AOH OBSERVER

June-July 2016

The Newsletter of the Astronomers of Humboldt

The weather in April and May was poor for observing but we still managed to hold a Messier Marathon on April 1, an outreach for the Kneeland School on May 1, and a successful viewing of the transit of Mercury on May 9. Write-ups about the Kneeland School and the transit of Mercury are in this issue of the Observer. Since the start of 2016, rain and clouds have interfered with our scheduled monthly observations at Kneeland. I want to thank all the club members who attended our indoor meetings. Let's hope for clear skies this summer.

In this issue of the AOH Observer we welcome Susie Christian who will be doing a cartoon feature for the newsletter. Susie is a talented artist, photographer, writer, and an astronomy fan. Susie's contribution, "Heavenly Bodies" can be seen on page 18. I hope you get a chuckle from it.

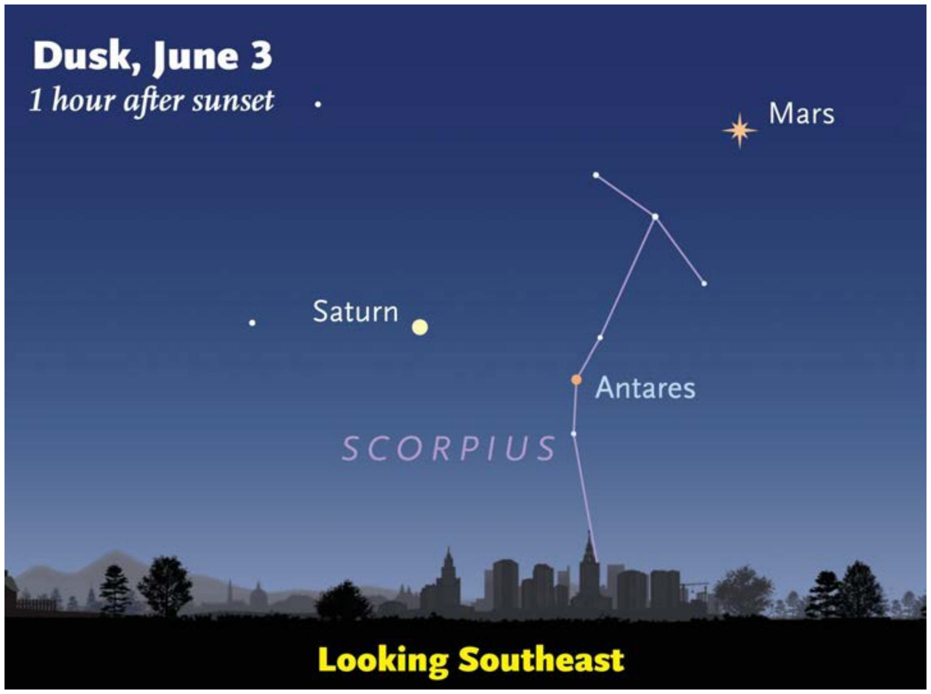
If you are interested in contributing an article or image to the newsletter, please contact me at president@astrohum.org.

Thank you to Don Wheeler and Ken Yanosko for editing the newsletter and for your helpful suggestions.

AOH Calendar for Summer 2016

(from “Upcoming Events” at http://www.astrohum.org)

Saturday, June 4. **Martian Perigee Party**. We will meet at Kneeland Observatory for a viewing session. Mars will be within a week of its closest approach to Earth. It will be 0.5 AU away with a disk diameter of 18 arcseconds. Mars will shine at a magnitude of -2. Saturn and Jupiter should be visible as well. Be sure to check back for last minute changes which may occur due to unfavorable weather.



By June 3rd, the triangle of Mars, Antares, and Saturn lengthens as Mars moves toward the upper right. Although the title says June 3, the scene is essentially the same from June 1 through 5. Use it for any of those days. See more at: http://www.skyandtelescope.com/press-releases/mars-closest-biggest-and-brightest-in-a-decade/#sthash.30UMhsA1.dpuf

Wednesday June 22, 6 p.m. ***Webinar: “NASA's Mars Trek: Powerful Online Tools for Exploring Mars.”**

Saturday July 2. **Regular Monthly Meeting TBA**

Thursday July 21. 6 p.m. ***Webinar: “The OSIRIS-REx Asteroid Sample Return Mission”**

Saturday July 30. **Regular Monthly Meeting TBA**

Friday August 12. **Perseid Meteor Shower**.

Tuesday August 23. 6 p.m**.** ***Webinar: “International Observe the Moon Night.”**

Saturday August 27. **Extremely close conjunction of Venus and Jupiter**. At 3 p.m. PDT, the two planets will appear less than 4 arcminutes apart (for comparison, Jupiter and its moon Callisto will be around 7 arcminutes apart). By local sunset at 8 p.m. Venus and Jupiter will still be less than 9 arcminutes apart.

*The live webinar broadcasts are sponsored by the NASA Night Sky Network and are viewed online. AOH members can access the broadcast link on the member’s page at **http://www.astrohum.org**.

Celestial events: June and July 2016

Moon Phase	Date	Rise time	Set time
New	6/4	5:44 a.m.	8:07 p.m.
1st Qtr.	6/12	1:33 p.m.	1:58 a.m. (6/13)
Full	6/20	8:47 p.m.	7:07 a.m. (6/21)
4th Qtr.	6/27	12:54 a.m.	1:19 p.m.
New	7/4	6:19 a.m.	8:47 p.m.
1st Qtr.	7/11	1:13 p.m.	1:00 a.m. (7/12)
Full	7/19	8:17 p.m.	6:53 a.m. (7/13)
4th Qtr.	7/26	12:10 a.m.	1:24 p.m.

Throughout June and July: Mars, Saturn, and Jupiter are out in the evening. The rise/set time of the major solar system bodies can be found at: http://aa.usno.navy.mil/data/docs/mrst.php

A more detailed calendar of sky events for northern California can be found at: http://rfo.org/jackscalendar.html

Thursday 6/2/2016: **Saturn Opposition**. Rise time at 8:20 p.m.; Magnitude 0.1; disk diameter 18.4 arcseconds; rings: 42 arcseconds.

Sunday 6/5/2016: **Mercury at Greatest Western Elongation**. Mercury will be at its highest point above the eastern horizon. Look for Mercury just before sunrise.

Thursday 6/9/2016: **Callisto Shadow Transit.** The shadow transit is already in progress across the north polar region when Jupiter becomes visible at twilight. The shadow transit ends at 10:16 p.m. ***This will be the last shadow transit of Callisto until 2019.***

Friday 6/24/2016: **Ganymede Shadow Transit**. The Ganymede Shadow is already in transit when Jupiter becomes visible at twilight. The transit ends at 11:42 p.m. (Note: Jupiter sets at 12:35 a.m.)

Friday 7/1/2016: **Ganymede Transit.** The Ganymede transit is already in progress when Jupiter becomes visible at twilight. The transit ends at 11:07 p.m. (note: Jupiter sets at 12:09 a.m.)

Thursday 7/7/2016: **Io Shadow Transit.** The shadow transit is already in progress at twilight. The transit ends at 10:37 p.m.

Friday 7/8/2016: **Crescent Moon very near Jupiter** at 10 p.m.

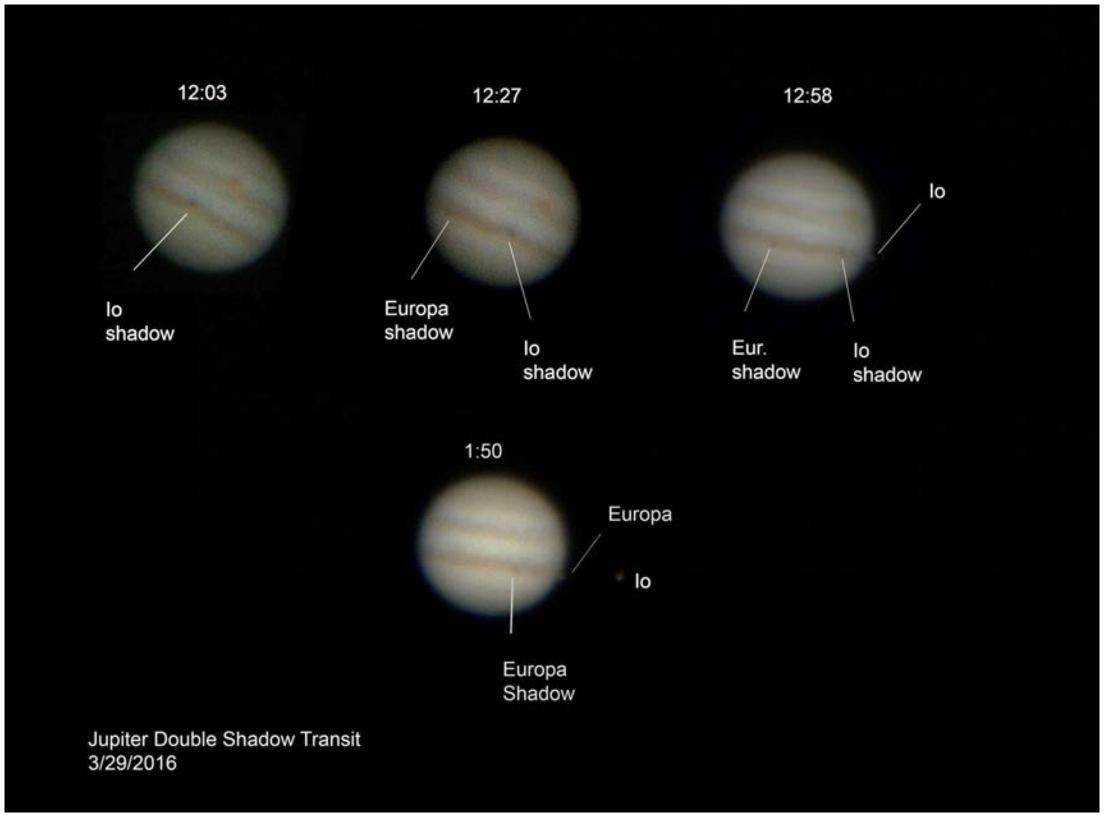
Backyard Astronomy: Double Shadow Transits and Mars' Opposition

