National Aeronautics and
Space Administration

2021 EXPLORE SCIENCE

www.nasa.gov

EXPLORE SCIENCE

Science and discovery have always required us to persevere. Through unprecedented times. Through storms and turbulence.

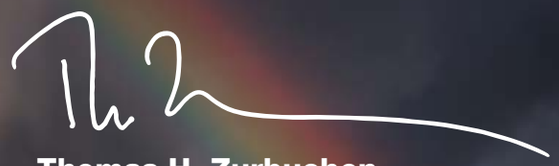
Perseverance is more than facing challenges. It demonstrates our ability to hold on to a worthy goal with resilience. It pushes us to keep doing the next right thing—to achieve something beyond ourselves. In that spirit, NASA Science, our nation, and the world continue to persevere.

The year 2020 often made me think of the anonymous quote: “The best view comes after the hardest climb.” I have never been so proud to lead our team of explorers and enablers. I watched as we began to hunker down in our homes at the start of the coronavirus pandemic, not knowing how long we would be out of the office or how productive we would be. I was impressed when work continued despite challenges, and innovative solutions started pouring out of our teams.

I was most proud of the mission teams who worked under extraordinary pressures to ensure Mars 2020 Perseverance made its slender planetary launch period. They inspired us and gave us hope.

All of our missions have that basic ingredient of perseverance, whether it is the OSIRIS-REx team finding many surprises at asteroid Bennu and adapting its work to still make bold discoveries, or the James Webb Space Telescope, whose team has also persevered in this period to continue advancing the world’s most complex telescope on its journey to the stars. Our teams also face challenges in missions closer to the Sun than we’ve ever ventured, and our fleet of Earth observation satellites and the teams behind them consistently strive to keep us focused on our own home planet so we can better understand and also protect it. And our newest division, Biological and Physical Sciences, helps us persevere by understanding and protecting life in space as part of our human exploration programs.

All of us persevere and discover together through the common experience of science. Our commitment to knowledge and doing hard things is what brings out the best in us. We will always persevere, because it is so worth it.



Thomas H. Zurbuchen

Associate Administrator
NASA Science Mission Directorate

January 2021

Hubble Marks 30 Years in Space with Tapestry of Blazing Starbirth. A colorful image resembling a cosmic version of an undersea world teeming with stars was released to commemorate the Hubble Space Telescope's 30 years of viewing the wonders of space. In the Hubble portrait, the giant red nebula (NGC 2014) and its smaller blue neighbor (NGC 2020) are part of a vast star-forming region in the Large Magellanic Cloud, a satellite galaxy of the Milky Way, located 163,000 light-years away. The image is nicknamed the "Cosmic Reef" because NGC 2014 resembles part of a coral reef floating in a vast sea of stars. The red nebula's sparkling centerpiece is a grouping of bright, hefty stars, each 10 to 20 times more massive than our Sun. The seemingly isolated blue nebula at lower left (NGC 2020) was created by a solitary mammoth star 200,000 times brighter than our Sun. The blue gas was ejected by the star through a series of eruptive events during which it lost part of its outer envelope of material. **Image and text credit:** NASA, European Space Agency, and Space Telescope Science Institute

https://hubblesite.org/contents/news-releases/2020/news-2020-16

Born in 1951, **Marcia J. Rieke** is an American astronomer who specializes in the observation of the infrared sky to study distant galaxies. Considered to be one of the "founding mothers" of infrared astronomy, she is the Principal Investigator of the Near Infrared Camera for the James Webb Space Telescope and had a leadership role on the Near Infrared Camera and Multi-Object Spectrograph for the Hubble Space Telescope. She is currently Regents Professor of Astronomy at the University of Arizona. She is a recipient of the NASA Exceptional Public Service Medal and the George van Biesbroeck Prize, and she is a member of the National Academy of Sciences. Photo credit: NASA/Carla Cioffi

December 2020

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

February 2021

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28						

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
					1 New Year's Day	2
3	4	5	6 Last Quarter	7	8	9
10	11	12	13 New Moon	14	15	16
17	18 Birthday of Martin Luther King, Jr. (observed date)	19	20 First Quarter	21	22	23
24 31	25	26	27	28 Full Moon	29	30

February 2021

Close Encounters with a Distant World. Originally discovered in 2014 by NASA's New Horizons science team using data from the Hubble Space Telescope, Arrokoth is a small Kuiper Belt object at the edge of our solar system. Formerly known as 2014 MU69, the object was officially named "Arrokoth" in 2019, a Native American term for "sky" in the Powhatan/Algonquian language. Arrokoth became the most distant and most primitive object ever explored by a spacecraft when NASA's New Horizons flew past it on January 1, 2019. The images captured by the New Horizons spacecraft, like the one shown above, reveal Arrokoth's unique shape, consisting of two lobes connected by a thin "neck." End to end, Arrokoth measures approximately 22 miles (~35 kilometers) in length and 12 miles (~20 kilometers) in width. Arrokoth's distinct shape leads researchers to surmise that it is made from two objects that gently merged into the one we see today. The object is estimated to be approximately 4 billion years old and orbits our solar system once every 298 years. Its orbit lies 44 times further away from the Sun than Earth, suggesting that Arrokoth has been only slightly heated since forming, thus keeping it well-preserved. Untouched by the usual turmoil and impacts of most small objects, Arrokoth is a pristinely preserved time capsule that is teaching us about our solar system's origins. **Image and text credit:** NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute/Roman Tkachenko

https://www.nasa.gov/feature/ames/arrokoth-first-look

Born in 1961, **Shelia Nash-Stevenson** is the first African American woman from Alabama to earn a Ph.D. in physics and is a three-time magna cum laude graduate of Alabama A&M University with a B.S. in electrical/electronic engineering technology and an M.S. in physics. At the time of earning her Ph.D. in 1994, Nash-Stevenson was one of fewer than twenty African American women to hold a Ph.D. in physics in the United States. She is currently employed at NASA's Marshall Space Flight Center (MSFC) as a Science Projects Manager in the Science & Technology Office. In 2016, Nash-Stevenson received NASA's Modern Figure award and was selected to attend the Red Carpet Premiere of *Hidden Figures* in New York City, where she took part in several panel discussions and interviews to encourage girls and African Americans to pursue degrees and careers in science, technology, engineering, and mathematics (STEM). Photo credit: NASA/MSFC photo lab

