Focused

The Valley of the Moon Observatory Association Newsletter
(a non-profit science and astronomy education organization)

ROBERT FERGUSON OBSERVATORY

Winter 2015 **Volume XVIII Number 1**

This IS Rocket Science

By Robert Davis

You may have heard that the European Space Agency (ESA) landed a space probe on a comet. That is way cool. I love space exploration and the knowledge that is gained because of it. As I was contemplating what I should write about in this article a thought occurred to me. Since this is not a live presentation at least I won't have to pronounce Comet 67P/Churyumov-Gerasimenko. Actually what occurred to me was how absolutely amazing it was that the ESA could figure out how to even get close enough to 67P to land something on it. I don't have the date of when the Rosetta mission was first conceived but somebody some time ago went "We should try to land a probe on a comet" or something to that effect. So now they have to find a comet that will be passing by relatively close in the not too distant future. Probably not much more than a database search and a few committee meetings and they had the target.

Now comes the amazing part. They can calculate the comet's path "easy enough". But they discover that there is no way to fly directly to the comet. We simply don't have rockets big enough to propel a space craft fast enough to meet up with the comet. Of course the rocket scientists have known how to deal with this issue for some time now. All you have to do is slingshot around a planet and steal some of its gravitational energy. I would have loved to have been in the meeting to watch whoever it was present the solution to the management team. Imagine seeing a chart of the inner solar system and somebody standing in front of it with some sort of pointer aimed at Earth. "So here we go. We start off with a trip around the Sun which will have Rosetta and Earth meet up with each other a year later for the first gravity assist. That will fling Rosetta out to Mars for the second assist a couple of years after that. That path will intersect with Earth a few months later for a third assist which will take us out to the asteroid belt where we can get a few pictures of 2867 Steins and 21 Lutetia while we are in the neighborhood. On our way back around the Sun we can get another assist from Earth which will hurl Rosetta out into deep space for five years when we will meet up with 67P." I can just envision the pointer going around and around tracing out

(turn to **ROCKET** *on Page 7)*

http://www.rfo.org

Public Events at Robert Ferguson Observatory

January 17, Saturday
Public Solar Observing 11 am – 3 pm
Public Observing Night 6 pm

February 14, Saturday
Public Solar Observing 11 am – 3 pm
Public Observing Night 7 pm

March 21, Saturday
Public Solar Observing 11 am – 3 pm
Public Observing Night 9 pm

April 25, Saturday
Public Solar Observing 11 am – 3 pm
Public Observing Night 9 pm

May 16, Saturday
Public Solar Observing 11 am – 3 pm
Public Observing Night 9 pm

June 13, Saturday
Public Solar Observing 11 am – 3 pm
Public Observing Night 9 pm

Evening public viewing is $3 per adult, 18 years or older, plus $8 per car parking fee. Donations accepted. Dress for cold nights!
For current observatory information call: (707) 833-6979.

RFO Classes **(see Page 3)**

Night Sky Spring Series

January 20 February 10
March 17 April 14
May 12 & 19

Be sure to check out our new website at http://www.rfo.org for more interesting astronomical events and information.

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dbraud@rfo.org

VMOA Mission Statement
The VMOA is a group of volunteer amateur and professional astronomers organized as a non-profit association to provide educational programs about science and astronomy for students and the public. To that end, the VMOA operates the Robert Ferguson Observatory in Sugarloaf Ridge State Park in association with California State Parks.

President's Message

By Robert Davis

Season's Greetings,

In our last episode I was looking forward to showing the Moon to the Sonoma County Forum. As their website (www.sonomacountyforum.org) puts it: "The Sonoma County Forum is one of the county's premier professional women's organizations. Twice-monthly programs provide stimulating speakers and enable members to connect with the community and learn about its vast resources." It turned out that it rained that morning so the Moon viewing did not happen. I still provided them with what I hope was stimulating talk about RFO. I talked about the history, the ongoing commitment to its mission and the volunteers that make it all happen. Since we had provided for some viewing time that we ended up not needing, there was a little extra time to just chat at the end and a few of the women made comments along the lines of, "sounds like you have an amazing group of volunteers". To which, of course, I had to reply "Yes we do." It made me feel that I at least did a good job of representing the people that make RFO the amazing place that it is.

