented on how their Project ASTRO experience built their confidence and knowledge in the content, improved their practice in the classroom, and how thrilling it is for them and their students to work with an expert.

The biggest wow moment for me was when [Astronomer] Russ Drum and I were preparing for the lesson ‘The reasons for the seasons.’ When he tilted the pencil and moved it around his head, the light bulb went off and I understood — the tilt! There are so many times when we work together, the light for me goes off, and then I can help get that point across to the students in preK-5…. He said to me, it is because of your first step that so many students got a chance to learn about the stars. I was honored. It is his patience that kept me, and the students, fascinated and always looking into the night sky. Brenda Cook-Johnson (Librarian).

I’ve gained more confidence in teaching space sciences. Through Project ASTRO I was able to attend teacher workshops offered during an Astronomical Society of the Pacific conference held in Baltimore. It was wonderful to discover ways to create hands-on learning experiences for space science lessons. I used to think, “How am I going to teach this stuff? Everything is so far away.” Rennie Watson (Teacher).

Joy

The fourth of the common characteristics described by successful partnerships was that both teachers and astronomers were amazed at the amount of joy the experience generated for all involved. Both described how students bubbled over with questions to be answered, and how their enthusiasm was barely containable.

The best thing has been watching students respond to [Astronomer] Matthew Knight. They love when he visits and always want to know when he will return. Both of us hope that working with him inspires students to consider careers in astronomy. Rennie Watson (Teacher).

After [Astronomer] Tom Krause built Galilean telescopes with the class, there were quite a number of parents that came to me to find out where to buy these telescopes. Their kids were begging for scopes. Also, my students think Tom is related to Albert Einstein. Trish Stadler (Teacher).
One of the best things about our partnership is that we are all really excited to be a part of it! We all enjoy finding new and innovative ways to tie our individual passions together with current astronomical events and news to create hands-on, project-based experiences for the students. Linda Scarth (Teacher).

Ripple Effect into Additional Outreach
The fifth and last of these common attributes of successful partnerships was, for the astronomers, how outreach through Project ASTRO had rippled into additional outreach elsewhere. Many astronomers described new trips, expanded star parties, and other events and projects and/or partnerships they had taken on as a natural extension to the work they had done with Project ASTRO.

In some cases, this was expanded to other content areas within the same school, as was the case for Nikole Manou (Teacher) and Roy Hayter (Astronomer). Roy quickly found himself helping in Nikole’s 5th grade classroom during chemistry lessons (his area of expertise) and in her 4th grade classroom doing Newton’s Laws of Motion, as well as planning additional star parties and a trip to a tech museum and a college planetarium.

Perhaps the greatest ripple effect we’ve seen is the creation of new Project ASTRO sites by astronomers who were partnered with teachers and then moved on to a new position in a new state that did not have an active Project ASTRO site. This has happened twice in recent years: Karen Vanlandingham and Jennifer Scott, both former astronomer volunteers in Tucson, are now both site leaders in new states.

When I was teaching as an adjunct faculty member at the University of Arizona I got involved in the local Project ASTRO program and was paired with a couple of 3rd grade teachers. The teachers were awesome and working with the kids was so much fun! We would do phases of the Moon activities with Styrofoam balls in darkened classrooms and you could hear the kids going “Ohhhhhh!” as the connection between the position of the Moon, Earth, and Sun and the observed phases finally clicked. What a great moment!
A Partnership: In Their Own Words

Debbie Dickinson (Teacher, Old Farmers Road School, Long Valley, NJ.): Our partnership thrives because Bob and I share similar values. It is obvious we both are interested in astronomy, but it goes way beyond that. It appears to me that we both possess an unquenchable need to provide students with experiences that will enrich the given curriculum, but more importantly, their lives! Another vital contributor to our success is a mutual respect for each other and the students. We work together, mindful and considerate of each other’s unique perspective, to provide the most beneficial inquiry-based experiences for our students. It is also very helpful that Bob interacts and relates to the students at whatever level they are at. His pleasant, warm, and down-to-earth demeanor makes the children feel comfortable and willing to ask questions.

Patience and understanding also play an important role in our partnership. Bob’s expertise and enthusiasm are astounding! His exuberance can be a bit overwhelming for me as I am more reserved and like to have a secure handle on things before I take the plunge. Bob always gives me the time and information I need to “get my ducks in a row” without making me feel incompetent or like a nuisance. I try not to quell his enthusiasm with my constant questions and need for clarification!

I believe my students and I have benefitted from my Project ASTRO partnership with Bob in immeasurable ways. I have definitely increased my knowledge and understanding of astronomy, life, and myself. Having the opportunity to work with someone in my class has made me reflect on my teaching style and practices. Project ASTRO’s lessons/activities affirm my belief that students grow and learn best from inquiry and problem-based, hands-on learning.

Also, two heads are better than one! Bob’s brains and my know-how complement each other during planning and in the classroom, as well as provide my students with an extraordinary opportunity and enrichment they would not otherwise receive as part of the regular curriculum.

Finally, as a result of my Project ASTRO relationship with Bob, I have acquired a friend and mentor. Bob’s vast experience and perspective of life has afforded me a new and objective way of looking at, and dealing with, situations that occur.

Bob Reichman (Astronomer): I’m a late-blooming amateur astronomer, and I’ve kept myself busy in astronomy outreach since the 2009 International Year of Astronomy. Since that time I’ve been a part of four Project ASTRO partnerships. My fourth and newest partnership is great, and our program is growing smoothly in its third year.

Debbie and I hit it off from the moment we introduced ourselves at a two-day Project ASTRO workshop here in New Jersey. She’s very personable and outgoing with a strong enough sense of self that I didn’t intimidate her as I do many people. My direct communication style and twisted humor didn’t faze her. We scheduled the entire year of class visits, including a star party, before the Saturday afternoon workshop wrapped up. I think the world of her, and we’ve developed a friendship and mutual admiration for one another. She can’t believe my willingness to come into her classroom four or five times a year and share my joy and passion for things astronomic with her and her students. I can’t believe she and her principal let me.