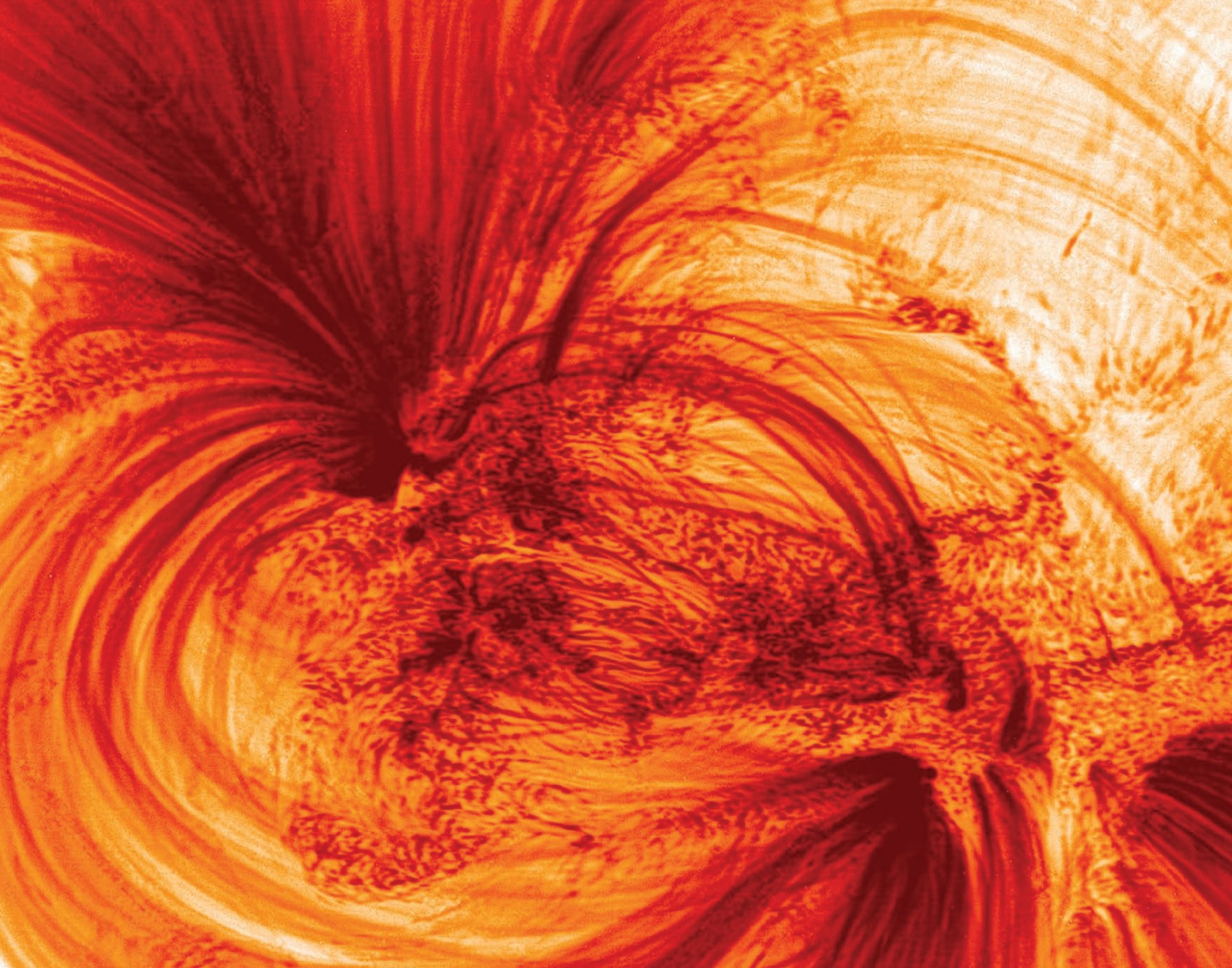
January 2021

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

March 2021

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	1	2	3	4 Last Quarter	5	6
7	8	9	10	11 New Moon	12	13
14	15 Washington's Birthday (observed date)	16	17	18	19 First Quarter	20
21	22	23	24	25	26	27 Full Moon
28						



March 2021

Rocket-Borne Telescope Detects Super-Fine Strands on the Sun. NASA's High-Resolution Coronal Imager (Hi-C) mission provided the highest-resolution views ever captured of the Sun's outer atmosphere, or corona, revealing fine strands of million-degree solar material. Hi-C captured this image on its third flight on a sounding rocket—a suborbital rocket that makes brief flights into space before falling back to Earth—from the White Sands Missile Range in New Mexico on May 29, 2018. The image shows loops as thin as 125 miles (~200 kilometers) across, in areas that otherwise appear dim and fuzzy in other Sun-watching telescope images. It's the first direct observation of the strands that are thought to combine and make up larger loops on the Sun. Images like this provide visual evidence that the staggeringly hot material filling the Sun's corona—which is some 300 times hotter than its surface—has definite structure on fine scales, rather than being a homogenous soup of particles. **Image and text credit:** NASA/University of Central Lancashire

https://www.nasa.gov/feature/goddard/2020/rocket-borne-telescope-detects-super-fine-strands-on-the-sun

Born in 1965, **Tai Phan** is a space physicist at the University of California, Berkeley, who is a research leader in the field of magnetic reconnection—a little-understood physical process where magnetic field lines cross and explosively realign, expelling energy and accelerating particles. Phan's work focuses extensively on a common material throughout space—a heated, electrified gas called plasma—and helps us understand the physics at work in this fundamental state of matter rarely encountered on Earth. Working with data from NASA's Magnetospheric Multiscale (MMS) mission, he discovered a new type of reconnection in turbulent material surrounding Earth's magnetic field, the magnetosphere. The more we understand about plasma, which makes up 99% of the universe, the more we understand the space environment and space weather around Earth. Photo credit: Tai Phan