G.D. Wheeler

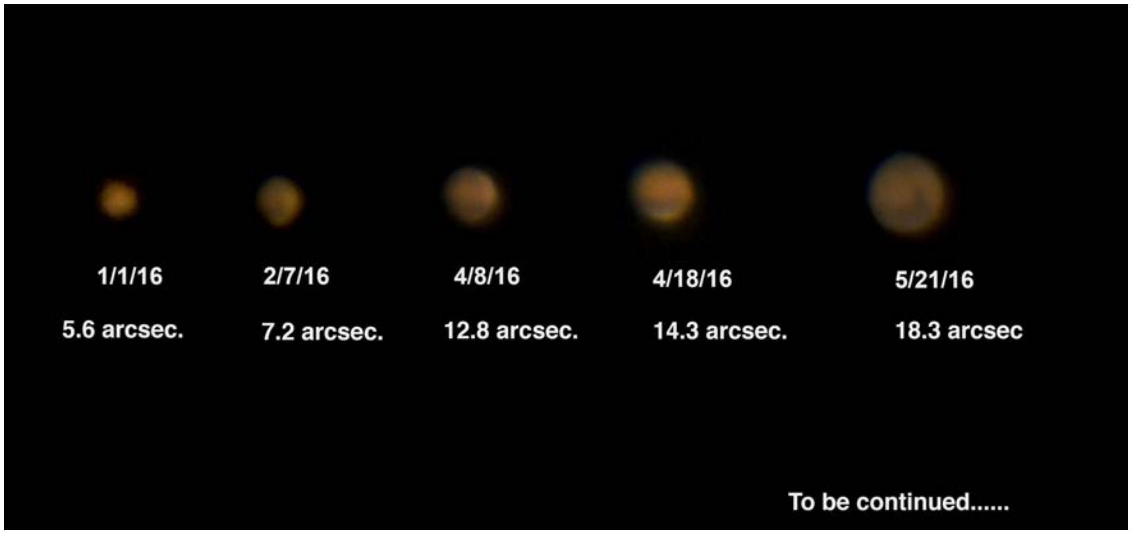
This year's Jupiter "double shadow transit" (DST) season ran from February to May. The yearly DST season always coincides with the opposition of Jupiter, i.e., Jupiter is directly opposite the Sun with the Earth in between. During opposition, Jupiter is out all night and observers on Earth have a line of sight view of the transiting Galilean moons and their shadows across the Jovian disk. Observing DST events is also optimized because Jupiter is at its closest approach to Earth, hence the apparent disk size is at its maximum for the year. Worldwide, there were 20 DST events between February to May 2016, but only five were visible in the western U.S. Due to weather, only two of the DST events were visible in Eureka: March 28 and April 5. The image below shows the shadow transits of Io and Europa on March 28-29. The time stamps below are given in a.m. local time.

Normally the transits of Europa and Io across the Jovian disk are not easily seen because these moons are reflective and blend in against Jupiter's bright background[1]. However, it is possible to see the moons enter and exit at the limb of the disk (see transit at 12:58 and 1:50). Although Io and Europa may not visible during their transit of Jupiter, their shadows moving across the disk are quite apparent. To read more about double shadow transits:

http://umich.edu/~lowbrows/reflections/2001/mdeprest.15.html



The other notable event this spring was the Martian opposition on May 22. "Mars watching" actually started in November 2015 when Mars was in the predawn skies. It wasn't until January that fuzzy images finally came into focus and surface features could be seen. In February it was possible to make out Syrtis Major and the frost on the Hellas Basin. March was clouded out so no observations were made that month. In April and May, Mars became increasingly brighter in the night sky. Through the telescope, the growth of the disk was noticeable. My last image of Mars was taken on May 21, the day before opposition, when the sky cleared for a brief time. On May 30, the Martian disk will be at 18.7 arcseconds. This is the largest apparent diameter since 2005. My fingers are crossed for clear skies.



1. Ganymede and Callisto are both darkly colored so it is possible to see the transits of these moons across the Jovian disk in addition to their shadow transits.

Kneeland School Outreach

G.D. Wheeler

Our last school visit of the year took place on May 1 at Kneeland Elementary School, which is also the site of the AOH Kneeland Observatory. Since many of the students had never seen the inside of the Observatory, Ken opened up the roof and set up the C-14 for a viewing of the crescent moon. My C-8 was equipped with a solar filter so that the students could also safely view the sun.

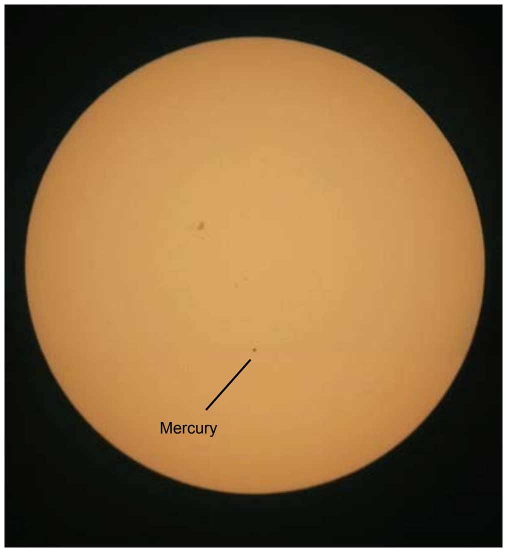
Ken started the program with a discussion of the moon and the sun and what the students could expect to see through the telescopes. Unfortunately by the time we started the viewing, the sky conditions to the south had deteriorated and the crescent moon was lost in haze and clouds. Only a few students were able to view the cratered surface through the C-14. We had better luck with the sun, and the students were able to see the solar disc and sunspots. Ken had printed out an image of that day's sunspot activity from the SOHO website. The students were able to compare what they saw through the telescope to the printed SOHO image. Ken also gave a small talk on the planets, and their arrangement within the solar system. We then used Ken's 60 foot solar system tape and had students stand at each planetary orbit to give them an idea of the distances between planets. We had a great time sharing with the students, and we are looking forward to returning next year.

Using the solar system distance tape: Neptune and Uranus patiently waiting for the other planets to get in line.

The Kneeland Observatory. The C-14 in the observatory is pointed at the moon, and the C-8 is aimed at the sun.

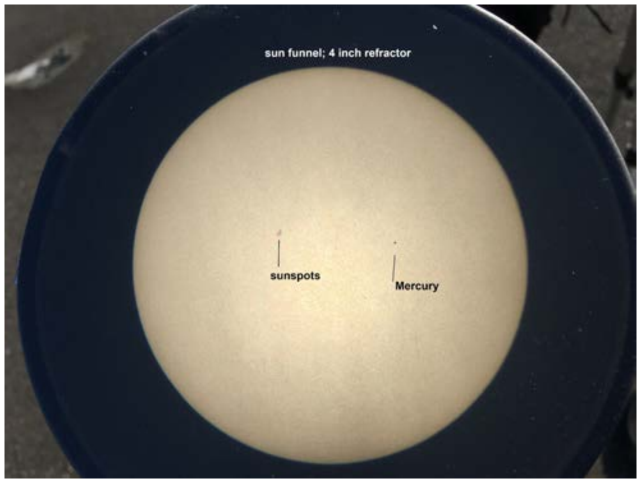
Transit of Mercury: May 9, 2016

G.D. Wheeler



The AOH met at the Kneeland Airport for the viewing of the May 9 transit of Mercury. Even though cloudy skies threatened to interfere with viewing the transit, as it happened, the airport that morning was severe clear.

Ken Yanosko, Dan Eaton, and Mark Pedley showed up early and were already set up by the time I arrived at 6:30 a.m. The transit started at 4:13 a.m. PDT, so Mercury was already in view at sunrise. Between the four of us there were six observing stations: Dan brought his solar telescope and a solar projection scope; Ken set up his 8 inch SC; Mark had his refractor telescope; I brought an 8 inch SC and a 4 inch refractor with a sun funnel.



We had a handful of visitors that came through to view the transit and ask questions. One visitor said that he attended the AOH transit of Venus event in June 2014, and was hoping we would be here for the Mercury transit. We were at the airport for about 5 hours and during that time, we traded views through each other's telescopes. One of the highlights was seeing solar prominences leap off the sun's surface through Dan's solar telescope. Towards the end of the transit, I was finally able to focus my camera on Mercury through the C-8. The last 10 minutes of the transit was videoed and can be viewed here: https://www.youtube.com/watch?v=5POGazwf9Ak

Thank you to Emily Jacobs of the Humboldt County Aviation Administration for facilitating the use of the airport by the AOH. (image credit : Ken Yanosko and Grace Wheeler)

The UCLA Meteorite Gallery

G.D. Wheeler

The UCLA Meteorite Gallery is the brainchild of Professor John Wasson and researcher Dr. Alan Rubin in the Department of Earth and Planetary Science at UCLA. Drs. Wasson and Rubin are both cosmochemists who use meteorites to study the evolution of the early solar system. They and their UCLA colleagues have spent several decades amassing a collection of 1500 different kinds of meteorites. UCLA has the largest meteorite collection on the west coast, and is the fifth largest collection in the world. Despite the importance of the collection, for many years, most of the meteorites were inaccessible to the public. This changed in 2012 when Dr. Wasson "bumped eight graduate students out of their office and converted the space into the UCLA Meteorite Gallery".

http://articles.latimes.com/2014/jan/10/science/la-sci-meteorite-museum-20140111.

Figure 1. An overview of the 900 square foot UCLA Meteorite Gallery. The center of the room contains three large iron meteorites. There are about 100 meteorites on display.

The gallery is made up of seven cases filled with meteorites, a floor display of three large iron meteorites, and various informational posters. Each display case has its own theme: differentiated meteorites, primitive chondrites, tektites, meteoritic basalts, impact brecciated meteorites, California meteorites, etc. The display cases have "QR" codes that can be used with a smartphone. The code retrieves the compositions of the various meteorites, as well as their history and significance. For those who are technically challenged, there are handouts available that correspond to each case of meteorites. On Sundays, a docent is available to answer questions. On my visit, Dr. Wasson was acting as tour guide. There were quite a few visitors, but he managed to meet with each one to answer questions and talk about the various displays. Below is a link to an interview with Dr. Wasson on his career as a cosmochemist:

http://blogs.agu.org/geospace/2011/10/

Figure 2. Three large iron meteorites on display: (A) Camp Wood (326 lbs., Tx, USA); (B) Gibeon (368 lbs., Namibia, Africa); (C) Clark (357 lbs., Az, USA).

What are Meteorites?