The bases for our continued successful partnership is respect, clear and direct communication, and thorough planning. Because of divergent schedules, we don’t speak on the phone a lot but do most of our back-and-forth via text or e-mail. We’re respectful of each other and responsive to each other. For instance, when planning our first star party Debbie expressed a concern for being overwhelmed by all the details, but we landed on a size, scope, and complexity with which everybody involved could be comfortable. We now have plans for our next star party, which is three times larger with many more moving parts. She is ready to go and comfortable taking on this far larger program.

The extent of my astronomy outreach has gone supernova since I began with Project ASTRO. Because of it? Probably not, but certainly buttressed by the great feedback I enjoy through my Project ASTRO classroom experiences. Since Project ASTRO, my additional outreach activities have grown to include volunteering for a month each fall as a Dark Ranger at Acadia National Park; sharing telescope skills and demonstrating inquiry-based, astronomy activities with public school teachers; visiting schools, libraries and nursing homes; and most recently learning about planetarium operations at a local community college.

Our partnership is a great example of one in which everyone benefits.
Ultimately I got a job at West Chester University (PA), and when I was packing up to move, I figured I would sign up for the local Project ASTRO once I got out east. Imagine my disappointment when I found out that there wasn’t a local office near me! Knowing how much the students, teachers, and astronomers got out of the program, I decided to look into building a new Project ASTRO site at West Chester. Six years later we’ve managed to create several dozen teacher-astronomer partnerships. Karen Vanlandingham, Project ASTRO site leader, West Chester, PA.

When I arrived in Baltimore as a post-doc in 2002, I began to think about how the Project ASTRO model might serve both the perennially challenged Baltimore City Public Schools and the many astronomers and astronomy experts in our region. It seemed such a shame that the vast intellectual resources and enthusiasm of these folks were not tapped for the purpose of drawing more kids into science.

It wasn’t until I began a position on the faculty of Towson University that I had the opportunity to realize this dream. The success of our program means many astronomers are as eager to reach out to students as I was as a graduate student. Jennifer Scott, Project ASTRO site leader, Baltimore/Towson, MD.

“You are about to embark on a rewarding and sometimes challenging partnership to improve science education.” Each of the partnerships described (and thousands more) have undertaken this journey during the 20 years since Project ASTRO began. Those teachers and astronomers who describe their partnership as successful have commented on the important attributes that kept their Project ASTRO going. Thousands upon thousands of students have had their lives touched in a positive way by the thrill of astronomy. The sky is certainly no limit for the next 20 years of Project ASTRO.

The authors would like to thank the following astronomers and teachers for sharing their stories, photos, and anecdotes.

Susan Benecchi (astronomer) & Megan Gover (teacher, Mount Washington School, Baltimore, MD).
Russ Drum (astronomer) & Brenda Cook-Johnson (Librarian, Summerfield Elementary School, Neptune, NJ).
Roy Hayter (astronomer) & Nikole Manou (teacher, Lucile M. Nixon Elementary, Palo Alto, CA).
Rich Huber and Linda Prince (astronomers) & Linda Scarth (teacher, Copiague Public Schools, Long Island, NY).
Matthew Knight (astronomer) & Rennie Watson (teacher, Academy of Science, Baltimore, MD).
Tom Krause (astronomer) & Trish Stadler (teacher, Medfield Heights, Baltimore, MD).
Bob Reichman (astronomer) & Debbie Dickinson (teacher, Old Farmers Road School, Long Valley, NJ).
Mike Smithwick (astronomer) & Kofo Oluwole-Orojo (teacher, Majestic Way School, San Jose, CA).
Jennifer Scott, Project ASTRO site leader, Baltimore/Towson, MD.
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For at least the next decade, the Next Generation Science Standards (NGSS — Next Generation Science Standards: For States, by States) will likely affect all aspects of science teaching and learning, including astronomy. The NGSS presents a new vision for science education and is based on A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (NRC 2012). This Framework provides our best understanding of how our nation’s students learn science and what is needed to create a competitive 21st-century workforce. The Framework further provides justification for the conceptual shifts that the NGSS presents, and helps to illuminate what is new and different about the NGSS compared to current classroom practices (NSTA 2013 position statement).

The main impetus for the NGSS and the Framework is the idea that K–12 science instruction be built around three dimensions that are intertwined and mutually supportive: Science and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas.

**Dimension 1: Science and Engineering Practices.** The eight science and engineering practices are derived from practices that scientists and engineers actually engage in as part of their work. Volunteer outreach astronomer Matthew Knight works with Rennie Watson’s Earth and Space Science class to create and learn how to use star charts to find constellations. [Courtesy Rennie Watson.]
They build on the principles of inquiry-based learning, but expand on them in several important aspects such as “Developing and Using Models” and “Engaging in Argument from Evidence” which are usually under-emphasized in an inquiry classroom.

**Dimension 2: Crosscutting Concepts.** The seven crosscutting concepts describe concepts that bridge disciplinary boundaries and have explanatory value throughout much of science. They help students connect knowledge from the various disciplines into a coherent and scientifically based view of the world. These crosscutting concepts provide excellent opportunities for students to make connections between content across disciplines and provide lenses for looking at the natural world.

**Dimension 3: Disciplinary Core Ideas.** Given the wealth of scientific information available today, an important role of science education is not to teach “all the facts” but rather to prepare students with sufficient core knowledge so that they can later acquire additional information on their own. Thus, an education focused on a limited set of ideas should enable students to evaluate and select reliable sources of scientific information, and allow them to continue their development well beyond their K–12 school years as science learners, users of scientific knowledge, and potentially producers of such knowledge. Accordingly, the Framework describes 13 core ideas in science and engineering: four in physical science, four in life science, three in Earth and space science, and two in engineering, technology, and applications of science. Such a limited set of core ideas allows for in-depth learning of these ideas as students engage in science and engineering practices and use crosscutting concepts to develop their understanding of these core ideas over time.

The NGSS also includes Performance Expectations (PEs) that integrate the science and engineering practices with the crosscutting concepts and disciplinary core ideas. These PEs require that students demonstrate their understanding of science by using and applying their knowledge. Although not all states are expected to adopt the NGSS, the Framework that serves as its foundation will likely affect future state standards for at least the next decade.