February 2021

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28						

April 2021

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	1	2	3	4	5	6 Last Quarter
7	8	9	10	11	12	13 New Moon
14 Daylight Saving Time Begins	15	16	17	18	19	20
21 First Quarter	22	23	24	25	26	27
28 Full Moon	29	30	31			

April 2021

The Black Sea Hosts Large Blooms During the Summer. This composite image shows a portion of Afro-Eurasia on July 2, 2019. Of the water bodies that are visible, the Black Sea (near the center of the image) stands out because of its bright color. During the summer, the Black Sea often hosts large phytoplankton blooms. The aquamarine hues are likely caused by a type of phytoplankton called coccolithophores, which are made up of little calcite plates that have a chalky appearance when seen from space.

The image was created using data from the Visible Infrared Imaging Radiometer Suite (VIIRS), which is currently operational on the National Oceanic and Atmospheric Administration (NOAA)/NASA Suomi National Polar-orbiting Partnership (NPP) and NOAA-20 weather satellites. In addition to flying on Suomi NPP and NOAA-20, the instrument will also be included on the Joint Polar Satellite System-2 (JPSS-2), scheduled to launch in 2022, as well as on JPSS-3 and JPSS-4. All of these satellites are operated by NOAA and are part of a decades-long partnership between NOAA and NASA that leverages the unique capabilities of each agency to provide critical data to both the operational and research communities. The image is a composite of data from nine NOAA-20 orbits collected over a span of 14 hours on July 2, 2019. Data from four orbits of Suomi NPP collected on the same day were used to replace sunglint-contaminated portions of the NOAA-20 data. **Image and text credit:** Norman Kuring/NASA's Ocean Biology Processing Group/Ocean Data Processing System

https://oceancolor.gsfc.nasa.gov/gallery/643

Born in 1951, **Kathryn D. Sullivan** joined NASA as part of the first group of U.S. astronauts to include women. She was the first American woman to walk in space, logging over 532 hours in orbit during three Space Shuttle missions. She received the NASA Medal for Outstanding Leadership and was inducted into the Astronaut Hall of Fame. Sullivan subsequently served as Administrator of the National Oceanic and Atmospheric Administration. She descended to the Challenger Deep in 2020, becoming the first person in history to both travel in space and visit the deepest point in Earth's ocean. Photo credit: Stephen Voss

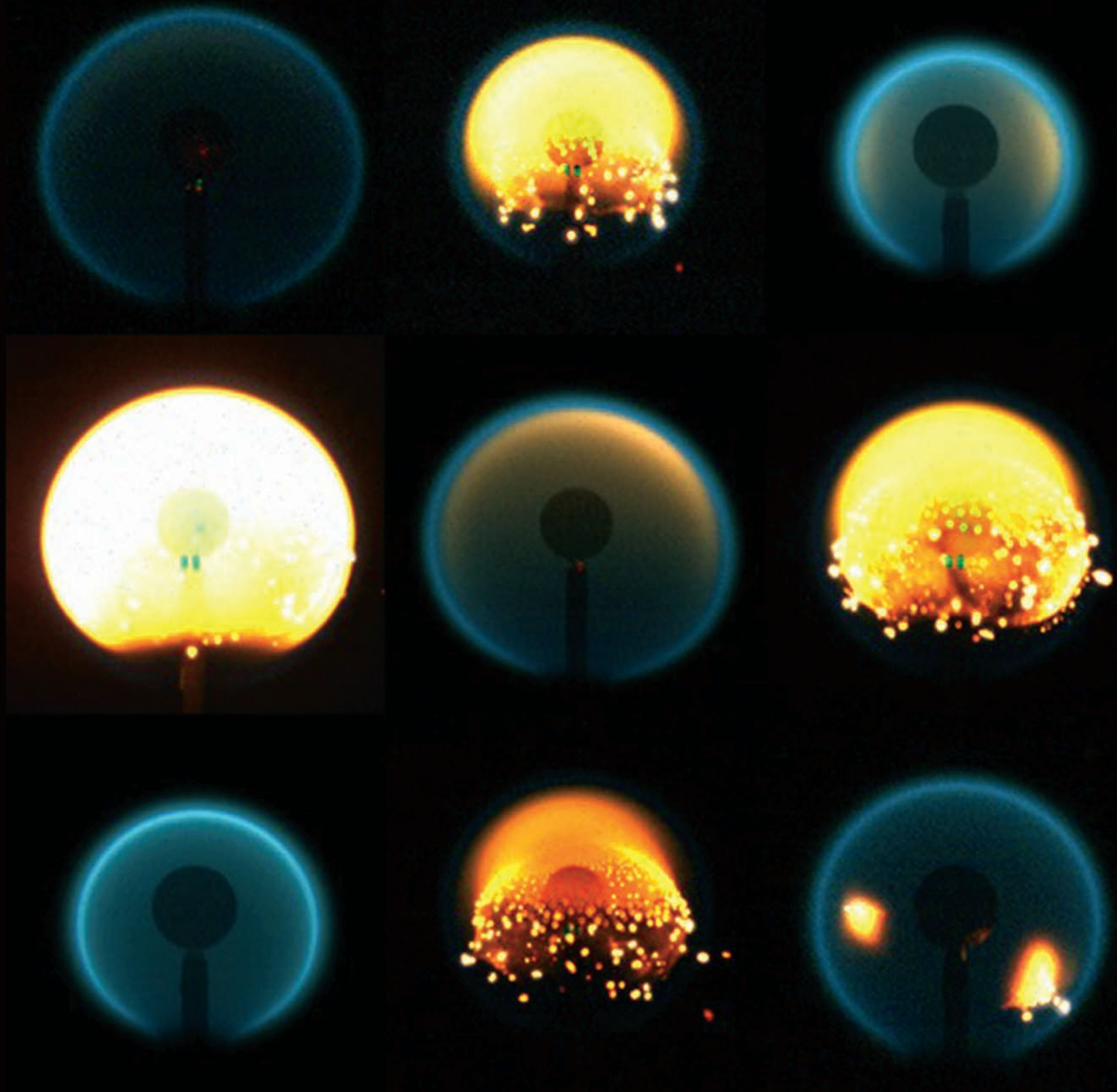
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				1	2	3
4 Last Quarter	5	6	7	8	9	10
11	12 New Moon	13	14	15	16	17
18	19	20 First Quarter	21	22	23	24
25	26	27 Full Moon	28	29	30	