The majority of meteorites are the remnants of earth-crossing asteroids that survived the entry into earth's atmosphere and are subsequently recovered. Asteroids are rocky bodies that were made at the beginning of the solar system about 4.6 billion years ago. They are the raw materials from which the planets were built. Most asteroids in our solar system reside in the asteroid belt, a circumstellar disk between the orbits of Mars and Jupiter (Fig. 3.). The presence of Jupiter perturbed the orbits of asteroids so that these were not accreted into planets. Cosmochemists are interested in studying meteorites since it is thought that their petrology reflect the composition and processes of the early solar system

When I took an astronomy class many years ago, the professor remarked that most meteorites actually look like ordinary rocks. According to Dr. Wasson, there are many characteristics that can be used to distinguish meteorites from earth rocks: size, shape, color, density, and the presence of magnetism and metal in the specimen (note: some meteorites such as those originating from the crust do not contain metal). A summary of differences can be found here:
http://www.meteorites.ucla.edu/faq/

Putative meteorites can be further characterized by petrographic analysis and by their mineralogy. Some institutions such as UCLA do this analysis for free, with the proviso that a sample of the meteorite is deposited into their collection. In part, this is how UCLA has been able to build such a large collection.

Primitive Meteorites: Ordinary and Carbonaceous

One of the highlights of the gallery is their large collection of ordinary and carbonaceous chondrites. Chondrites are classified as primitive because they have undergone little change since their formation. The major component of chondrites are millimeter sized particles known at chondrules (Fig. 4.). Chondrules are primarily composed of the silicate minerals olivine and pyroxene and small quantities of iron and nickel. These are thought to have been made from the dust and gas of the presolar nebula that were melted by shock waves or lightning and then cooled very quickly. *Ordinary chondrites (O-type)* make up 87% of all found meteorites. These chondrites are made of tightly packed chondrules contained within a fine-grained matrix. O-type chondrites come from three parent asteroids that differ with respect of iron and metal content (Fig. 5.).

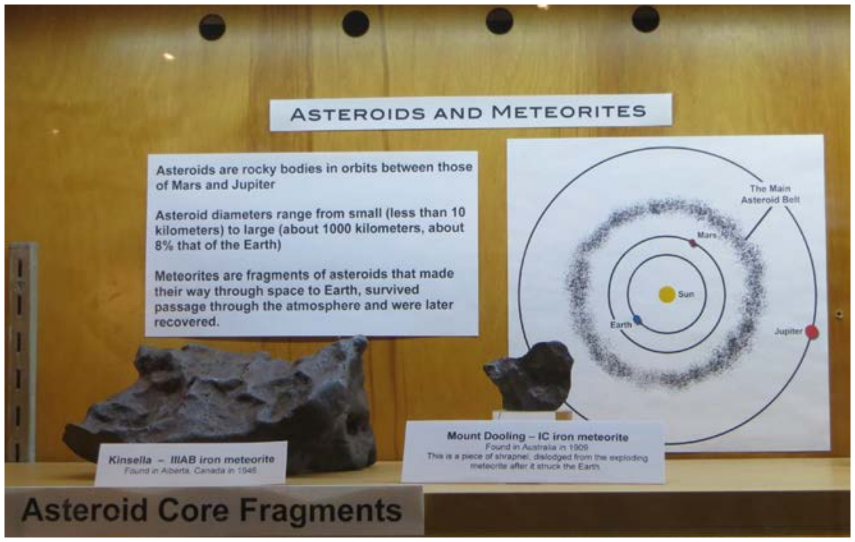


Figure 3. The asteroid belt and an introduction to meteorites.

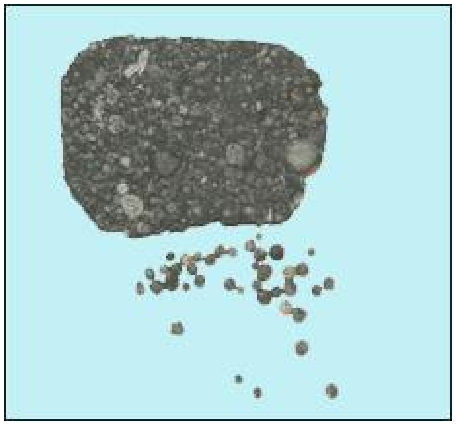


Figure 4. Chondrite and isolated chondrules. (image credit: NASA/JPL)

Figure 5. Display of ordinary chondrites. The O-type are thought to be derived from three parent asteroids and are grouped as H (high iron), L (low iron) and LL (Low iron, low metal). Displayed in the case are images of a thin section of an ordinary chondrite, and of a carbonaceous chondrite. The thin section is part of the petrographic analysis for identifying meteorite type.

The *carbonaceous (C-type) chondrites* make up 5% of the found meteorites, and have chondrules contained within a carbon matrix (Fig. 6.). These chondrites also contain water and volatiles which suggests that these were formed far from the sun. C-type chondrites are divided into five major groups (CI, CM, CR, CV, CK) based on their composition, and the grouping is thought to reflect their origin from five different parent asteroids. The presence of calcium aluminum inclusions (CAI) in carbonaceous chondrites suggests that these chondrites were formed at the beginning of the solar system. CAIs (Fig. 6BC.) were one of the first substances to condense out of the very hot solar nebula. From an astrobiology perspective, the C-type chondrites are thought to be the source of planetary carbon, and many have been found to contain organic compounds such amino acids and nucleic acids. To read more about chondrites:

https://en.wikipedia.org/wiki/Chondrite

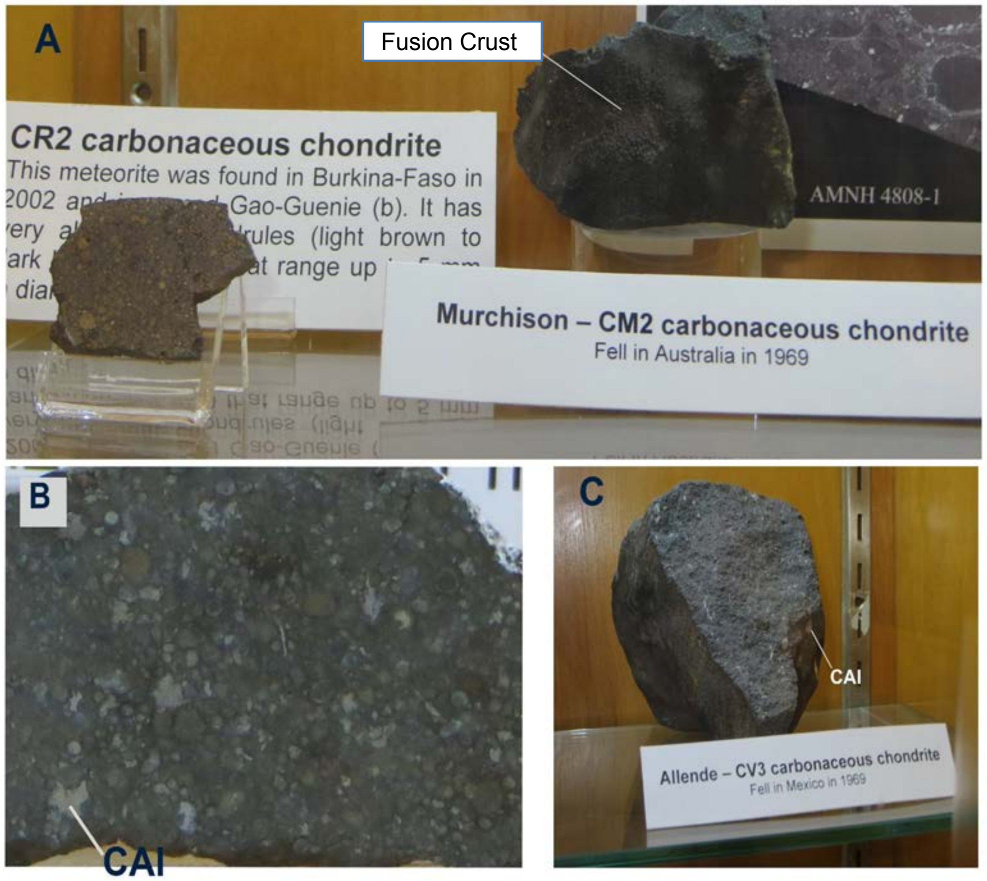


Figure 6. Examples of carbonaceous chondrites displayed at the Gallery. (A) textured fusion crust on the Murchison chondrite and a section of CR chondrite showing chondrules, (B) a section of CV3 chondrite showing chondrules and white patches of calcium aluminum Inclusions (CAI) in a carbon matrix (C) Allende chondrite with patches of CAI.

Differentiated Meteorites

The differentiated meteorites are derived from the asteroids[1], that have melted and separated into distinct layers. Melting of asteroids can occur through high velocity impacts or radioactive decay. As the asteroid heats up, any chondrules contained within the asteroid is melted. The melted chondritic material forms two immiscible layers: a metal-sulfide rich liquid and a silica-rich liquid. The dense iron liquid sinks and becomes the ***metal core***. As the silica rich liquid rises to the top to form the ***crust***, heavier minerals are left behind which becomes the ***mantle***. The differentiated body is later shattered and gives rise to the following meteorite types: (1) stony achondrites from the crust, (2) stony-iron meteorites from the mantle/core, (3) the iron meteorites from the core (Fig. 7.). The meteoritic fragments from differentiated asteroids have given scientist a better understanding about the layered interior of planets and moons.

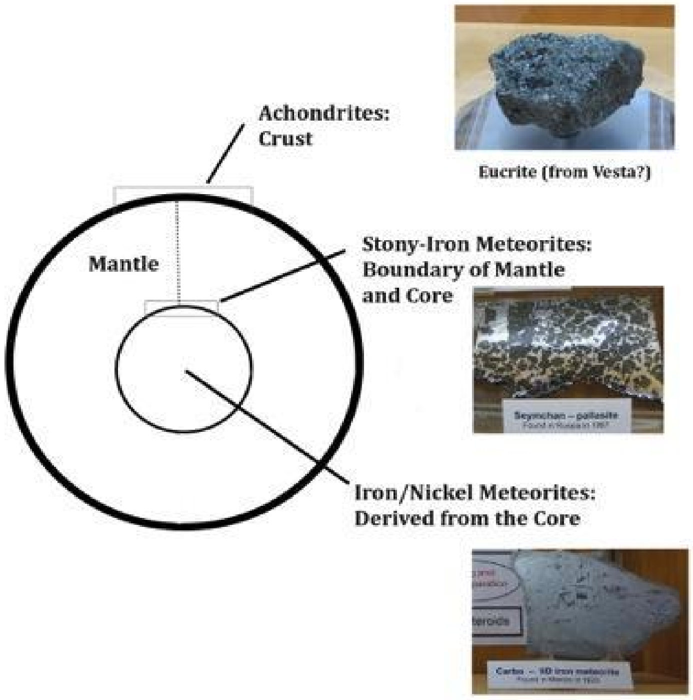


Figure 7. Differentiation of an asteroid

1. Differentiated meteorites can also come from planets and moons. Examples of these include basaltic meteorites from the crust of Mars and the Moon.