**Astronomy Education and the Next Generation Science Standards**

To better understand the implications of the NGSS for astronomy education, it is essential to take a closer look at how astronomy is represented in the NGSS. One of the 13 core disciplinary ideas directly relates to astronomy. This core idea, named “Earth’s Place in the Universe”, is divided into three component ideas: “The Universe
and Its Stars,” “Earth and the Solar System,” and “The History of Planet Earth.” However, only the first two component ideas are typically taught as part of an astronomy unit. In the NGSS, astronomy can be divided into five sub-topics, which include Earth-Sun-Moon System, Sun and Stars, Gravity, Solar System, and Galaxies and the Universe.

• Ideas about the Earth-Sun-Moon System are introduced in the 1st grade and further developed in grades 5 and grades 6–8; four of the 12 astronomy PEs target these ideas.

• Ideas about the Sun and Stars are introduced in the 1st grade and further developed in grades 5 and grades 9–12; four astronomy PEs target these ideas.

• Ideas about Gravity are introduced in the 5th grade and further developed in grades 6–8 and grades 9–12; three astronomy PEs target these ideas.

• Ideas about the Solar System are introduced in grades 6–8 and further developed in grades 9–12; three astronomy PEs target these ideas.

• Ideas about Galaxies and the Universe are introduced in grades 6–8 and further developed in grades 9–12; two astronomy PEs target these ideas.

The choice of the elementary grade levels (1 and 5) and the content per grade level is intentional to ensure that students have the required prerequisite knowledge to understand these astronomy ideas at a deeper level. Only 12 PEs are directly related to astronomy: two in the 1st grade, three in the 5th grade, three in grades 6-9, and four in grades 9–12. Examples include:

• Grade 1: Use observations of the Sun, Moon, and stars to describe patterns that can be predicted.

• Grade 5: Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

• Grade 6–8: Develop and use a model of the Earth-Sun-Moon system to describe the cyclic patterns of lunar phases, eclipses of the Sun and Moon, and seasons.

• Grade 9–12: Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.

Although each PE includes only one of eight science and engineering practices and one of seven crosscutting concepts, a unit or sequence of lessons to prepare students for such a Performance Expectation should include most or all of them. Nevertheless, it is illustrative to examine which practices and crosscutting concepts are most frequently included in the astronomy PEs and are considered to be especially important for deepening students’ understanding of the content addressed in those PEs.

The following practices are most often included in astronomy PEs:

• Analyzing and Interpreting Data (three),

• Developing and Using Models (three), and

• Engaging in Argument from Evidence (two).

The other five practices are included one time each, except for “Asking Questions” which is not included in any astronomy PEs.

The following crosscutting concepts are most often included in astronomy Performance Expectations:
• Patterns (four),
• Scale, Proportion, and Quantity (four), and
• Energy and Matter (two).

Two crosscutting concepts — Cause and Effect, and Systems and System Models — are included one time each, and the remaining two crosscutting concepts — Structure and Function, and Stability and Change — are not included in any astronomy PEs.

Project ASTRO and the Next Generation Science Standards

To remain relevant in our nation’s dynamic educational environment, the Astronomical Society of the Pacific’s Project ASTRO will have to adapt to support teachers with the implementation of the NGSS. The NGSS presents a number of challenges as well as opportunities. Astronomy is only a very small part of the NGSS. In elementary school, students learn about astronomy only in grades 1 and 5, and are held accountable for only five PEs. Although astronomy is better represented in middle school and high school, it is rarely taught in our nation’s high schools except maybe as an elective. Thus, there is the danger that astronomy will not be taught to students, even as part of the NGSS, especially if it will be a very small part of high-stakes testing. On the other hand, astronomy as one of the applied sciences is an excellent vehicle for use and application of knowledge, and an important goal of the NGSS. Additionally, astronomy continues to fascinate students of all ages.

So what can we do to ensure that astronomy remains an integral part of the K–12 curriculum? First, we will need to examine all the astronomy activities and investigations currently used and assess how well they are aligned to the NGSS. Project ASTRO is rightly proud of its Universe at Your Fingertips (UAYF) DVD resource. It contains more than 150 astronomy activities that, during the past two decades, have moved teachers and their students away from reading about astronomy toward doing astronomy.

Now is the time to think about how we can modify these great activities and transform them into exemplary investigations that are aligned with the NGSS. We have to determine which of the UAYF activities best support the core ideas in the NGSS and how to sequence these activities to support individual astronomy PEs. We have to consider how to modify these activities so that students will engage in science and engineering practices and select and use crosscutting concepts to make sense of astronomical phenomena. At the very least, the practices of Analyzing and Interpreting Data, Developing and Using Models, and Engaging in Argument from Evidence — and the crosscutting concepts of Patterns; Scale, Proportion, and Quantity; and Energy and Matter — should be emphasized based on the frequency at which they are included in the astronomy PEs.
Second, we will have to provide high-quality professional development for our volunteer astronomers and in-service teachers so that they understand the conceptual shifts presented by the NGSS. This will also present a major shift for our volunteer astronomers and for scientists in general. Scientists are used to being a source of information, but now we need to tap into their experience with science practices and using knowledge to create new knowledge. We need to provide them with the tools so that they can model this for teachers and students and engage them in astronomy. Accordingly, scientist-educator partnerships will need a significant amount of support to implement the NGSS.

**Moving Toward a Transformative Educational Research Agenda**

During the past two decades, scientist-educator partnership programs have rapidly emerged across the United States with the goal of enhancing the teaching and learning of science to students in our nation’s schools. The National Research Council has noted that scientists play a critical role in achieving a vision of a scientifically literate populace. Reports also suggest that K–12 science education could be strengthened if scientists partner with teachers in local area schools to share their knowledge, passion, and expertise in science with students (Linn et al., 1999; Munn et al., 1999; Wheeler, 1998).

Although many published articles and reports often describe the outcomes of scientist-educator partnership programs anecdotally, the influence of scientist-educator partnerships on the teaching and learning of science to students has not been well documented in the extant research literature. Given the lack of empirical evidence, a more comprehensive understanding of the influence of scientist-educator partnerships is vital, especially for designers and facilitators of such educational programming.