March 2021

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

May 2021

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

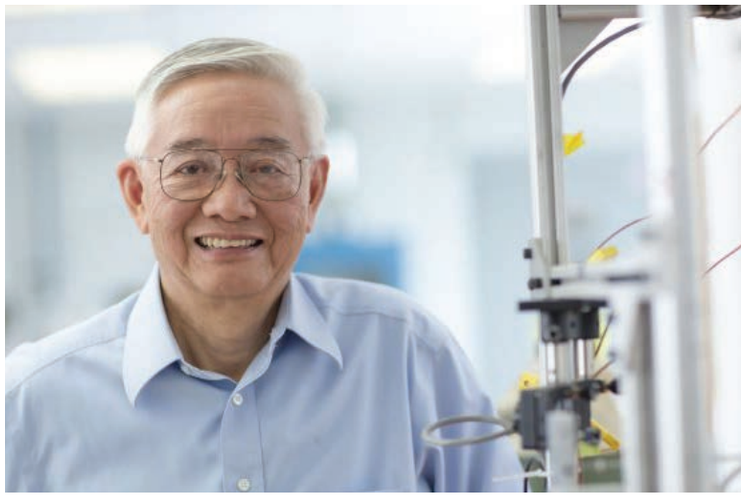


May 2021

Studying Spherical Flames on the International Space Station. When you ignite flames in microgravity, they burn differently than here on Earth—and can form spheres, simplifying the analysis. The composite image above reveals how spherical flames of ethylene, a gaseous fuel that is naturally sooty, burn in an experiment called Flame Design conducted on the International Space Station. Led by **Rich Axelbaum**, of Washington University in St. Louis, the experiment is part of the Advanced Combustion via Microgravity Experiments (ACME) project. The goal of the experiment is to improve our understanding of soot inception and control in order to enable the optimization of oxygen-enriched combustion and the "design" of non-premixed flames that are both robust and soot-free.

Unlike a lit candle that quickly extinguishes when you blow it out, these spherical flames extinguish in a fascinating way. Although not seen in the images above, Axelbaum explains that, "Before going out completely, they begin to go through an oscillatory behavior where the spherical flame disappears from one side and then returns, only to disappear and return once again. This behavior can occur for tens of seconds until the flame finally goes out." Experiments like Flame Design could help scientists improve burn efficiency and reduce pollutant emission (e.g., from soot) in practical terrestrial combustion. **Image and text credit:** NASA

http://www.flickr.com/photos/space-flames



Born in 1942, **James T'ien** currently serves on the Committee on Biological and Physical Sciences in Space. He is a professor emeritus at Case Western Reserve University, where he began as a professor in 1971. He is the recipient of a NASA medal of public service, a NASA Silver Snoopy award, and an American Institute of Aeronautics and Astronautics (AIAA) space processing award. T'ien has mentored and served as a doctoral research advisor for numerous students who went on to spend their entire careers as NASA scientists. He has made major contributions to the theoretical and experimental understanding of combustion and spacecraft fire safety in microgravity. He is the Principal Investigator of Growth and Extinction Limits as part of the Solid Fuel Ignition and Extinction experiment destined for the International Space Station (ISS) and has been Principal Investigator of the Burning and Suppression of Solids ISS experiment and numerous other spaceflight experiments. He has also led multiple microgravity combustion test campaigns in the NASA Zero Gravity Research Facility and aboard KC-135 parabolic flight aircraft. Photo credit: Case Western Reserve University

April 2021

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

June 2021

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
						1
2	3 Last Quarter	4	5	6	7	8
9 Mother's Day	10	11 New Moon	12	13	14	15
16	17	18	19 First Quarter	20	21	22
23 30	24 31 Memorial Day	25	26 Full Moon	27	28	29

June 2021

Galaxy Galaxy, Burning Bright (NGC 3583). This image, taken by the Hubble Space Telescope, shows galaxy NGC 3583—a barred spiral galaxy with two arms that twist out into the universe. This galaxy is located 98 million light-years away from the Milky Way. Two recent supernovae exploded in this galaxy, one detected in 1975 and another, more recently, in 2015. Supernovae can occur a few different ways. These two supernovae explosions arose from stars in binary systems in which the stellar remnant of a Sun-like star, known as a white dwarf, was fed by material from its companion star. The white dwarf gorged on the material until it reached a maximum mass. At this point, the star collapsed inward before exploding outward in a brilliant supernova. Two of these events were spotted in NGC 3583, and though not visible in this image, we can still marvel at the galaxy's fearful symmetry. **Image and text credit:** ESA/Hubble & NASA, A. Riess *et al*.

https://www.spacetelescope.org/images/potw2018a

Born in 1969, **Adam G. Riess** is an astrophysicist who was named a co-winner of the Nobel Prize in Physics in 2011 for his leadership in the High-Z Supernova Search Team's discovery that the expansion rate of the universe is accelerating, a phenomenon widely attributed to a mysterious, unexplained "dark energy" filling the universe. The discovery was named by *Science* magazine in 1998 as "the Breakthrough Discovery of the Year." He is the Thomas J. Barber Professor in Space Studies at the Krieger School of Arts and Sciences, a distinguished astronomer at the Space Telescope Science Institute, and a member of the National Academy of Sciences. His accomplishments have been recognized through the years with a number of other awards, including the Albert Einstein Medal, a MacArthur Fellowship, the Gruber Foundation Cosmology Prize (shared), and the Shaw Prize in Astronomy. Photo credit: Johns Hopkins University