Achondrites: HED meteorites from Vesta

The Gallery has a collection of achondrite meteorites from the crust of the differentiated asteroid Vesta. These meteorites are known as the HED group: howardites, eucrites, and diogenites (Fig. 8.). Vesta is classified as a protoplanet and is the only known example of a differentiated rocky asteroid in our solar system. Shown below are examples of eucritic meteorites which are compositionally related to basalts, and diogenite which is mantle rock. To read more about HED and Vesta:

http://www.planetary.org/blogs/guest-blogs/2016/0411-lpsc-2016-differentiated-meteorites.html

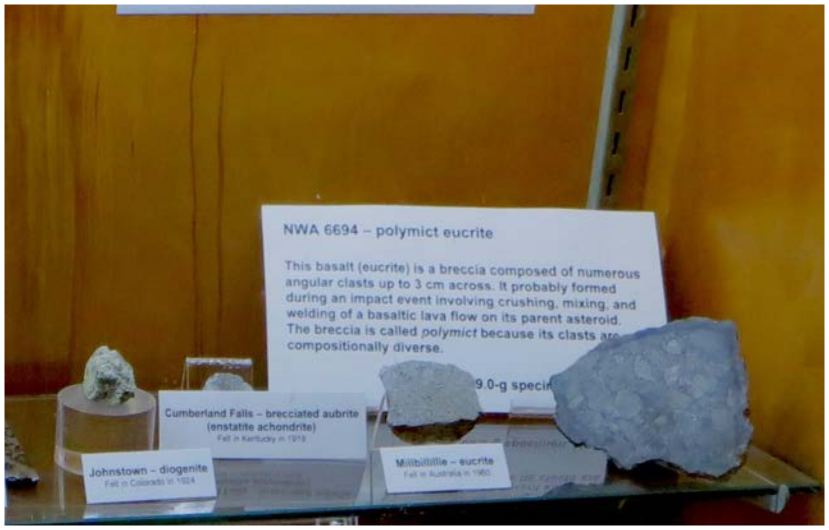


Figure 8. Examples of HED Meteorites from Vesta: eucrite and diogenite.

Stony Irons: Meteorites from the Mantle/Core of Differentiated Asteroids

As the name implies the stony-irons are meteorites made of stone and iron. In the case of pallasites (Fig. 9.), these meteorites are composed of 50% olivine (mantle rock) and 50% nickel-iron (core). Because of the composition, pallasites are thought to represent the boundary layer between the mantle and the core. Even though olivine is a common mineral, olivine meteorites are quite rare because these often shatter on impact. Below is a link to article about finding and excavating a pallasite in Missouri .

Figure 9. Pallasite meteorites are composed of olivine and nickel-iron.

http://www.astrobio.net/topic/solar-system/meteoritescomets-and-asteroids/farmer-unearths-a-rare-meteorite/

Irons: Meteorites from the core of Differentiated asteroids

Iron meteorites come from the iron cores of shattered differentiated asteroids. These are thought to originate from M type asteroids in the Asteroid Belt. Iron meteorites are among the largest meteorites recovered on earth because these are more likely to survive the entry through the atmosphere, and are more resistant to erosion.

The crisscross pattern seen in iron meteorites is known as the “Widmanstatten” pattern (Fig. 10. It helps to enlarge the image). This pattern is caused by the intergrowth of two different nickel phases as the core cools very slowly, i.e. one degree per 1000 years. Because of this slow cooling rate, Widmanstatten patterns can only happen in iron cores.

http://blogs.agu.org/georneys/2012/10/07/geology-word-of-the-week-w-is-for-widmanstatten-pattern/

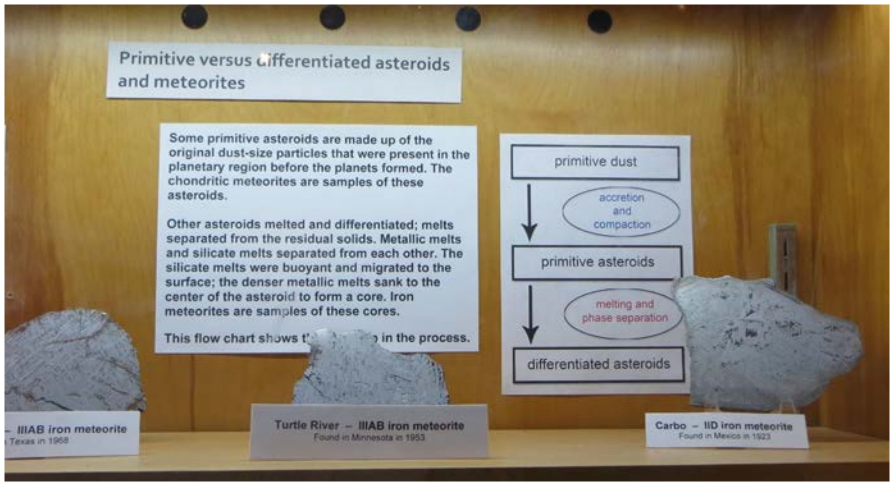


Figure 10. Sections of iron meteorites showing the Widmanstatten pattern.

Tektites

Tektites are not meteorites, but are the result of meteoritic impacts that melt the particles in soil. The resulting ejecta is glassy due to the high silica content found in soils. Tektites are similar to volcanic glasses, but they have a composition that is closer to shales and sedimentary rock.

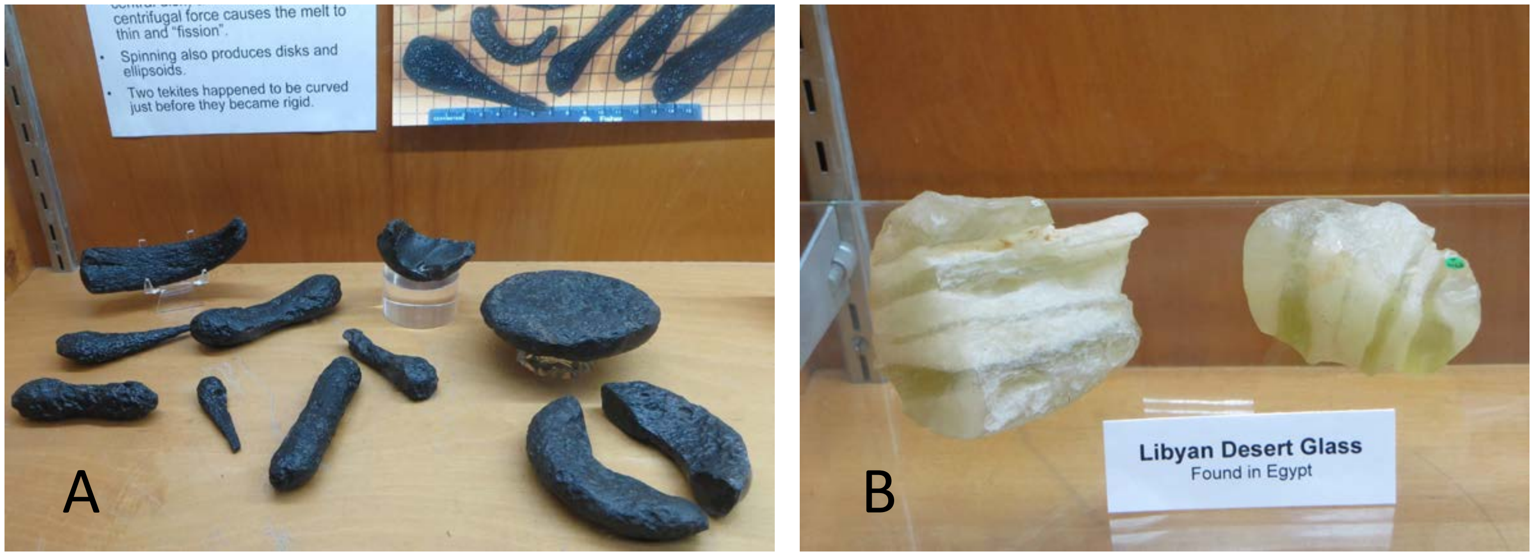


Figure 11. (A) Splash form tektites form while spinning in the atmosphere producing ellipsoids and disk shapes. (B) Libyan desert glass is a type of tektite formed by the melting of sand during a meteoritic impact. The layered glass is almost pure silica.

Final Thoughts on the UCLA Meteorite Gallery

I was interested in visiting the UCLA Meteorite Gallery after hearing about the diversity of its collection. There were many meteorite types on display, and several were rare. I learned how the different types relate to each other, as well as their origin and significance. I also learned how scientists analyze meteorites to understand the formation and evolution of the solar system.

After my visit to the Meteorite Gallery, I walked around the geology building and viewed the 30+ cases of rocks, minerals, and fossils on display in the hallways. It was a nice juxtaposition to the Meteorite Gallery and a great way to end the visit.