In the same vein, Project ASTRO has been linking professional and amateur astronomers with local K–12 teachers and students to bring inquiry-based astronomy activities to classrooms during the last 20 years. Project ASTRO is an example of a successful model for astronomer-educator partnerships (Fraknoi et al., 1998) that has been sustained for many years beyond extramural funding, and has been listed among the most effective programs in the United States involving scientists and engineers in K–12 education (Connolly, 1997). In its first 10 years of operation, Project ASTRO served more than 100,000 students (Fraknoi and Zevin, 2003). Research studies suggest that teachers participating in Project ASTRO believed that their partnership with an astronomer positively influenced their
students’ behaviors, and their students’ attitudes toward science (Gibbs and Berendsen, 2007; Miranda, 2012).

Other empirically based studies on Project ASTRO suggest that participating educators believed that their partnership with an astronomer largely influenced their students’ level of motivation, increased their students’ level of questioning, and enhanced their students’ learning experiences in astronomy by making the subject area more realistic, relevant, and scientifically rigorous (Miranda, 2010; Miranda, 2012). The implications of these findings suggest that astronomer-educator partnerships may enhance students’ learning experiences in astronomy and promote their engagement with science.

While the programmatic goals of Project ASTRO make a great deal of intuitive sense, the program generally lacks empirical evidence or validation. When we reviewed the literature base for articles on Project ASTRO, we found it difficult to find papers with clearly articulated research questions, or specific details regarding how programmatic data would be collected, analyzed, and assessed. Consequently, this demonstrates the inherent difficulty in determining the overall success and effectiveness of Project ASTRO, since many manuscripts in the extant literature base often present programmatic outcomes anecdotally. Thus, the continued expansion and emphasis for a research agenda on Project ASTRO is vital to help create new knowledge that can impact K–12 students and teachers, as well as astronomy education at a national level.

Based on our background as science education researchers and as professional development providers, we strongly encourage facilitators of astronomer-educator partnership programs in K–12 schools to take a more critical, empirically-based research perspective to assess their programmatic goals. Additionally, they should plan to disseminate their research-based findings with the astronomy education community through local, regional, and national conferences; research and practitioner journals; and popular publications so that they can be used as a basis for discussion.

The Evolution of Project ASTRO

Amidst our nation’s dynamic educational environment, we believe that Project ASTRO can evolve to remain relevant by moving toward a transformative educational research agenda. Although this concept can have multiple meanings, transformative educational research implies a radical change in our understanding of an educational practice and is at the forefront of creating new knowledge as a means to achieve some change in society. This suggests that the societal impacts of transformative research could be done by conducting research on the broader impacts of Project ASTRO on K–12 schools across the nation, integrating research with societal goals of science education such as the NGSS, and through collaborative reflection on the societal effects of Project ASTRO on astronomy education in general as part the evaluation. Only by doing so can we create new knowledge and a more coherent and articulated astronomy education experience for K–12 teachers and students in the US.

During the 2013 Project ASTRO National Network (PANN) meeting in Baltimore, site leaders recognized that an examination of the PANN could provide a unique research opportunity, because each
lead institution’s local coalition of scientific and educational organizations, and the communities they serve, vary from site to site. Accordingly, during the 2014 PANN meeting in Michigan, site leaders plan to systematically assess Project ASTRO’s diverse programmatic structure among Project ASTRO lead institutions (currently active in 12 regions throughout the United States) and their broader impacts on K–12 schools across the nation during the last 20 years. This investigation will be done to specifically generate new research knowledge to support the improvement of science teaching and learning through astronomy in our nation.

Site leaders also plan to share their experiences and values with one another to establish the culture and foundation upon which to build a transformative educational research agenda. Moreover, the findings of this kind of agenda can help to advance our knowledge base in science education by yielding research-based best practices for fostering partnerships that involve astronomers and educators, by yielding research-based best practices for providing professional development for astronomers and educators, and by helping to guide others who may be interested in designing and facilitating programs that involve scientist-educator partnerships that are culturally responsive in their classroom practice.

The implementation of the NGSS in K–12 classrooms across the United States, and the movement toward a transformative educational research agenda, will be a very challenging endeavor. In light of our nation’s dynamic educational environment, we hope that our ideas in this article will get the conversation started in the astronomy education community. The advantage for astronomy is that we are a fairly small community with a relatively small amount of content to cover in K–12. If we can come together and collaborate, astronomy could set an example for other science disciplines to follow.

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The “Perfect” Solar Storm
University of New Hampshire

In a paper published [March 18, 2014] in *Nature Communications*, an international team of scientists, including three from the University of New Hampshire’s Space Science Center, uncovers the origin and cause of an extreme space weather event that occurred on July 22, 2012, at the Sun and generated the fastest solar wind speed ever recorded directly by a solar wind instrument.

The 2012 storm was so powerful that had it been aimed at Earth instead of at the STEREO A spacecraft, which was located 120 degrees off to the side of Earth, the consequences would have been dramatic: widespread aurora, satellite malfunctions, and potential for failures with ground-based electricity grids.

To date, it has been unclear how extreme space weather storms form and evolve. Developing a better understanding of their causes is vital to protect modern society and its technological infrastructures, and is one of the goals of the STEREO mission.

“These results provide a new view crucial to solar physics and space weather as to how an extreme space weather event can arise from a combination of multiple solar eruptions,” says research assistant professor Noé Lugaz of the UNH Institute for the Study of Earth, Oceans, and Space (EOS).

The authors suggest it was the successive, one-two punch of solar eruptions known as coronal mass ejections that was the key to the event, which blasted away from the Sun at 3,000 kilometers per second. “In a sense, this was the ‘perfect storm,’” Lugaz says. “The first, fast eruption greased the skids for the quick propagation of the subsequent, extremely fast eruptions through interplanetary space.”

Says EOS research professor Charles Farrugia, “Remarkably, this is reminiscent of the great solar flare in 1859, the Carrington Event, and the geomagnetic storm of unheard of intensity in Earth’s magnetosphere…that occurred less than one day later.”