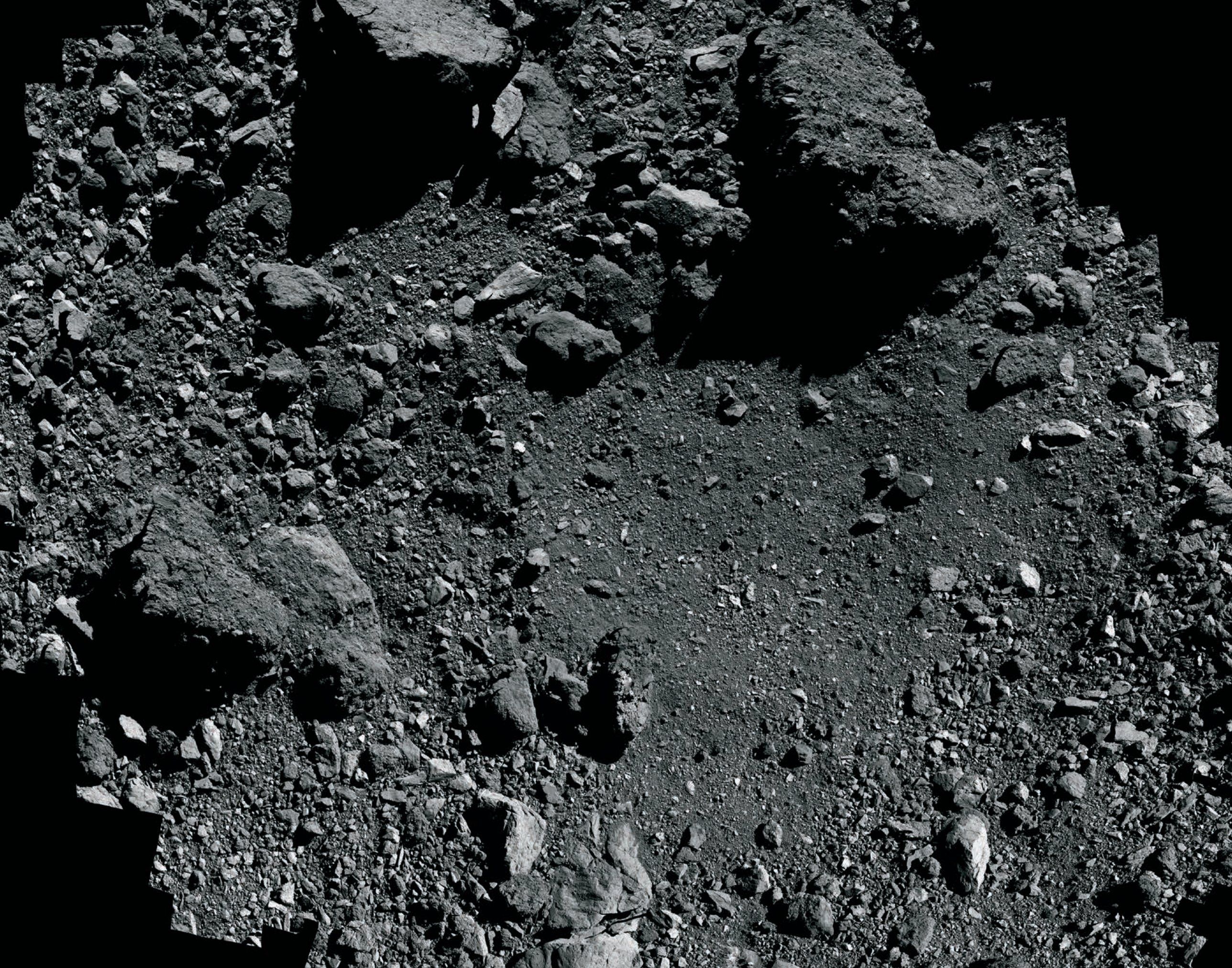
May 2021

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

July 2021

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
		1	2 Last Quarter	3	4	5
6	7	8	9	10 New Moon	11	12
13	14 Flag Day	15	16	17	18 First Quarter	19
20 Father's Day	21	22	23	24 Full Moon	25	26
27	28	29	30			



July 2021

Bird's-Eye View of OSIRIS-REx Sample Site Nightingale. NASA's Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer (OSIRIS-REx) will be the first asteroid-sampling spacecraft to retrieve and return a sample from the carbon-rich asteroid Bennu. The primary sample collection site, named Nightingale, is located within a crater in Bennu's northern hemisphere. This view of Nightingale is a mosaic of 345 PolyCam images collected by OSIRIS-REx on March 3, 2020, when the spacecraft performed an 820-foot (250-meter) reconnaissance pass over the sample site. At the time, this was the closest the sample site had been imaged. Studying these images allowed the OSIRIS-REx team to identify the best location within the site to target for sample collection, with the first collection attempt at Nightingale on October 20, 2020. During sample collection, OSIRIS-REx's sampling mechanism touches Bennu's surface and fires a charge of pressurized nitrogen to disturb the asteroid's surface and collect a sample before the spacecraft backs away. Asteroids are leftover debris from the formation of our solar system, and Bennu is believed to be a carbon-rich asteroid that could contain organic material similar to the molecular precursors that led to the origin of life on Earth. **Image and text credit:** NASA/Goddard Space Flight Center/University of Arizona

https://www.nasa.gov/feature/goddard/2020/osiris-rex-produces-nightingale-mosaic

Born in 1940, **Walter Álvarez** is most known for the theory he developed alongside his father, Nobel Prize–winning experimental physicist Luis W. Álvarez, stating that the extinction of the dinosaurs was caused by an asteroid impact. Álvarez earned a B.A. in geology from Carleton College in 1962 and a Ph.D. in geology from Princeton University in 1967. He then moved to Italy to pursue an interest in archaeological geology and study the volcanoes of Rome and their influence on early Roman times. Álvarez joined the faculty of the University of California, Berkeley, in 1977, where he began a study of the mass extinction of the Cretaceous period as recorded in the Italian limestones. His research led to his hypothesis that the dinosaurs were killed by an asteroid impact, which was later confirmed by discovery of one of the largest impact craters on the planet in the subsurface of the Yucatán Peninsula. Álvarez is the recipient of several prestigious awards, including the Penrose Medal and the Vetlesen Prize. Photo credit: NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute/Henry Throop