Back to the story. I was of course bummed that I didn't get to share views of the Moon with the group but it was OK because the next night was one of RFO's Observing Labs. I like working the Observing Labs because they are limited to a small number of attendees, so you can really spend a good amount of time talking to the folks, and it is the only time I ever look at objects like the Turtle Nebula. Those fainter and fuzzier objects that don't really make good Public Star Party targets. It turned out that we had no skies that night. But it was OK because the next night was a star party night. The skies were not very good but I set my telescope up hoping at least some of the clear patches would stay clear. As the public starting coming up I was notified that we did not have a presenter lined up for that evening. Since the skies were patchy at best I decided to turn over control of my scope to my buddy Loren and go inside for the night. I really enjoy doing presentations so it was not such a sacrifice but I had been looking forward to doing some viewing and had already been thwarted the previous two days. But all is well that ends well and it was a well-attended star party despite the poor viewing conditions. Which brings me to a different sort of observation.

This was not a very good year for clear skies for many of RFO's events but that didn't really seem to prevent too many people from coming out. Last year was our record year for attendance but this year is a good solid second place. It would have been interesting to see if the numbers would have gone up if the weather was better but as Asher Peres said, "Unperformed experiments have no results". I guess I can take some solace knowing that in some theoretical universe there were crystal clear skies for every event. All in all it was a very good year so thanks to everybody who made it possible.

As the year winds down to a close one often reflects on the past years' events, good and bad, looks forward to the new year, and sometimes even contemplates what donations one might make that one could deduct from one's taxes. Renewing, or starting up, a VMOA membership works. I feel a bit like a PBS host. We are able to do what we do thanks to contributions from our members and people like you. RFO will be starting off the New Year with new carpeting thanks, in part, to funds raised through donations. I'm thinking that the new carpet may put a bit of an emphasis on how old the chairs in the classroom are, but one project at a time.

So thanks everybody for a great 2014 and here's looking forward to a great 2015. Cheers…

RFO 2015 Class Schedule

Night Sky Classes

Each class includes a lecture on the constellations of the season, their history and mythology, and how to find objects within them. Learn the bright stars, deep-sky objects, and visiting planets of the night skies. After each presentation (sky conditions permitting), you will enjoy a review of the constellations in the actual night sky and learn how to find them for yourself. The constellations, and the objects within them, will be viewed through binoculars and telescopes, including the Observatory's 24-inch reflecting telescope, until or beyond 10:30 pm (depending upon interest and enthusiasm).

The upcoming Spring Series classes will begin on Tuesday, January 20 at 7:00 pm.
The Spring Series classes continue on February 10;
class start time changes to 7:30 pm for March 17, April 14, and May 12 & 19
Fee: $75 for 6-class series or $23 for a single class

E-mail: nightsky@rfo.org to reserve a space in this popular class
Look for more information about RFO's Night Sky Classes online at http://www.rfo.org

Observing Labs

An intensive telescope observing session after a brief presentation on the night's theme.
Handouts/Observing lists provided.
Attendance limited to 6.
Fee: $30.
For reservations, email: nightsky@rfo.org
Look for information on upcoming Observing Labs in the next issue of 'Focused' or online at http://www.rfo.org

Team Sugarloaf Update

by Colleen Ferguson

Our partners in Team Sugarloaf - Sonoma Ecology Center, United Camps, Conferences and Retreats, Sonoma County Trails Council, and Valley of the Moon Natural History Association - continue to do a fabulous job operating Sugarloaf Ridge State Park.

These are some recent activities:

Popular theme hikes: Black Friday (the day after Thanksgiving), Geology, History, Hippies of Sugarloaf, Mushrooms, Quest (family-focused natural treasure hunt), and Trees.

Campground service earning an excellent rating of 4.8 out of 5 stars from campers.

Volunteer trail work days to maintain and upgrade trails, including trails near the observatory.

Preparation for and work through a very large storm event, including clearing a tree that came down across the park entry road.

Construction work days to maintain buildings in the park.

Park Volunteer training. We rely on park volunteers to help RFO docents on public star party nights. Thanks to Park Steward and RFO Docent Loren Stokes for making sure new park volunteers learn about RFO as part of their training.

Here's to continued success for Team Sugarloaf in 2015!

RFO New Docent Training

by Colleen Ferguson

Would you like to become an RFO Docent? Do you know someone who would be a great addition to the RFO team? RFO is truly a place where individual volunteers make a difference; it's a place where ideas come to life. The Observatory was built and is maintained by volunteers. All of the public events, private events, classes, and labs were conceived by and brought to fruition by volunteers. RFO's volunteers work together, combining skills and talents to create this special place.