MORE INFORMATION

This image combines data from two coronagraphs and an extreme ultra-violet imager (green) on STEREO A. The CME is the bright streaks emanating from the Sun. A coronagraph is a telescope that uses a disk to block the Sun’s bright surface revealing the solar corona. (NASA)
Mercury’s Contraction Much Greater Than Thought

*Carnegie Institution for Science*

New global imaging and topographic data from MESSENGER show that the innermost planet has contracted far more than previous estimates. The results are based on a global study of more than 5,900 geological landforms, such as curving cliff-like scarps and wrinkle ridges, that have resulted from the planet’s contraction as Mercury cooled. The findings are key to understanding the planet’s thermal, tectonic, and volcanic history, and the structure of its unusually large metallic core.

Unlike Earth, with its numerous tectonic plates, Mercury has a single rigid, top rocky layer. Prior to the MESSENGER mission only about 45% of Mercury’s surface had been imaged by a spacecraft. Old estimates, based on this non-global coverage, suggested that the planet had contracted radially by about ½ to 2 miles (0.8 to 3 kilometers) substantially less than that indicated by models of the planet’s thermal history.

The new results, which are based on the first comprehensive survey of the planet’s surface, show that Mercury contracted radially by as much as 4.4 miles (7 kilometers) — substantially more than the old estimates, but in agreement with the thermal models. Mercury’s modern radius is 1,516 miles (2,440 kilometers).

“These new results resolved a decades-old paradox between thermal history models and estimates of Mercury’s contraction,” remarked lead author of the study, Paul Byrne, a planetary geologist and MESSENGER visiting investigator at Carnegie’s Department of Terrestrial Magnetism. “Now the history of heat production and loss and global contraction are consistent.”

MORE INFORMATION
Gravity Measurements Confirm Subsurface Ocean on Enceladus

*California Institute of Technology*

In 2005, NASA’s Cassini spacecraft sent pictures back to Earth depicting an icy Saturnian moon spewing water vapor and ice from fractures known as “tiger stripes” in its frozen surface. It was big news that tiny Enceladus — a mere 500 kilometers in diameter — was such an active place. Since then, scientists have hypothesized that a large reservoir of water lies beneath that icy surface, possibly fueling the plumes. Now, using gravity measurements collected by Cassini, scientists have confirmed that Enceladus does in fact harbor a large subsurface ocean near its south pole, beneath those tiger stripes.

“For the first time, we have used a geophysical method to determine the internal structure of Enceladus, and the data suggest that indeed there is a large, possibly regional ocean about 50 kilometers below the surface of the south pole,” says David Stevenson, the Marvin L. Goldberger Professor of Planetary Science at Caltech and an expert in studies of the interior of planetary bodies. “This then provides one possible story to explain why water is gushing out of these fractures we see at the south pole.”

During three flybys of Enceladus, between April 2010 and May 2012, the scientists collected extremely precise measurements of Cassini’s trajectory by tracking the spacecraft’s microwave carrier signal with NASA’s Deep Space Network. The gravitational tug of a planetary body, such as Enceladus, alters a spacecraft’s flight path ever so slightly. By measuring the effect of such deflections on the frequency of Cassini’s signal as the orbiter traveled past Enceladus, the scientists were able to learn about the moon’s gravitational field. This, in turn, revealed details about the distribution of mass within the moon. “This is really the only way to learn about internal structure from remote sensing,” Stevenson says.

The key feature in the gravity data was a so-called negative mass anomaly at Enceladus’s south pole. Put simply, such an anomaly exists when there is less mass in a particular location than would be expected in the case of a uniform spherical body.
Kepler Mission Announces a Planet Bonanza, 715 New Worlds

NASA / Ames

NASA’s Kepler mission announced, at the end of February, the discovery of 715 new planets. These newly verified worlds orbit 305 stars, revealing multiple-planet systems much like our own solar system. Nearly 95 percent of these planets are smaller than Neptune, which is almost four times the size of Earth. This discovery marks a significant increase in the number of known small-sized planets more akin to Earth than previously identified exoplanets, which are planets outside our solar system.

Since the discovery of the first planets outside our solar system roughly two decades ago, verification has been a laborious planet-by-planet process. Now, scientists have a statistical technique that can be applied to many planets at once when they are found in systems that harbor more than one planet around the same star.

To verify this bounty of planets, a research team co-led by Jack Lissauer, planetary scientist at NASA’s Ames Research Center in Moffett Field, Calif., analyzed stars with more than one potential planet, all of which were detected in the first two years of Kepler’s observations — May 2009 to March 2011.

The research team used a technique called verification by multiplicity, which relies in part on the logic of probability. Kepler observes 150,000 stars, and has found a few thousand of those to have planet candidates. If the candidates were randomly distributed among Kepler’s stars, only a handful would have more than one planet candidate. However, Kepler observed hundreds of stars that have multiple planet candidates.

Through a careful study of this sample, these 715 new planets were verified. Said Lissauer. “We’ve now developed a process to verify multiple planet candidates in bulk to deliver planets wholesale, and have used it to unveil a veritable bonanza of new worlds.”

MORE INFORMATION

The artist concept depicts multiple-transiting planet systems, which are stars with more than one planet. The planets eclipse or transit their host star from the vantage point of the observer. [NASA]
Closest, Brightest Supernova in Decades is also a Little Weird

University of California, Berekley

A bright supernova discovered in early 2014 in a nearby galaxy is provoking new questions about the exploding stars that scientists use as their main yardstick for measuring the universe.

Called SN 2014J, the glowing supernova was discovered by a professor and his students in the United Kingdom on January 21, about a week after the stellar explosion first became visible as a pinprick of light in its galaxy, M82, 11.4 million light-years away in the Big Dipper. It is the brightest supernova seen from Earth since SN1987A 27 years ago, and may be the closest Type Ia supernova — the kind used to measure cosmic distances — in more than 77 years.

When University of California, Berkeley, astronomer Alex Filippenko’s research team looked for the supernova in data collected by the Katzman Automatic Imaging Telescope (KAIT) at Lick Observatory, they discovered that the robotic telescope had actually taken a photo of it 37 hours after it appeared, unnoticed, on January 14.