June 2021

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

August 2021

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				1 Last Quarter	2	3
4	5 Independence Day (observed date)	6	7	8	9	10 New Moon
11	12	13	14	15	16	17 First Quarter
18	19	20	21	22	23	24 Full Moon
25	26	27	28	29	30	31 Last Quarter

EXPLORE SCIENCE

OPERATING & FUTURE MISSIONS

HUBBLE
WEBB
XMM-NEWTON*
XRISM*
SPHEREX
IXPE
CHANDRA
FERMI
NUSTAR
GEHRELS SWIFT
EUCLID*
TESS
SOFIA
ARIEL*
ROMAN
NEW HORIZONS
JANUS
VOYAGER 1
VOYAGER 2
SOLAR ORBITER*
WIND
THEMIS
PARKER SOLAR PROBE
TIMED
AIM
SUNRISE
MMS
HINODE*
ACE
ICON
GEOTAIL*
GOLD
SET-1
IRIS
BEPICOLOMBO*
SOHO*
PUNCH
SDO
STEREO
IMAP
TRACERS
IBEX
DRAGONFLY
JUICE*
PSYCHE
JUNO
DART
EUROPA CLIPPER
LUCY

NEOWISE

OSIRIS-REX

MARS ODYSSEY

MMX*

MARS EXPRESS*

CURIOSITY

EXOMARS 2016*

MAVEN

EXOMARS 2022*

INSIGHT

ESCAPADE

MRO

PERSEVERANCE

TSIS-2

TEMPO

GLIMR

MAIA

TROPICS

AQUA

BION*

RAD-SEED

CALIPSO

OCO-2

CLOUDSAT

SWOT

PACE

AURA

CLARREO-PF

EMIT

GEDI

ECOSTRESS

LIS

TSIS-1

OCO-3

SAGE III

APH

CELL BIO

MICRO

RR

VEGGIE

SENTINEL-6 MICHAEL FREILICH/B*

ACME

SMAP

CAL

CYGNSS

BECCAL*

PREFIRE

LMM

THEMIS-ARTEMIS

SOFIE

FBCE

GRACE-FO

HERMES

NICER

MSRR

LANDSAT 9

NOVA-C+

LRO

ZBOT

LANDSAT 7, 8

PEREGRINE MISSION ONE+

LUNAR TRAILBLAZER

JPSS-2, 3, 4*

AWE

VIPER

DSCOVR*

LEIA

BIOEXPT-1

NOAA-20*

GPM

ICESAT-2

GEOCARB

SUOMI NPP

NISAR

TERRA

EARTH SCIENCE

HELIOPHYSICS

PLANETARY SCIENCE

ASTROPHYSICS

BIOLOGICAL & PHYSICAL

FUTURE MISSIONS IN BOLD

* PARTNER-LED

+ COMMERCIAL PARTNERSHIP

science.nasa.gov/missions

SEPTEMBER 2020

Tribute to NASA Earth Trailblazer

Dr. Michael Freilich

1954 – 2020

NASA and the entire science community mourn the loss of Dr. Michael Freilich, former Earth Science Division Director and trailblazer. Mike was a force of nature in Earth science for decades, and his loss will be deeply felt.

In January 2020, it was NASA's great privilege to join our European and U.S. colleagues in naming an ocean-observing satellite in his honor, and in that spirit, I want to celebrate Mike's life, accomplishments, and his legacy.

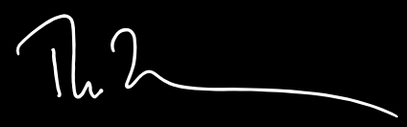
I had the pleasure of serving with Mike during the early days of my tenure as head of NASA Science, and I quickly grew to respect his keen mind and his passion for telling the story of our planet and what we could learn from it as well as about it.

Earth science shows perhaps more than any other discipline how important partnership is to the future of this planet. Mike exemplified the commitment to excellence, generosity of spirit, and unmatched ability to inspire trust that made so many people across the world want to work with NASA to advance big goals on behalf of our planet and all its people. The fact that our European partners gave him the unprecedented honor of naming a mission after him demonstrates that respect and admiration. When Sentinel-6 Michael Freilich launches to study Mike's beloved oceans, he will truly take to the heavens.

Those who worked with Mike respected him. His knowledge and his forthrightness. His willingness to make the hard decisions. These were all characteristics that made him the leader he was. He always wanted to do the right thing—for NASA and for Earth science—and I learned a lot from his example. His strength was in his directness. You always knew where Mike stood! And that counts for a lot, not only in the workplace, but also in science as a whole.

Because of that quality, and the breadth of knowledge backing it up, people across the world trusted Mike. He had high standards and held no one to a harder standard than himself. Many missions launched under Mike's watch, and things happened that wouldn't have been possible if he hadn't been there to push them through, to see that NASA remained true to its spirit of international partnership as we study our home planet—the only one we have!

We've lost a trailblazer, but we will feel his presence as his namesake orbits above us, continually reminding us to be vigilant sentinels, to keep learning, and to keep doing the right thing for each other and our planet. Godspeed, Mike Freilich. You are missed already.