New Docent Training begins:
Wednesday, April 15, 2015

To register for the next training, contact Steve Smith at ssmith@rfo.org. We're looking forward to having you join us!

Watching the 2015 Winter Sky

by Jack Welch

Jupiter deserves special attention this year. As mentioned in the last newsletter, Jupiter is now at equinox. This occurs about every 6 years and allows us to observe some special "mutual satellite" events, as explained in a moment. Also, Jupiter is at opposition on 2/6, adding to our special events in an interesting way.

Jupiter's four large Galilean satellites, in order of distance from Jupiter starting with the closest, are *Io, Europa, Ganymede* and *Callisto*. They orbit Jupiter quite rapidly and one can easily watch them move about during a few hours of observing. When moving east to west they cross in front of ("transit") Jupiter; when moving west to east they move behind (are "occulted" by) Jupiter. Prior to opposition, Jupiter's shadow angles to the west, which means that the satellites disappear into Jupiter's shadow (are "eclipsed" by Jupiter) then reappear from behind Jupiter (occultation reappearance) a while later. After opposition the shadow angles east and the pattern reverses: the satellites have an occultation disappearance followed by an eclipse reappearance. Not only the satellites transit Jupiter's disk; their shadows can also transit Jupiter. Before opposition, a satellite's shadow transits before the satellite transits; after opposition, the shadow transits after the satellite.

Now, with Jupiter at or near equinox, additional things happen. First, the satellites can cast their shadows on (eclipse) each other. The eclipsed satellite will dim. If the eclipse is significant (the shadow makes a "direct hit") the dimming will be noticeable to a scope observer. Second, the satellites can pass in front ("occult") each other. At a minimum, a scope observer will see the two dots merge and then separate. Third, the satellites and their shadows transit Jupiter at the same Jovian latitude (rather than north or south of each other), both very near Jupiter's equator. Near opposition, the satellites and their shadows will be so close to each other during a transit that they may even overlap, creating a sort of crescent shaped shadow on Jupiter (as we see it, blocked partially by the transiting satellite). These "partly occluded shadow transits" only occur during a period of a couple of weeks every 6 years. We will have an opportunity to observe a few such events from about 1/30 to 2/12.

Typical (unoccluded) shadow transits are easily observed with almost any telescope, as are substantial mutual satellite eclipses (large dimming) when the satellite is not transiting Jupiter, and as are (non-transiting) mutual occultations, seen as two dots merging then separating. Large aperture scopes (with at least moderately good "seeing") can observe satellite transits of Jupiter as well as substantially occluded shadow transits (where the shadow is a crescent) and occultations and eclipses involving satellites that are transiting Jupiter. Large scopes at high magnification might even be able to image the overlapping satellite disks during an occultation or the partial eclipsing of a satellite. These latter observations would require high magnification and stable "seeing". However, the chance to see such rare events "with one's own eyes" makes the effort very alluring!

There are several double shadow and/or satellite transits of Jupiter this winter, in addition to the special mutual satellite events … far too many to list here. You can access details at our website ("What's Up in the Night Sky" link) or subscribe to our "sky_news" email list (link at rfo.org). But I need to point out an extra special such event. On the evening of 1/23 there will be a very rare *triple satellite and shadow transit* of Jupiter. We are lucky if we get the opportunity to view more than two of these each decade so try to get out that night with your scope or someone else's scope!

The moon will be near Jupiter on the evening of 1/7, the morning of 2/4, late on the evening of 3/2, and on the morning of 3/30.

Rising around 4am at the New Year, *Saturn* moves from Libra to Scorpius in mid-January and begins retrograde motion on 3/14, rising around midnight by the end of March. The crescent moon will be very near Saturn on 1/16, the pair rising before 4am.

Mars stays low in the early evening southwest sky all winter, setting during twilight by the end of March. It joins *Venus* in late February with the two very close together on 2/21. The crescent moon will join this pair the previous evening, 2/20. Look for them about 35 minutes after sunset (about 7pm at RFO) both evenings. The crescent moon also joins Mars around 7pm on 1/22.

Venus emerges as the "Evening Star" in late December, staying low in the southwest at first. Look for an ultra-thin 3.6% crescent moon near Venus 40 minutes after sunset on 1/21. The crescent moon joins Venus

and Mars on 2/20 (see above), and is near Venus again around 8:30pm on 3/22.