Combining this observation with another chance observation by a Japanese amateur astronomer, Filippenko’s team was able to calculate that SN 2014J had unusual characteristics — it brightened faster than expected for a Type Ia supernova and, even more intriguing, it exhibited the same unexpected, rapid brightening as another supernova that KAIT discovered and imaged last year — SN 2013dy.

“Now, two of the three most recent and best-observed Type Ia supernovae are weird, giving us new clues to how stars explode,” said Filippenko, referring to a third, though apparently ‘normal,’Type Ia supernova, SN 2011fe, discovered three years ago. “This may be teaching us something general about Type Ia supernovae that theorists need to understand. Maybe what we think of as ‘normal’ behavior for these supernovae is actually unusual, and this weird behavior is the new normal.”
Spiral Galaxy Spills Blood and Guts

NASA

This new Hubble image shows ESO 137-001, a galaxy located in the southern constellation of Triangulum Australe — a delicate and beautiful spiral galaxy, but with a secret. This image not only captures the galaxy and its backdrop in stunning detail, but also something more dramatic — intense blue streaks streaming outwards from the galaxy, seen shining brightly in ultraviolet light.

These streaks are actually hot young stars, encased in wispy streams of gas that are being torn away from the galaxy by its surroundings as it moves through space. This violent galactic disrobing is due to a process known as ram pressure stripping — a drag force felt by an object moving through a fluid. (A quick and simple analogy for this effect would be to imagine leaning out of a car window as it traveled quickly along a motorway, or walking within a swimming pool.) The fluid in question here is superheated gas, which lurks at the centers of galaxy clusters.

This image also shows other telltale signs of this process, such as the curved appearance of the disc of gas and dust — a result of the forces exerted by the heated gas. The cluster’s drag may be strong enough to bend ESO 137-001, but in this cosmic tug-of-war the galaxy’s gravitational pull is strong enough to hold on to the majority of its dust — although some brown streaks of dust displaced by the stripping are visible.

Studying ram pressure stripping helps astronomers to better understand the mechanisms that drive the evolution of galaxies. For example, it will leave this galaxy with very little of the cold gas that is essential for star formation, rendering the galaxy effectively incapable of forming new stars.
Bullying Black Holes Force Galaxies to Stay Red and Dead

EUROPEAN SPACE AGENCY

Giant elliptical galaxies are the most puzzling type of galaxy in the universe. Since they mysteriously shut down their star-forming activity and remain home only to the longest-lived of their stars — which are low-mass ones and appear red — astronomers often call these galaxies ‘red and dead’.

Up until now, it was thought that red-and-dead galaxies were poor in cold gas — the vital raw material from which stars are born. While cold gas is abundant in spiral galaxies with lively star formation, the lack of it in giant ellipticals seemed to explain the absence of new stars.

Astronomers have long been debating the physical processes leading to the end of their star formation. They speculated that these galaxies somehow expelled the cold gas, or that they had simply used it all to form stars in the past. Although the reason was uncertain, one thing seemed to have been established: these galaxies are red and dead because they no longer possess the means to sustain the production of stars.

This view is being challenged by a new study based on data from ESA’s Herschel Space Observatory. “We looked at eight giant elliptical galaxies that nobody had looked at with Herschel before and we were delighted to find that, contrary to previous belief, six out of eight abound with cold gas,” explains Norbert Werner from Stanford University in California, USA, who led the study.

This is the first time that astronomers have seen large amounts of cold gas in red-and-dead galaxies that are not located at the centre of a massive galaxy cluster. The cold gas manifested itself through far-infrared emissions from carbon ions and oxygen atoms. Herschel’s sensitivity at these wavelengths was instrumental to the discovery.

MORE INFORMATION

This image shows a composite view of the giant elliptical galaxy NGC 5044. The stellar component, as observed at optical wavelengths, is shown in white at the centre of the image. The other stars scattered around the image are foreground stars from our own Galaxy. The galaxy is embedded in a hot atmosphere of ionized hydrogen gas, which is shown in blue. With temperatures up to tens of millions of K, the hot gas shines brightly in X-rays. [Digitized Sky Survey/NASA Chandra/Southern Observatory for Astrophysical Research/Very Large Array (Robert Dunn et al. 2010)]
These Aren’t the Voids You’re Looking For
*International Centre for Radio Astronomy Research*

Australian astronomers have shown galaxies in the vast empty regions of the universe are actually aligned into delicate strings. A team of astronomers based at The University of Western Australia node of the International Centre for Radio Astronomy Research (ICRAR) has found short strings of faint galaxies in what were previously thought to be extremely empty parts of space.

The universe is full of vast collections of galaxies that are arranged into an intricate web of clusters and nodes connected by long strings. This remarkably organized structure is often called the ‘cosmic web,’ with busy intersections of galaxies surrounding vast spaces, empty of anything visible to us on Earth.

“The spaces in the cosmic web are thought to be staggeringly empty,” said Dr Mehmet Alpaslan, who led the research. “They might contain just one or two galaxies, as opposed to the hundreds that are found in big clusters.” These huge, empty regions are called voids, and for years, astronomers have been trying to understand the small population of galaxies that inhabit them.

Using data from the Galaxy and Mass Assembly (GAMA) survey, Alpaslan and his colleagues found that the small number of galaxies inside these voids are arranged in a new way never seen before. “We found small strings composed of just a few galaxies penetrating into the voids, a completely new type of structure that we’ve called “tendrils,”” said Alpaslan.

To discover tendrils, the GAMA team created the largest ever galaxy census of the southern skies using observations from the Anglo-Australian Telescope in NSW, Australia. “We weren’t sure what we’d find when we looked at voids in detail, but it was amazing to find so many of these tendrils lurking in regions that have previously been classified as empty,” said Dr Aaron Robotham from The University of Western Australia node of ICRAR.