Thomas H. Zurbuchen

Associate Administrator
NASA Science Mission Directorate

2021 Year at a Glance

January

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

February

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28						

March

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

April

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

May

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

June

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

July

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

August

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

September

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

October

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

November

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

December

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

August 2021

Spectacular Aurora Seen from the International Space Station. On August 13, 2016, the International Space Station (ISS) flew over this sparkling aurora display of magenta and green. SpaceX's Dragon resupply vehicle is seen docked to the Earth-facing port of the Harmony module. Such colors get their start at the Sun: The Sun continuously produces a solar wind, a stream of charged particles that continuously flow outward into the solar system. When the solar wind reaches Earth's magnetic field, it can cause magnetic reconnection, an explosive process that allows charged particles from the magnetosphere to accelerate into lower atmospheres. As the particles bombard oxygen and nitrogen in the atmosphere, the atoms release a photon of light that we see as a flash of color. The result: an aurora, and a special sight for the astronauts aboard the ISS. Observing auroras—and discovering what causes them to change over time—gives scientists insight on how our planet's magnetosphere reacts to space weather near Earth. **Image and text credit:** NASA

https://www.flickr.com/photos/nasa2explore/28725341993

Born in 1938, **William Wagner** led solar physics research at NASA from 1990 to 2006 and thus had a direct hand in an entire generation of NASA missions and program creations. His vision helped launch NASA's Living with a Star program, which studies how energy, radiation, and particles outflowing from our Sun influence the space environment around Earth—including driving space weather that can affect astronauts and satellites in space. He worked at the Space Environment Laboratory in Boulder, CO, where he established a continuing series of Solar X-Ray Imagers on the Geostationary Operational Environmental Satellite (GOES) weather satellites to provide 24-hour activity coverage of the Sun. During his tenure at NASA, he was involved with numerous Sun-watching missions. Photo credit: William Wagner

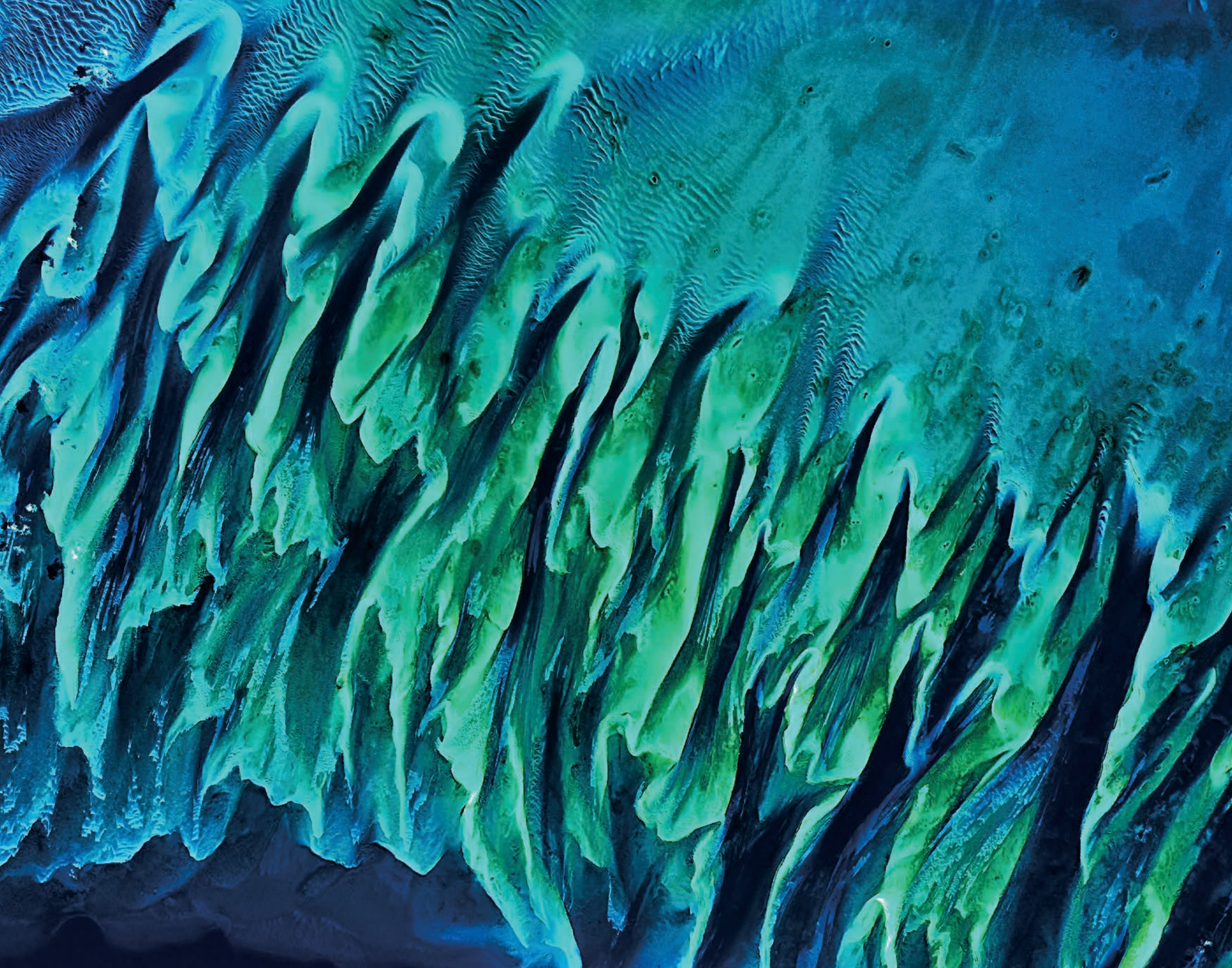
July 2021

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

September 2021

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2	3	4	5	6	7
8 New Moon	9	10	11	12	13	14
15 First Quarter	16	17	18	19	20	21
22 Full Moon	23	24	25	26	27	28
29	30 Last Quarter	31				