The Gallery is located on the third floor of the Geology Building at the UCLA campus. It is open Monday-Friday from 9 a.m. to 4 p.m. for self-guided tours. On Sundays, the gallery is open from 1-4 p.m. with a docent available. Admission is free. For more information on the UCLA Meteor Gallery: http://www.meteorites.ucla.edu

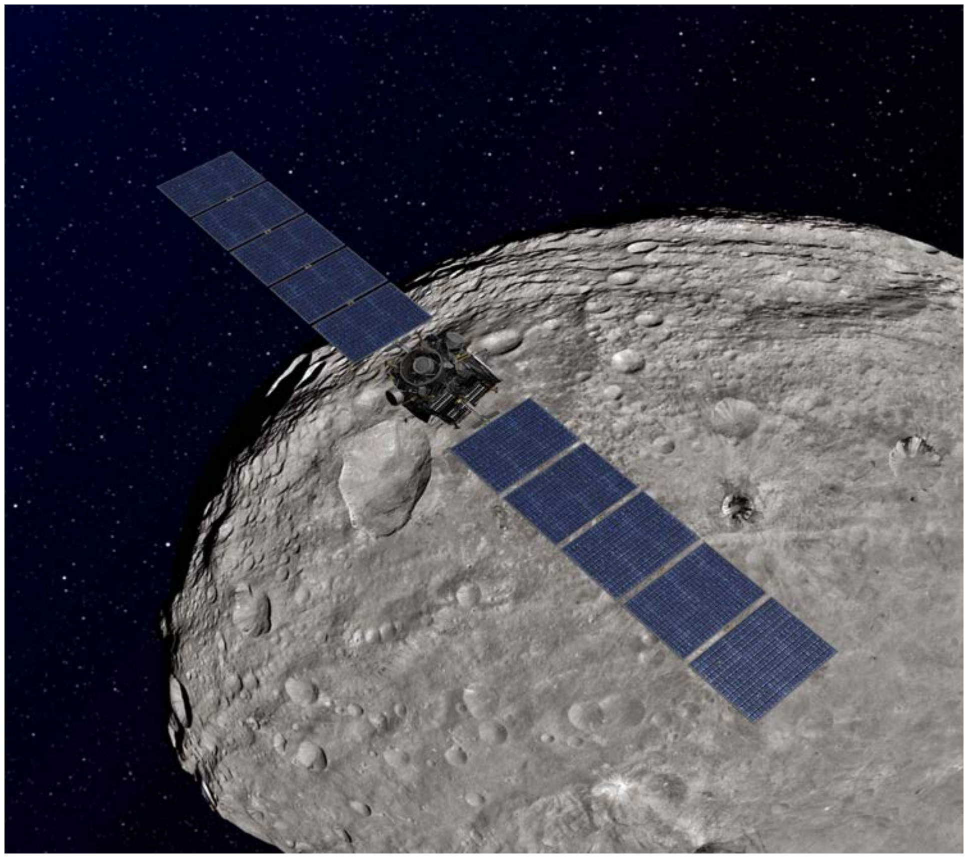
Acknowledgement: Thank you to Dr. John Wasson for patiently answering my many questions.

References: (1) http://www.meteorites.ucla.edu/gallery/
(2) http://www.meteorites.ucla.edu/teaching-guide/

Note: All images except for Figure 4. are credited to the author.

Dawn at Vesta

G.D. Wheeler



Artist Conception of the Dawn spacecraft at Vesta (image credit: NASA/JPL).

The Dawn mission is part of NASA's Discovery Program. It was launched on September 27, 2007 with the goal of traveling to and establishing an orbit around two of the three known protoplanets of the asteroid belt: Vesta and Ceres. Both of these asteroids are thought to represent remnants of the early solar system, yet they have different characteristics. Vesta is a dry differentiated body resembling the rocky planets and moons of the inner solar system. Ceres appears to be made of rock and ice closely resembling some of the icy moons of the outer solar system. By studying both of these protoplanets with the same instruments aboard the same spacecraft, Dawn project scientists hope to understand the different pathways that led to their formation, as well as the conditions existing in the early solar system.

This article focuses on Dawn's exploration of Vesta which concluded in September 2012. The Dawn orbiter is currently at Ceres, and we will follow up on the Ceres' portion of the mission in a later issue.

About Vesta

Vesta was discovered in 1807 by Heinrich Oblers. It is the brightest asteroid in the solar system, and the second largest asteroid in the asteroid belt (Ceres is the largest). Vesta contains about 9% of the mass of the asteroid belt. It has an oblate shape (Fig. 3.) which is thought to have been caused by at least one massive impact. It is 525 km wide, has a mass of 2.6×10^{20} kg, and a density of 3.42 gm/cm^3 (as a comparison the density of rock is about 2 gm/cm^3 and most asteroids are assumed to have this density). Vesta was formed about 4.56 billion years ago. It is thought to be the last remaining rocky protoplanet in the solar system.

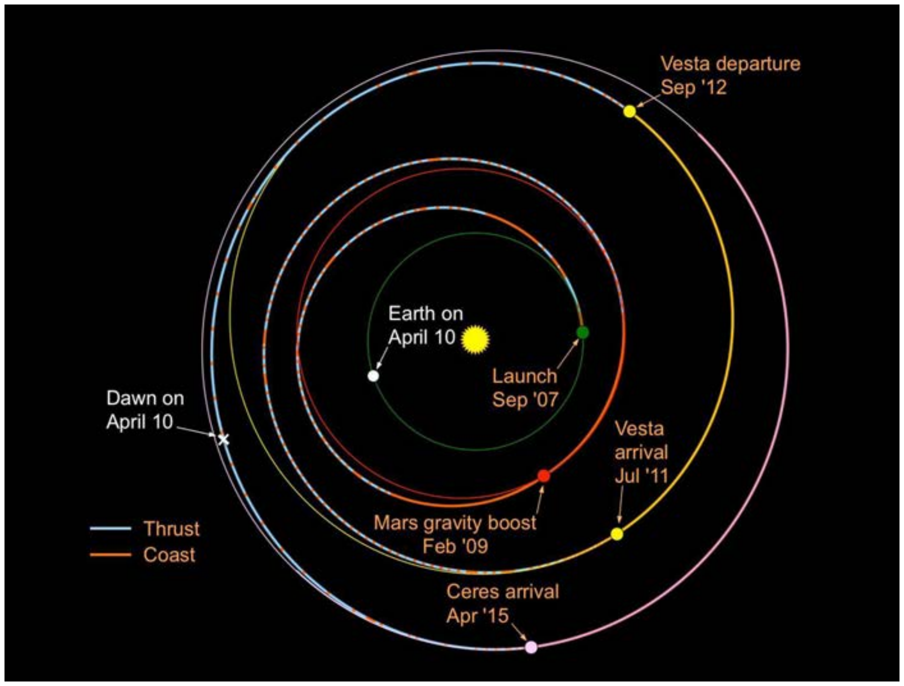


Figure 1. The trajectory of the Dawn spacecraft to Vesta and Ceres. Using efficient ion propulsion thrusters, Dawn is the first spacecraft to orbit two extraterrestrial bodies. (image credit: NASA/JPL)

The Dawn Mission to Vesta

The Dawn Orbiter arrived at Vesta on May 3, 2011 and left on September 4, 2012. The Dawn spacecraft gave us our first good image of Vesta revealing it to be a world with light and dark craters of different ages. The Dawn orbiter used three instruments to survey the Vestan landscape: the ***framing camera*** designed to take images of the topography in three colors and grayscale; the ***gamma ray and neutron detector*** (GRaND) designed to determine the elemental composition; the ***visible and infrared*** (VIR) spectrophotometer designed to assess the mineralogy.

The Vesta-HED Meteorite Connection

One of the goals of Dawn was to confirm that Vesta was indeed the source of the HED class of achondritic meteorites: howardite, eucrite, and diogenite (Fig. 2.). Compositionally, eucrites are basaltic and presumably come from the upper portion of the crust. Diogenite is related to mantle rock and would come from deeper layers. Howardite appears to be a mixed rock composed of fragments of eucrite and diogenite. Previous studies using ground based telescopes showed that spectral properties of Vesta matched that of the HED meteorites. Using Dawn's GRaND and VIR spectrometers, the chemical signatures of the Vestan crust was found to be identical to that of HED meteorites thus confirming the connection between the two. Dawn found that most of the surface of Vesta was made of howardite. Scientists theorize that the howardite was formed by meteor impacts piercing the surface (eucrite) and deeper layers (diogenite) of the crust causing these two rock layers to mix.

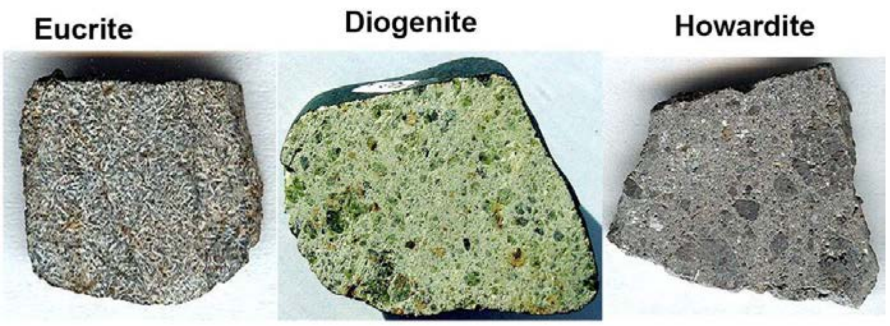


Figure 2. HED meteorites (image credit: Northern Arizona University Meteorite Laboratory)

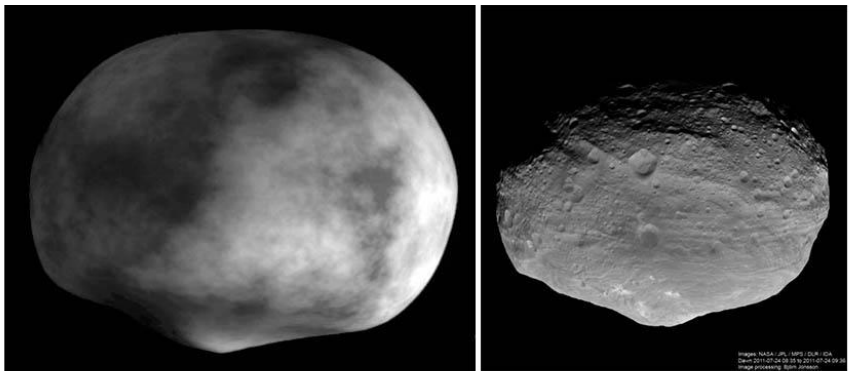


Figure 3. Two views of Vesta. The left is a 3D topographic model made from images taken by the Hubble Telescope (1995). A large impact was seen on the southern hemisphere. The right was taken by the Dawn Spacecraft. (image credit: Hubble: *Ben Zellner, Peter Thomas, and NASA; Dawn: NASA / JPL / MPS / DLR / IDA / Björn Jónsson)*