Mercury provides two appearances this winter though only the first, from about 1/5 to 1/22 in the evening sky, will be easy to view. It spends the first half of this appearance near Venus, especially between 1/8 and 1/12. It reaches a maximum altitude 45 minutes after sunset of 8° on 1/15, then starts to fade as it drops lower over the next week. The second apparition from about 2/10 to 2/25 is poor, with a maximum altitude of less than 6° 45 minutes before sunrise on 2/16.

The moon will produce large tides this winter due to the new moons occurring near perigee (when the moon is closest to earth). Look for large tides from about 1/21 to 1/24, 2/18 to 2/21, and 3/20 to 3/23. For the same reason (i.e. the full moons occur near apogee), the full moon of 3/5 is the smallest of 2015. The moon will be very near the bright red-orange star *Aldebaran* in *Taurus* around 4am on 1/2, 7:30pm on 2/25, and 11:30pm on 3/24. Look for thin crescent moons on 1/21 (see Venus, above), 2/19 (1.9% crescent 7° high 11° south of due west 35 to 40 minutes after sunset), and 3/21. And the moon will occult a number of bright stars this winter, including a near miss followed closely by an occultation of a pair of Hyades cluster stars on the evening of New Year's Day (see rfo.org for all occultation details).

We have two opportunities to view the *Zodiacal Light* in the west after twilight during moonless periods. The Zodiacal Light is a faint glow along the path of the Ecliptic caused by sunlight reflecting off fine debris in the plane of our solar system. You need a reasonably dark location with no western light pollution to spot it. Look for it between 7:15 and 7:50pm from 2/6 to 2/19, and again between 8:45 and 9:30pm from 3/8 to 3/21.

The minor planet (aka asteroid) *Juno* is at opposition in *Hydra* on 1/29. At magnitude 8.2 it is an observing challenge and a finder's chart is essential.

Finally, don't forget that winter is a good time to observe eclipse dimming of the famous eclipsing binary variable star *Algol* in *Perseus*. You can watch the star dim during the 3 hours before a minimum and brighten during the 3 hours after a minimum. Predicted minimum times are available at rfo.org's "What's Up in the Night Sky" link. There you can also find details on many other sky events not mentioned in these articles.

Winter will officially end at 3:45pm PDT on 3/20, the *vernal equinox*.

Ranger Robyn is Retiring

by Colleen Ferguson

Robyn Ishimatsu, the State Park Ranger dedicated to Sugarloaf Ridge State Park for many years, is planning to retire in January 2015. Robyn consistently supported the Robert Ferguson Observatory and worked closely with RFO docents to coordinate observatory and park activities. Robyn had a difficult job: welcoming park visitors; providing interpretation of the park's natural, historic and cultural resources; protecting the park's resources; managing the park; and enforcing the law.

One of the times that having an observatory in the park provided a challenge for Ranger Robyn was a well-publicized meteor shower. RFO was not scheduled to be open to the public that night but people came to the park anyway – lots and lots of people. They filled the parking areas and still kept coming. When it became clear that they wouldn't be able to drive into the park, people just parked their cars on the entry road and spread out on the pavement to watch the meteor shower. Robyn was very concerned about everyone's safety and managed the chaos as best she could. It was after that event that we decided that RFO should be open for all well-publicized astronomical happenings. Now we have docents on hand and engaged to help manage the visitors that are likely to come to Sugarloaf Ridge State Park and the observatory.

Another time, during an intense rain and wind storm, Robyn got a call that the observatory alarm had been tripped. She went to the building during the storm and found the door locked with nothing apparently amiss. She entered the observatory and was looking around when the building suddenly shook and gave Robyn quite a start. She quickly realized that a gust of wind had blown the east wing sliding roof open – again. So that was what tripped the alarm! The east wing was so flooded from the storm that the water was starting to flow down the stairs into the classroom. Robyn called her RFO contacts right away. (Our docents responded to get the telescopes, computer, carpet and everything else in the room dried out and in good operating condition before our next event – quite an impressive feat). After that we improved the roof latch systems. Thank goodness for Ranger Robyn!

As Robyn retires, I salute Robyn for all she did to support RFO and Sugarloaf Ridge State Park and wish her a long and happy retirement.