MORE INFORMATION

A simulation of the ‘cosmic web’ showing clusters of galaxies and a void in the middle of the image, where Dr Alpaslan and team discovered tendrils of galaxies. [Cui, Newton and Power (ICRAR), Cunnama (UWC)]
Michel Gibbs Memorial Fund Established

As many of you will recall, the ASP lost one of its greatest champions in December with the untimely passing of Michael Gibbs, former employee (2005–08), and Board member and officer (2009–13). Following discussion with Michael’s family, and in response to the generous donations received in Michael’s name, the ASP has established the **Michael Gibbs Memorial Fund**. Donations received thus far, and any donations received in the future, will be equally divided between an endowed fund in Michael’s name to help ensure the ASP’s sustainability, and the ASP’s infrastructure program that enables the delivery of science education workshops, trainings, and services.

You may make your gift easily and securely [online](#) or via regular mail to our San Francisco headquarters located at 390 Ashton Avenue, San Francisco, CA 94112.

Updated Guide: Science Fiction with Good Astronomy

Andrew Fraknoi’s revised and updated resource guide to science fiction stories with good astronomy and physics is [now available](#) on the ASP’s website. This edition of the guide includes more than 270 stories organized into more than 40 topical categories. This is a selective list of some short stories and novels that use more or less accurate science and can be used for teaching or reinforcing astronomy or physics concepts. Included are both traditional science fiction and (occasionally) more serious fiction that derives meaning or plot from astronomy or physics ideas.

For the first time, this list gives the URLs for a number of stories that are available free on the Web. All the listed stories could be used for class supplements or recommending to interested audiences.

Celebrating Science: Putting Education Best Practices to Work

Along with our education and public outreach friends and colleagues, we look forward to **Celebrating Science: Putting Education Best Practices to Work**. Please visit the [2014 Annual Meeting site](#) for continual event updates and helpful destination information. **Abstract proposals** for the ASP’s 2014 Annual Meeting are now welcome in support of the categories below. Please note that this year we invite a new category of abstracts: two-hour special sessions. Abstracts are due by May 4 and the topics include:

- Supporting the Next Generation Science Standards (NGSS)
- Engaging with 21st Century Media and Technology

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• Promoting Multicultural Diversity and Gender Equity
• Using Authentic Science and Citizen Science
• Improving Our Professional Practice

In addition, there are a number of plenary sessions including the Next Generation Science Standards (NGSS), enhancing the science communication skills of research scientists, NASA E/PO impacts and metrics, public science literacy, “big science,” and amateur astronomers’ impact on research and outreach.

Our featured plenary speaker is Dennis Bartels, Executive Director of the Exploratorium, who will address connections across formal and informal STEM learning. See you in Burlingame August 4–6, 2014!

NEW MEMBERS — The ASP welcomes new members who joined between January 1 and March 31, 2014.

Individual
James M. Bauer, Sunland, CA
Spence E. Blakely, Portsmouth, RI
George L. Davis, Plano, TX
Michael Devirian, La Crescenta, CA
Dale L. Fields, Winnetka, CA
Stuart Forman, Pleasant Hill, CA
Joel W. Goodman, Glenwood, MD
Scott B. Gracie, Maribyrnong, Victoria, Australia
James R. Hamm, Moses Lake, WA
Debra B. Herbst, Eagle Nest, NM
Kenneth C. Hess, Carmel, CA
David W. Ingram, Kent, WA
Suzanne H. Jacoby, Tucson, AZ
David D. Kolb, Lawrence, KS
Larry Lambert, Pinoles, CA
Nancy Lanning, Wheaton, IL
Seanan Murphy, Arlington, MA
Brad Neugebauer, Anchorage, AK
Demetris Nicolaides, Dumont, NJ
Laird A. Thompson, San Diego, CA
Christopher Ubing, Sierra Vista, AZ
Linda L. Winkler, Moorhead, MN

Student
Rachael L. Beaton, Charlottesville, VA
Bob Guzik, Orangevale, CA
Jennie King, Roanoke, VA
Ava Van Natta, San Francisco, CA

Supporter’s Circle
Robert T. O’Dell, Huntington Beach, CA
Philip M. Sadler, Cambridge, MA

Technical
Thomas Banys, Lodz, Poland
William C. Bucklew, Lake Worth, FL
Joseph H. Jones, Dahlonega, GA
Joseph R. Pasek, Murrieta, CA
Joseph A. Auer Jr., Palatine, IL
Jack Davis, Carson City, NV
Edward L. Fitzpatrick, Villanova, PA
Keith Olson, Spanish Fork, UT

Asp tidings

 Legacy Giving
Astronomy compels the soul to look upwards and leads us from this world to another
— Plato
Leave a universal legacy...
Astronomy shows us that we are part of something much greater than ourselves, and that our actions on Earth have a lasting impact. A legacy gift to the ASP as part of your estate plan reflects this understanding, and will support future generations as they reach for the stars.

astrosociety.org/donate or (415) 337-1100 x106
The Skies of May
Astronomers are always making discoveries about the cosmos, but the days of seeing something — with just your eyes — that nobody else has seen before are long past. Or are they?

During the night of May 24th, step outside and gaze north. You’re looking for meteors, short-lived streaks of light in the sky. Of course on any given night you’ll see the occasional (random) meteor, but on this night you’ll be looking for more than one or two. Astronomers think there may be a meteor shower heading our way…one that has never been witnessed before.

Meteors occur when Earth plows into the debris trail left behind by a comet. There are plenty of known meteor showers (the Perseids in August and the Geminids in December are two of the best). But this May a new one might appear, caused by debris from Comet 209P/LINEAR (discovered in 2004). According to a paper published by Quanzhi Ye and Paul A. Wiegert, “the size distribution of the arrived particles is skewed strongly to larger particles. …we think that the event, if detectable, may be dominated by bright meteors.”

The “consensus” on the time of shower maximum is 7:10 Universal Time on the 24th — 03:10 Eastern time; 00:10 Pacific. The duration is expected to be short: 90 minutes on either side of maximum. The meteors may be bright and slow-moving, with numerous fireballs a distinct possibility. If your skies are clear, have a look. You may be among the few to see the first-ever outburst of this meteor shower.

Jupiter is the bright “star” high in the west as the sunset glow fades. It sets before midnight and so is nicely positioned for viewing.
during the evening. The crescent Moon is below Jupiter on the 3rd and to Jupiter's left the next evening. On the 31st, the Moon is back, sitting just below this giant planet.