A Large impact at the South Pole of Vesta launched HED fragments into space

Even before Dawn's arrival at Vesta, scientists already knew of a large impact crater near the south pole of Vesta (Fig. 3.). Dawn revealed that there are actually two large impact craters: the older 400 km Veneneia crater, and a younger 500 km Rheasilvia crater that overlies Veneneia (Fig. 4.). The Rheasilvia crater is 12 miles deep and has a central peak with a height of 22 km. Dawn scientists estimate that the Rheasilvia impact launched about 1% of Vesta's mass as ejecta. The HED meteorites are thought to have originated from the Rheasilvia impact. This crater region is rich in diogenite excavated by the giant impact. A computer animation of the Rheasilvia impact can be found here: https://vimeo.com/19578888

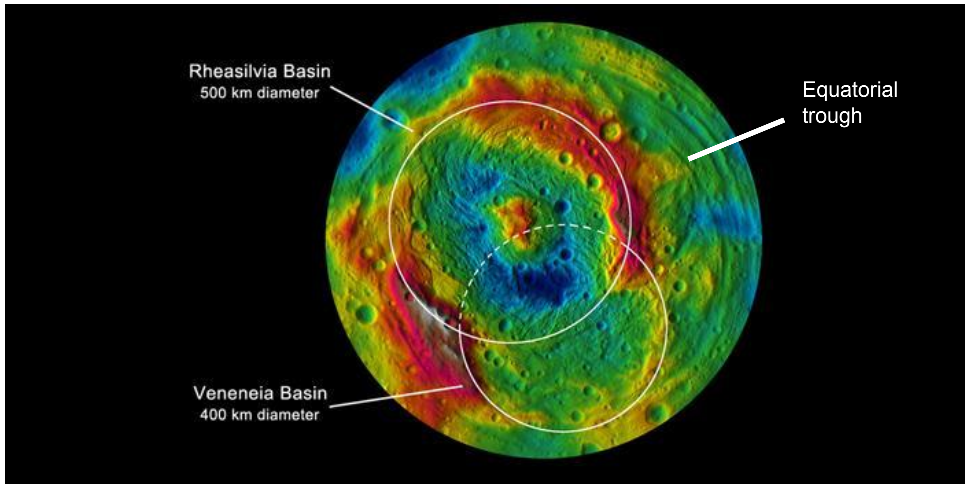


Figure 4. Topographic map of the two large impact basins in the southern hemisphere of the giant asteroid Vesta. (Image credit: NASA/JPL-Caltech/UCLA/ MPS/DLR/IDA/PSI); modified by GDW.

Gravity studies suggests that Vesta has a dense central core

Dawn's gravitational field studies shows that Vesta has a dense central core. Although identifying a metal core was not possible, the gravity study along with the presence of crust (and a hint of deeper mantle rock) suggests that Vesta is differentiated. Figure 5. shows the putative interior structure of Vesta based on Dawn's gravity field studies.

http://www.lpi.usra.edu/meetings/lpsc2012/pdf/2600.pdf

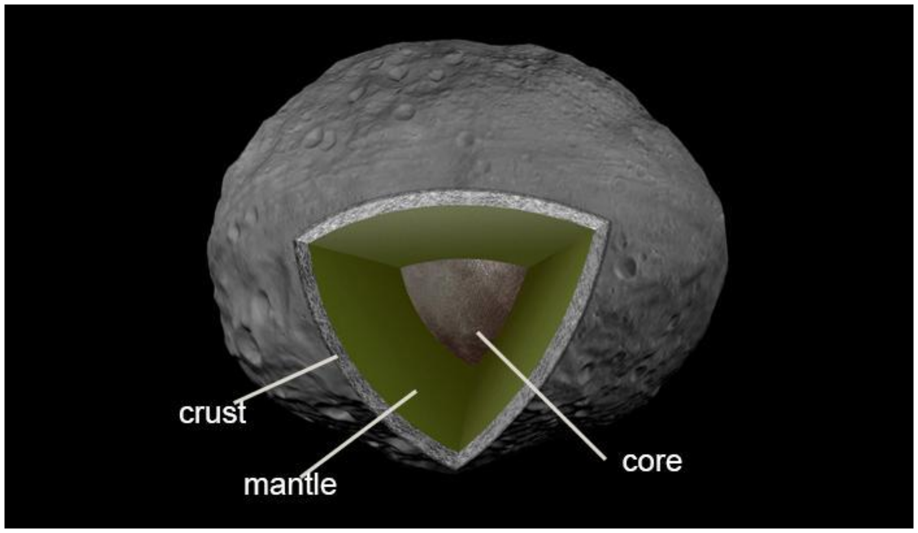


Figure 5. Artist's conception of the interior of Vesta based on Dawn's gravity studies. (image credit: NASA/JPL-Caltech). modified by the author

Trough-like structures (grabens) are also evidence for the differentiation of Vesta

Trough-like structures were found encircling the equator (Fig. 6.) and northern hemisphere of Vesta. Dawn scientists believe that these troughs resemble grabens which are dips in the surface bounded by parallel faults (Fig. 7.). They propose that the grabens were formed when the giant impacts that formed the Veneneia and Rheasilvia craters sent shock waves through the interior of Vesta. As the mantle stretched due to tension, there was block fault displacement of the crust. The formation of grabens is significant because this implies a layered interior. The trough structures seen on Vesta are different from cracks formed by asteroid impact. http://news.agu.org/press-release/asteroids-troughs-suggest-stunted-planet/

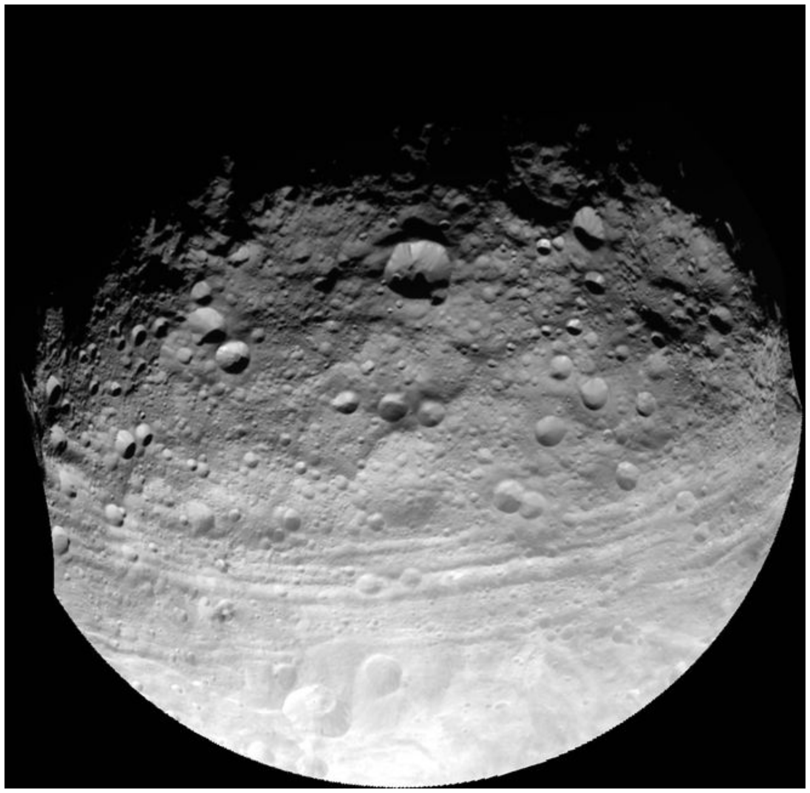


Figure 6. Equatorial troughs at Vesta.
(image credit: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA)

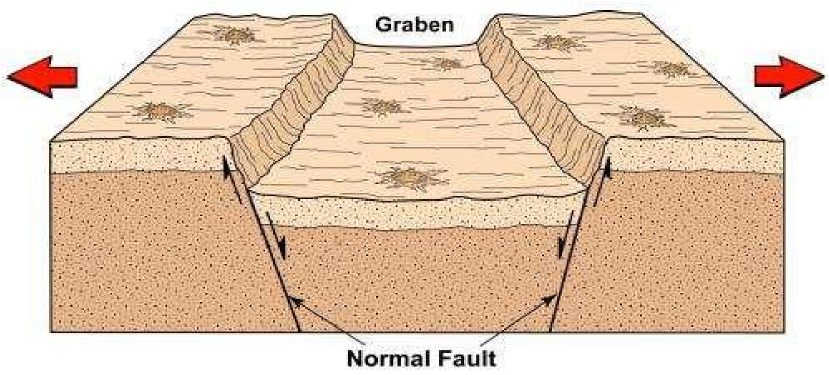


Figure 7. The formation of a graben. (image credit: Arizona State University/Smithsonian

Carbon and Water on Vesta

Using the framing camera, Dawn mapped out the distribution of dark and light areas on the surface of Vesta. The bright material was found to be basaltic soil. The dark material contained carbon and water and was found mainly inside the walls and rims of the impact craters and in their ejecta (Fig. 8.). Dawn project scientists think that the source of carbon and water is meteoritic. One theory is that a massive carbonaceous chondritic asteroid impacted the

southern hemisphere of Vesta and showered Vesta with carbon and water. Another possibility is that a series of small impacts delivered a steady supply of carbon and water to Vesta. The presence of hydrated materials was surprising to scientists and contradicted the idea that Vesta was a “dry” body. Other data (not shown here) showed carved gullies in some of the craters suggesting the presence of subsurface water at some point in Vesta’s past.
https://www.mpg.de/6771105/carbon-vesta

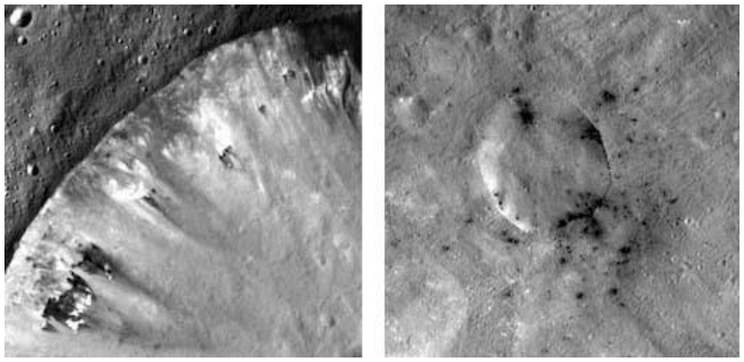


Figure 8. Most of the dark, carbonaceous material on Vesta is found on the rims of small craters (L) or scattered in their surroundings (R). (image credit: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA)