The Difficulty of Modeling Our Environment

By Loren Stokes

On public solar viewing days we continue to field questions related to climate change. Climate scientists model Earth's future climate using supercomputers and a variety of input parameters. Often the models are based on a concept called Equilibrium Climate Sensitivity (ECS). The concept assumes the atmospheric concentration of the greenhouse gas carbon dioxide doubles since the beginning of the industrial revolution. That is, the carbon dioxide concentration starts at 280 parts-per-million (ppm) around the year 1750, and reaches 560 ppm sometime in the future. Today it is nearly 400 ppm and is currently increasing at 2.3 ppm per year. This does not mean that we will actually get to 560 ppm. It is just a value used to compare different climate models and see how sensitive Earth's surface temperature is to atmospheric carbon dioxide.

If atmospheric carbon dioxide acted alone, with no enhanced feedback effects, the models agree that the Earth's surface temperature would increase by only 1 degree Celsius once the temperature stabilized at the new 560-ppm carbon dioxide concentration. However, once enhanced feedback effects are included, the climate models don't agree. They predict anywhere from 1.5 to 4.5 degrees Celsius (or even up to 6 degrees Celsius) temperature increase resulting from doubling atmospheric carbon dioxide.

Here is the difficulty of modeling our climate. As the atmosphere heats up by 1 degree Celsius, it can hold up to 7% more water vapor. Water vapor is a more powerful greenhouse gas than carbon dioxide as it absorbs a greater amount of infrared radiation emitted by the Earth's surface. This increases Earth's surface temperature.

As more of the Arctic ice cap melts each summer and fall, the ice reflects less sunlight back to space, and more sunlight is absorbed by the dark exposed Arctic Ocean. As the ocean gives up its heat to the atmosphere, the surface temperature increases.

As arctic permafrost starts to thaw and organic matter decomposes, more carbon dioxide is emitted. Also emitted is methane, a powerful greenhouse gas.

The Earth's oceans absorb about one quarter of the carbon dioxide released into the atmosphere. This increases the acidity of the oceans. However, a warmer ocean can hold less dissolved carbon dioxide than a cooler ocean, so in the future some dissolved carbon dioxide can be returned to the atmosphere. As an aside, the Earth's plant life also absorbs about one quarter of the carbon dioxide released into the atmosphere. This adds to Earth's total biomass.

Some feedback effects due to doubling of atmospheric carbon dioxide can actually cool the surface temperature. For example, more clouds in the atmosphere can reflect some sunlight back to space, cooling the surface temperature.

Here is an ironic enhanced feedback effect. Burning coal releases small particulates (soot) into the atmosphere that reflect some sunlight back to space. As we replace dirty coal power plants with ones burning clean natural gas, this cooling effect is diminished.

The isotope carbon-14 is produced in our atmosphere by cosmic rays at a relatively steady rate. Fossil fuels are very old and contain no carbon-14 (it has all decayed). We can see the additional carbon dioxide we add causes the fraction of carbon-14 in the atmosphere to decrease. New tree rings have less carbon-14 than do 50 or 100 year-old tree rings.

Well, it looks like we will get to see which climate model is correct. If we continue to emit carbon dioxide at today's rate, increasing the atmospheric concentration by 2.3 ppm per year, we will reach 560-ppm concentration in the year 2085. If our emissions increase by just 1% per year, 560 ppm will come in 2068. A 2% annual increase gives 2059, while a 3% increase gives 2053.

In my book "The Little Book of Big Energy" I take a more optimistic view. Today, fossil fuels supply 82% of worldwide energy needs. In 30 years, I predict that will be 60%. However, worldwide energy consumption will increase by 40% in 30 years as the entire world becomes industrialized. So in absolute terms, about as much fossil fuel will be consumed. In 60 years, fossil fuel will represent 40% of energy consumed, and by the year 2100 will represent just 20%. Still, by 2100 the predicted atmospheric carbon dioxide concentration will be 550 ppm, just short of the ECS value of 560 ppm.

It should be noted that the amount of oil, coal, and natural gas in proven reserves is about twice the amount already burned since the industrial revolution began. So, in theory, we could raise the atmospheric carbon dioxide level to about 640 ppm, well above the ECS value of 560 ppm.

References: "False Hope", Michael E. Mann, Scientific American, April 2014; "Climate Change: Evidence, Impacts, and Choices", (US) National Research Council, 2013 (free at the Amazon Kindle store).