During the last half of the month, look for little Mercury low in the west-northwest at dusk. This is a very favorable appearance for this diminutive world as it sets roughly 90 minutes after sunset. It's at its highest as twilight deepens on the 25th, but your best chance to spot it might be on the 30th, when it is 12° (about the width of your clenched fist held at arm's length) to the right of the 2-day-old Moon.

Mars was at opposition on April 8th, so it is still glowing bright orange, high in the southeast at dusk. On the 10th the waxing gibbous Moon sits to the right of the "red planet." On this same night, Saturn is at opposition, which means it rises when the Sun sets and is visible all night. The ringed planet is to the left of the nearly full Moon on the 13th.

In the morning sky Venus rises more than 90 minutes before the Sun, but it isn't very high in the east as dawn breaks. Still, it is the brightest "star" at dawn. The crescent Moon will hang just above Venus on the 25th, making for a very photogenic sight.

**The Skies of June**

As the month opens, there are planets aplenty in the dusk sky. If you head outside about 40 minutes after sunset during first 10 days of June, you'll see four of them: Mercury (low in the west-northwest), Jupiter (higher in the west), Mars (high in the south), and Saturn (up in the southeast). During these 10 evenings you can watch the Moon sweep across the sky from Jupiter to Saturn. This lineup lets you visualize the **ecliptic** — the imaginary line in the heavens that marks the annual path of the Sun through the sky. The ecliptic is also where you'll find the Moon and the planets (though they do stray slightly off this path as they wander through the heavens).

Jupiter is rapidly disappearing into the twilight as the month progresses. On the 1st, this giant world sets more than 2.5 hours after the Sun, but by month's end, it's a mere 10° above the horizon at sunset and difficult to see. Your best chance for a last glimpse of Jupiter (before it emerges at dawn in mid-August) may be the 29th, when the planet sits to the far right of the crescent Moon shortly after sunset.

Also low in the west is Mercury, though the planet is rapidly sinking into the sunset glow. After the first week, it has pretty much vanished from sight.

High in the south-southwest after sunset is Mars. Although it's dimmer than it was in April, its reddish appearance keeps it obvious. The red planet hangs above the waxing gibbous Moon at dusk on the 7th. The next evening, the pale bluish-white star Spica sits to the right of the Moon. Keep an eye on Mars and Spica, and you'll see the planet approach and pass the star during the next two months.

One night later (the 9th), Saturn hovers to the left of the Moon; both are high in the south after sunset and set well after midnight. During the next couple of months, be sure to have a look at Saturn through a telescope. Saturn's rings are nicely inclined (21.7°), with their north face (and Saturn's north pole) tilted toward Earth. It's a beautiful sight in any telescope.
Finally, **Venus** continues to rise nearly two hours before the Sun and is the brightest object in the dawn sky. On the 24th, the thin crescent Moon and Venus again make a lovely morning pair.

The **solstice** occurs on June 21st at 6:51 am Eastern time; 3:51 am Pacific. This marks the celestial start of summer in the northern Hemisphere and winter in the Southern.

**The Skies of July**

Have you been watching **Mars** and **Spica**? If so, you’ll have seen Mars rapidly close the gap between the two. This month, both are high in the southwest as darkness falls. On the 5th, the first quarter Moon slides between the two and comes within 1° of Mars. Then on the 13th, the red planet sits a mere 1.3° above blue-white Spica. Mars now rapidly pulls away and heads off in the direction of Saturn for a rendezvous with the ringed world late next month.

Although **Jupiter** starts July low in the west-northwest after sunset, realistically it’s too close to the Sun to see. **Saturn** continues to be nicely placed for viewing high in the south and southwest during the evening. On the 7th, Saturn sits above the waxing gibbous Moon.

In the dawn sky, **Venus** hangs low in the east-northeast. Despite rising two hours before the Sun, it never dominates the morning twilight. Little **Mercury** also pops up in the morning, though it’s closer to the Sun than Venus. From the 14th to the 18th, see if you can spot this dim planet some 6° to the lower left of Venus. On the 24th, Venus and the thin crescent Moon rise side by side. The next morning, an even thinner crescent Moon sits to the lower left of Mercury.

**Star Charts**

If you’d like a star chart to help you explore the naked-eye night sky, you have several options: purchase a star wheel (planisphere) or planetarium software, download a PDF showing the sky this month, find an online star chart, or locate an app for your tablet or smartphone.

**PDF Star Charts.** [Skymaps](http://www.skymaps.com) produces a well-done chart that goes beyond a mere monthly star chart. It includes a list of monthly highlights and observable celestial objects. The downside: each month is available only at the very end of the previous month.

Another nice star chart is available from [Orion Telescopes and Binoculars](http://www.oriontelescopes.com); you can download it one month in advance. If you’d like simple star charts that don’t show the planets, a [set of 12](http://www.ianraphael.co.uk/StarCharts/sky-sights-star-charts.pdf) is available from the Canada Science and Technology Museum.

**Online Star Charts.** [Sky View Café](http://www.skyporn.net) gives you control over the chart’s date, time, and location, plus a few other options. But the chart names only a few bright stars, doesn’t identify the constellations, and the printout of the resulting chart is poor. The star chart created on the [Tau Astronomy Club](http://www.tauastronomy.com) website offers fewer options but a better printout. But it lists no star names and the stars are color coded based on their spectral type.

**Apps For Tablets and Smart Phones.** [SkySafari 4](http://www.big揩reast.com/skysafari/) ($2.99 for the basic version; available for iPhone, iPad, and iPod touch; now available for Android) is a very well done star chart app and is the one I use consistently. [The Sky HD](http://www.skyhd.co.uk) by Software Bisque is one of the most popular planetarium programs out there, and is now available for the iPad. If ASP stargazers have a favorite night sky app, regardless of the device, I’d like to hear about it.

— P.D.
A Vast Lagoon

The VLT Survey Telescope (VST) at ESO’s Paranal Observatory in Chile has captured this new, richly detailed image of the Lagoon Nebula (M8) in the constellation Sagittarius. This giant cloud of gas and dust, roughly 100 light-years across, is creating intensely bright young stars and is home to numerous young stellar clusters. Image courtesy ESO/VPHAS+ team.