Geological Map of Vesta

By the end of Dawn’s one year orbit of Vesta, the spacecraft had gathered enough topographic and compositional data to generate a detailed geologic map of Vesta (Fig. 9.). The Dawn data showed that the northern hemisphere of Vesta had the oldest terrain and was heavily cratered. The southern hemisphere was younger and the terrain was heavily affected by the Rheasilvia impact. Dawn project scientists found that the Vestan landscape was shaped by three main impact events: Veneneia (2.1 bya), Rheasilvia (1.1 bya), and Marcian (120-390 mya). The Rheasilvia impact appears to have had the greatest influence on the geomorphology of Vesta. The details of how the map was constructed can be found here:

https://repository.asu.edu/attachments/144861/content/C_Williams_etal_2014_preprint.pdf

What we learned from Dawn

Before Dawn’s arrival at Vesta, the best images we had of Vesta were a series of fuzzy images taken by the Hubble Space Telescope. The Dawn mission gave us our first detailed views of Vesta and showed it to be a heavily cratered world with some geological features that were akin to what was being discovered on the Moon and Mars. While Dawn helped answer some long-standing questions such as the origin of the HED meteorites and whether or not Vesta has a dense central core, the orbiter also revealed several enigmas. There is still the question about how giant impacts may have effected the shape of Vesta and its layered interior. Other unresolved questions include the age of the Veneneia and Rheasilvia impacts (did these occur during the Late Heavy Bombardment or long after), the origins of equatorial troughs, the delivery of carbon and water to Vesta, and if Vesta ever had flowing water. Even though Dawn left Vesta four years ago, the science teams continue to analyze data with the goal of understanding the events that shaped the evolution of Vesta. Currently the Dawn orbiter has been at Ceres for just over a year. It will be interesting to see how these two ancient worlds compare.

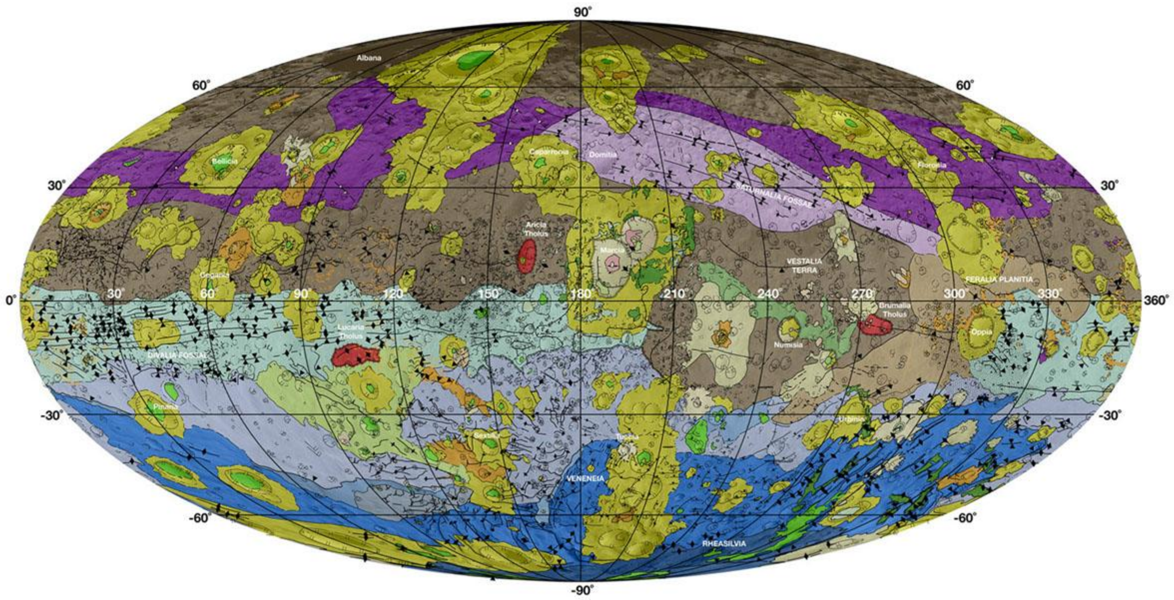
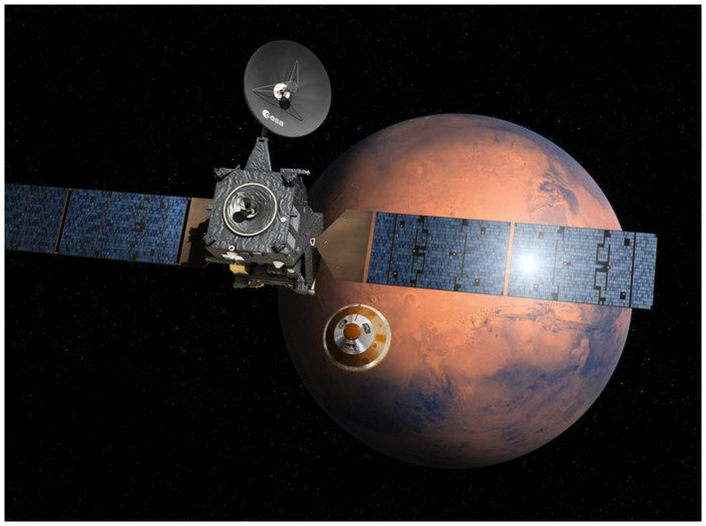


Figure 9: Geologic map of Vesta. The areas of brown in the northern hemisphere represent the heavily cratered ancient terrain. The areas of blue and light purple in the southern hemisphere represent the younger terrain formed by the impact that created the Rheasilvia crater. The light green belt around the equator is the trough (graben) formed by the Rheasilvia crater impact. The purple belt in the northern hemisphere is the trough (graben) formed by the Veneneia crater impact. (image credit: NASA/JPL-Caltech/ASU). For a more detailed explanation:

http://www.hou.usra.edu/meetings/lpsc2015/pdf/1126.pdf

How the ExoMars mission could sniff out life on Mars – and what to do next

By Manish Patel



Schiaparelli separating from Trace Gas Orbiter (image credit: ESA)

Manish Patel is a Senior Lecturer in Planetary Science at The Open University, and conducts research in the exploration of the solar system using spaceflight instrumentation. His focus is on the exploration of the Martian atmosphere and surface, and is currently involved in the ExoMars 2016 and 2018 missions to Mars.

"It (could be) life Jim, but (perhaps) not as we know it." This is not just a sci-fi catchphrase, but also something some planetary scientists have uttered in response to the discovery of methane in Mars' atmosphere.[1] That's right – scientists believe that some kind of past or present microbial lifeform on Mars could have produced the methane. While it is far from the only possible explanation, it is actually so plausible that a special mission is being sent there to find out.

The first part of what could be a series of missions – the European Space Agency's ExoMars Trace Gas Orbiter[2]--launched on March 14 from Baikonur in Kazakhstan and I watched nervously after having spent 13 years working on one of its instruments. Needless to say, it was one of the most exciting and nerve-wracking days of my life.

Many possibilities

The mission is an orbiter that will map trace gases in the atmosphere of Mars, over an entire Martian year (two Earth years). Of course the methane in the atmosphere doesn't have to be from microbial life, it could also be caused by cosmic dust or geological processes. ExoMars will test for current geological processes that might be releasing the methane. If all goes well this mission will be followed by a more ambitious ExoMars Rover, designed to test for traces of ancient life, that will launch after 2018.

The first proposed observations[3] of methane plumes on Mars was made over a decade ago, from Earth. The data required a lot of processing, and led to controversy among planetary scientists.[4]

According to our current understanding of atmospheric chemistry, methane on Mars should be destroyed relatively rapidly (on the order of a few hundred years). That means it is a gas that we shouldn't really be seeing on Mars – unless there is some active process creating or releasing it. On Earth, the majority of methane in the atmosphere comes from biological organisms, which raises the question of whether Mars could also host life – past or present.

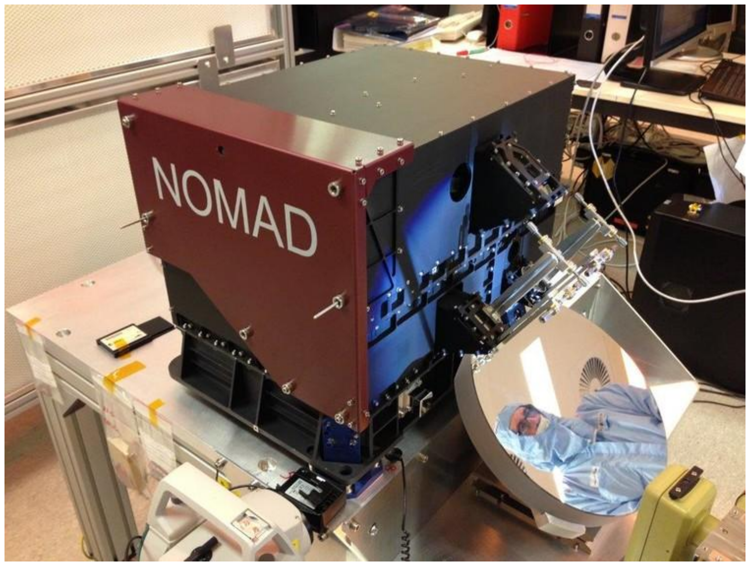
Rocket with ExoMars as it is getting ready for launch. (image credit: ESA)

The orbiter is uniquely designed to map the minute constituents of the Martian atmosphere (such as methane), using a set of highly specialised spectroscopic and imaging instruments.[5] The spectrometers, which can analyse what a gas is made of by measuring the specific wavelengths of sunlight they absorb, are key to measuring the presence of methane and other gases. The relative mixture of the gases observed, along with their composition, can be compared to measurements on Earth in order to provide clues as to whether the origin of the methane could be geological or biological.

I co-led the development of one of these methane-sniffing instruments, NOMAD,[6] with colleagues from the UK and Belgium. Having worked on it for the last 13 years, it has been one of the most important achievements in my career.

The spacecraft will get to Mars in mid-October. The first thing it will do is to eject a technology demonstrator, the Schiaparelli lander, to prove that Europe can successfully reach the surface of Mars. The lander will provide a few days of surface weather measurements, lasting as long as the batteries on the lander permit.

In the meantime, the orbiter will begin manoeuvres to get into a circular orbit. It will use a fuel-free braking process called "aerobraking" (a somewhat terrifying concept of delicately dragging the spacecraft through the very top of the atmosphere in order to use the friction from the gas molecules to slow it down). This presents another first for Europe, in performing this type of dangerous manoeuvre around Mars.