(**ROCKET** *from Page 1)*
some sort of 'Spirograph' pattern. If there were any of us mere mortals in the room we probably would have got quite dizzy and thought "That's Nuts!" but I can imagine a room full of rocket scientists nodding their heads and saying "Looks good. Let's do it."

Part of my brain says this is just good ole Newtonian mechanics. You've got some bodies in motion, some massive objects interacting through gravitational forces. No big deal. The other part of my brain says "Holy Moly!" "How could anybody ever figure something like that out?" Hitting a target that small in the vastness of space is impressive enough. Hitting a target in the vastness of space after having traveled a few hundred million miles and performing a few loop-the-loops along the way boggles my mind. You know, if Rosetta was a passenger vehicle somebody would have went to the pilot and said, "This is third time we've been past Earth. Don't you think it's about time you stop somewhere and ask for directions?"

While perusing the ESA website to research what I might write about the Rosetta mission I made an interesting discovery. 2014 is the 50th anniversary of ESA. So landing on a comet is a pretty impressive way to celebrate such a milestone. So rather than spend more time talking about Rosetta, which every space reporting entity is doing already, I think I'll spend a little time talking about some of ESA's other accomplishments over the years. If you visit ESA's website (www.esa.int) there is a very nice time-line charting out ESA's history over the past fifty years with a link to a page for each year. But don't worry. I'm only going to call out a few of the more significant missions.

The European Space Agency was born when the European Space Research Organization and the European Launch Development Organization combined forces in 1964. I was only a year but I remember it well. Not really but it is kind of cool to think that ESA and I are almost the same age. In 1965 they started building ESTEC, the European Space Research and Technology Centre, in the Netherlands, which is basically their headquarters. In 1966 they built the European Space Research Institute in Italy and in 1967 they built the European Space Operations Centre (their Mission Control) in Germany. Now they had the pieces in place to do research, plan and manage missions, and in 1968 launched their first successful satellite: ESRO-2B. It was designed to study cosmic rays and solar x-rays. These guys did not hang about and launched COS-B to study gamma rays the very next year. The French space agency, CNES, offered to share their launch facility in French Guiana and the first launch from there was in 1970. In 1972 ESA agreed to work with NASA to develop Spacelab and a maritime navigation satellite system. In 1977 they launched METEOSAT-1, Europe's first weather satellite. It was the first in a series of satellites to provide images and weather data from a geostationary orbit. I know this is sounding a bit like a history lesson with a list of dates and events but it is cool stuff and it gets cooler.

For instance, in 1978 ESA launched IUE, the International Ultraviolet Explorer. This was the world's longest lived and one of the most productive satellites ever built. With the exception of one week in 1985, it ran non-stop for 18 years. Fourteen years longer than the original planned shutdown date. The first Ariane rocket was launched on Christmas Eve, 1979. They continued to develop the Ariane rocket and did some other good stuff but I'm trying to keep this article at a reasonable length. But in 1985 they sent their first deep space mission to Halley's Comet and got the first close-up photo of a comet's nucleus. They did some more good stuff like working on the International Space Station and in 1989 they launched the first space-based astronomical surveyor: Hipparcos, dedicated to the precise measurement of the positions, parallaxes, and proper motions of the stars. 1990 saw the launch of a joint effort project between ESA and NASA. Just a little thing called the Hubble Space Telescope. In 1995 they launched the first infrared observatory and in 1997 launched the Cassini-Huygens mission to Saturn. Some more cool stuff happens and in 2003 they launched their first mission to Mars, Mars Express. In 2005 the Huygens probed landed on Titan – way cool. And, of course, this year they landed on a comet. There was much more than I could write up here and it can all be found on the ESA website. I've said it before, and I'll probably say it again – ESA Rocks!

Recognize that the very molecules that make up your body, the atoms that construct the molecules, are traceable to the crucibles that were once the centers of high mass stars that exploded their chemically rich guts into the galaxy, enriching pristine gas clouds with the chemistry of life. These gas clouds then condense to form new generations of solar systems, stars with orbiting planets; and those planets now have the ingredients for life itself, so that we are all connected to each other biologically, to the earth chemically and to the rest of the universe atomically. That's kinda cool! That makes me smile and I actually feel quite large at the end of that. It's not that we are better than the universe; we are part of the universe. We are in the universe and the universe is in us."

— Neil deGrasse Tyson

Valley of the Moon Observatory Association

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