The NOMAD spectrometer (image credit: Manish Patel)

What to do if we find life

So what would happen if we learned that there is microbial life on Mars, or that it has existed there in the past? Well it would only challenge everything we know. We would have to come to grips with not having a unique status in the universe and will have to work out how to include extraterrestrial "life" in our existential or religious beliefs – to name a few.

On a scientific level, there's a lot at stake. Of course, it would also lead to major new efforts to find life on planets beyond Mars and even beyond our own solar system.

The first challenge if life is ever detected will be to prove that we didn't bring it there from Earth – a difficult task to achieve. Careful cataloguing of the "bioburden" load on the spacecraft and from the cleanrooms it was assembled in can provide a check on what organisms might have been present on the spacecraft when it left the Earth. Fundamentally though, life that arose beyond the Earth would likely result from subtly different chemical processes, so to find out for sure, a detailed in situ biochemical analysis would be required.

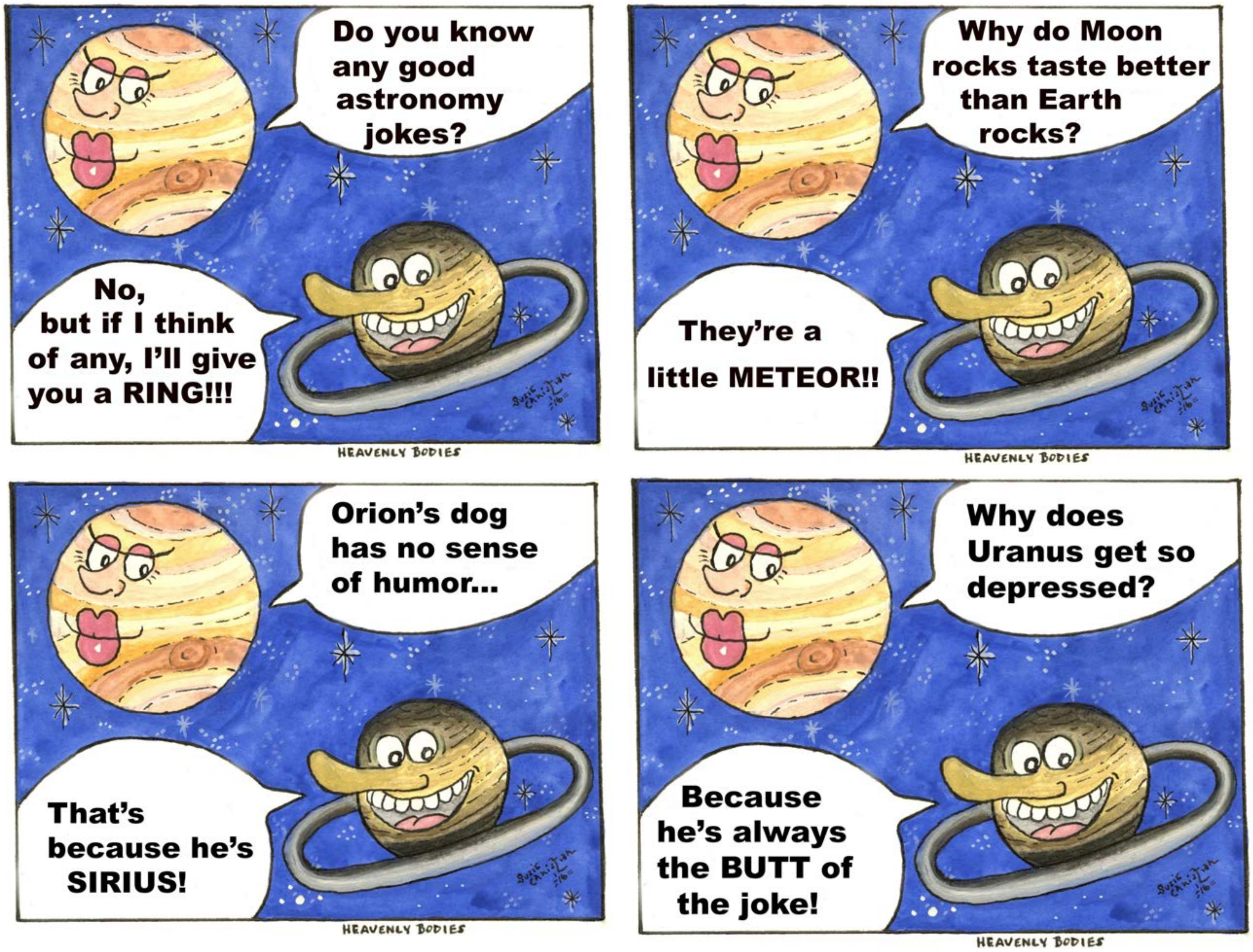
1. http://science.nasa.gov/science-news/science-at-nasa/2014/16dec_methanespike/
2. http://exploration.esa.int/mars/
3. http://www.sciencedirect.com/science/article/pii/S0019103504002222
4. http://www.sciencedirect.com/science/article/pii/S001910351000446X
5. https://theconversation.com/explainer-seeing-the-universe-through-spectroscopic-eyes-37759
6. http://mars.aeronomie.be/en/exomars/nomad.htm

The implications for future exploration of the Solar System are also profound – at present we take great care not to contaminate areas that are considered “special regions of relevance to potential life”; knowing with certainty that life is present will likely impose even stricter cleanliness requirements for any future exploration. In this respect, there lies an interesting debate for the future: should we pursue human exploration of a world that has been found to harbour life?

But even if we don’t find life, the benefits are huge. Ventures like the ExoMars orbiter have taught us to overcome a number of technological challenges, such as miniaturising sophisticated instruments and increasing technical performance, which also underpin many devices we use in everyday life. The skills developed are also of vital importance. Building such a complex spacecraft requires technical, management, software and creative skills that are directly applicable to many different industries and vocations. Pushing the boundaries of what is technically possible to achieve groundbreaking new science is what triggers the leaps that take us forward.

Heavenly Bodies

By Susie Christian



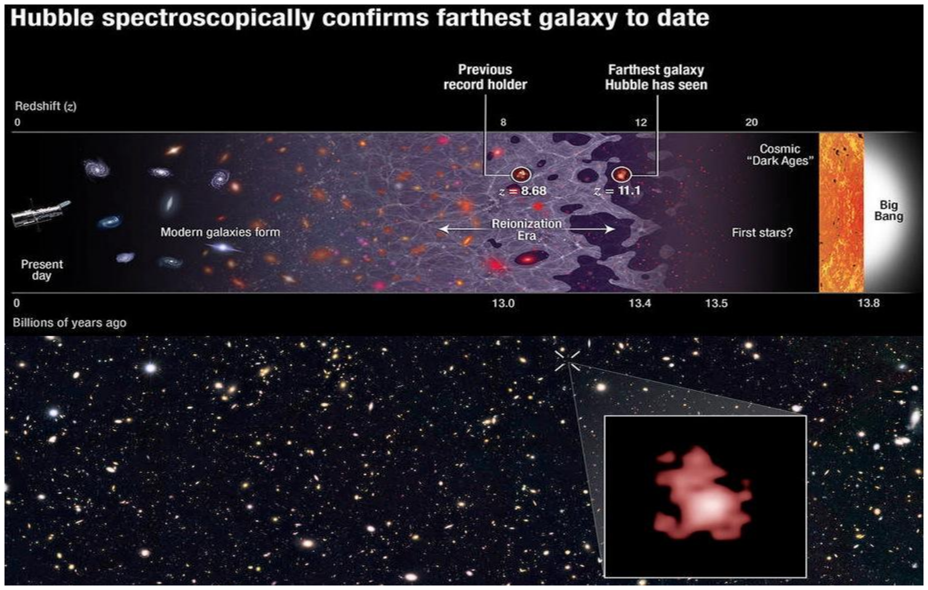
Hubble Shatters The Cosmic Record For Most Distant Galaxy

By Ethan Siegel

The farther away you look in the distant universe, the harder it is to see what's out there. This isn't simply because more distant objects appear fainter, although that's true. It isn't because the universe is expanding, and so the light has farther to go before it reaches you, although that's true, too. The reality is that if you built the largest optical telescope you could imagine -- even one that was the size of an entire planet -- you still wouldn't see the new cosmic record-holder that Hubble just discovered: galaxy GN-z11, whose light traveled for 13.4 billion years, or 97% the age of the universe, before finally reaching our eyes.

There were two special coincidences that had to line up for Hubble to find this: one was a remarkable technical achievement, while the other was pure luck. By extending Hubble's vision away from the ultraviolet and optical and into the infrared, past 800 nanometers all the way out to 1.6 microns, Hubble became sensitive to light that was severely stretched and redshifted by the expansion of the universe. The most energetic light that hot, young, newly forming stars produce is the Lyman-α line, which is produced at an ultraviolet wavelength of just 121.567 nanometers. But at high redshifts, that line passed not just into the visible but all the way through to the infrared, and for the newly discovered galaxy, GN-z11, its whopping redshift of **11.1** pushed that line all the way out to 1471 nanometers, more than double the limit of visible light!

Hubble itself did the follow-up spectroscopic observations to confirm the existence of this galaxy, but it also got lucky: the only reason this light was visible is because the region of space between this galaxy and our eyes is mostly ionized, which *isn't true* of most locations in the universe at this early time! A redshift of 11.1 corresponds to just 400 million years after the Big Bang, and the hot radiation from young stars doesn't ionize the majority of the universe until 550 million years have passed. In most directions, this galaxy would be invisible, as the neutral gas would block this light, the same way the light from the center of our galaxy is blocked by the dust lanes in the galactic plane. To see farther back, to the universe's first true galaxies, it will take the James Webb Space Telescope. Webb's infrared eyes are much less sensitive to the light-extinction caused by neutral gas than instruments like Hubble. Webb may reach back to a redshift of 15 or even 20 or more, and discover the true answer to one of the universe's greatest mysteries: when the first galaxies came into existence!



Images credit: (top); NASA, ESA, P. Oesch (Yale University), G. Brammer (STScI), P. van Dokkum (Yale University), and G. Illingworth (University of California, Santa Cruz) (bottom), of the galaxy GN-z11, the most distant and highest-redshifted galaxy ever discovered and spectroscopically confirmed thus far.