September 2021

Great Bahama Bank. The colors and curves of the Great Bahama Bank are composed of white carbonate sand and limestone made up largely of coral fragments. Once dry land during past ice ages, the bank slowly submerged as sea levels rose, and now it is covered by water. Its shapes were formed over time by geologic processes and ocean creatures. The wave-shaped ripples are sand on the sea floor, while the curves follow the shapes of underwater dunes. The blues and greens are sand and seagrass in different quantities and depths. The image above was captured on February 15, 2020, by the Operational Land Imager (OLI) on the Landsat 8 satellite, launched in February 2013. The joint NASA/U.S. Geological Survey (USGS) Landsat program provides the longest continuous space-based record of Earth's land in existence. An earlier Landsat image of this area from 2002 was the winner in NASA's Earth Observatory "Tournament Earth 2020" competition. **Image and text credit:** NASA Earth Observatory image by Joshua Stevens, using Landsat data from USGS

https://earthobservatory.nasa.gov/images/146697/still-sandy-after-all-these-years

Born in 1970, **Paula Bontempi** recently became Dean of the Graduate School of Oceanography at the University of Rhode Island, her alma mater, after serving as Acting Deputy Director of NASA's Earth Science Division. Earlier, Bontempi was Program Manager for Ocean Biology and Biogeochemistry at NASA Headquarters, as well as the Lead for NASA's Carbon Cycle and Ecosystems Focus Area and the agency's Carbon Cycle Science research. Bontempi was Program Scientist for several NASA Earth-observing missions and taught the Earth Science module of the agency's astronaut training class. She began her career as a research intern at the New England Aquarium as an undergraduate at Boston College, later entering the fields of phytoplankton taxonomy and physiology in the Department of Oceanography at Texas A&M University. Bontempi graduated from the University of Rhode Island's Graduate School of Oceanography in 2001 with a Ph.D., spending time during her studies as a research fellow at the Supreme Allied Commander Atlantic (SACLANT) Lab in La Spezia, Italy; in Friday Harbor, Washington; and as a summer intern at NASA's Goddard Space Flight Center. She moved from the faculty at the University of Southern Mississippi's Department of Marine Science to NASA Headquarters in 2003. Photo credit: Paula Bontempi

August 2021

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

October 2021

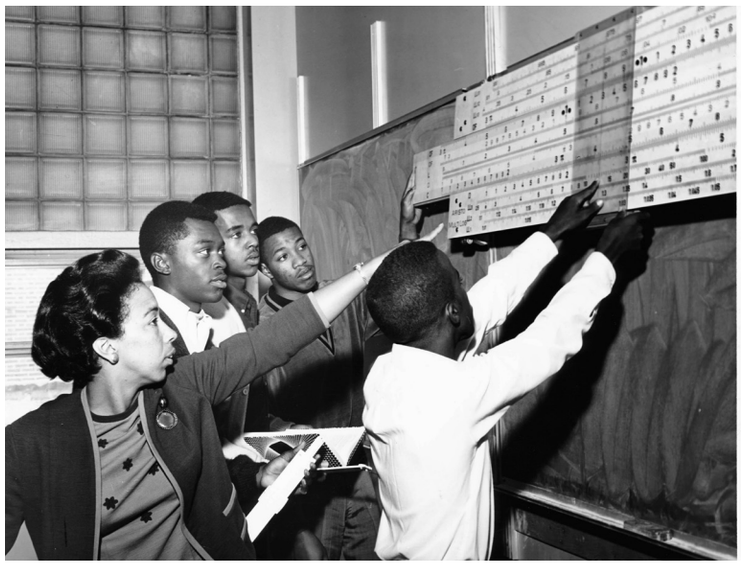
S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			1	2	3	4
5	6 Labor Day	7 New Moon	8	9	10	11
12	13 First Quarter	14	15	16	17 Constitution Day	18
19	20 Full Moon	21	22	23	24	25
26	27	28	29 Last Quarter	30		

October 2021

Juno Captures Io's Shadow on Jupiter. Io is Jupiter's third largest moon and is the most volcanically active world in our solar system, with hundreds of volcanoes, some erupting lava fountains dozens of miles (or kilometers) high. Little is known about Io's characteristics, such as whether a magma ocean exists in its interior. The constant tug-of-war between Jupiter's powerful gravity and the smaller but precisely timed pulls from Europa and Ganymede—two of Jupiter's neighboring moons—results in Io's surface constantly renewing itself, filling in any impact craters with molten lakes of lava. This dramatic image of Io's shadow racing across Jupiter's clouds was captured by NASA's Juno spacecraft on September 11, 2019, as Juno performed its twenty-second close flyby of Jupiter when the spacecraft was about 4,885 miles (7,862 kilometers) from Jupiter's cloud tops. Citizen scientist **Kevin M. Gill** created this enhanced-color image using data from the spacecraft's JunoCam imager. JunoCam's raw images are available for the public online to view and process into image products. **Image and text credit:** NASA/Jet Propulsion Laboratory–California Institute of Technology/Southwest Research Institute/Malin Space Science Systems. Image processing by Kevin M. Gill,

https://www.nasa.gov/image-feature/jpl/moon-shadow



Yvonne Y. Clark (1929–2019) was the first woman to earn a B.S. in mechanical engineering from Howard University in 1951, the first woman to join the faculty of the Tennessee State University (TSU) mechanical engineering department in 1956, and the first woman to earn an M.S. in engineering management from Vanderbilt University in 1972. While at TSU, Clarke chaired the mechanical engineering department from 1965 to 1970, and then again from 1977 to 1988. She also made great efforts to encourage women to pursue degrees in science, technology, engineering, and mathematics (STEM), and she helped found the university's mechanical engineering society, Pi Tau Sigma. Affectionately referred to as "TSU's First Lady of Engineering," Clark taught mechanical engineering in TSU's College of Engineering and Technology for 55 years until she retired as a professor emerita in 2011, working at NASA's Marshall Space Flight Center during summer breaks. Photo credit: Tennessee State University Archives

September 2021

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

November 2021

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
					1	2
3	4	5	6 New Moon	7	8	9
10	11 Columbus Day	12	13 First Quarter	14	15	16
17	18	19	20 Full Moon	21	22	23
24 31	25	26	27	28 Last Quarter	29	30

November 2021

Star-Forming Region LHA 120-N 44. Stars are the most widely recognized astronomical objects and represent the most fundamental building blocks of galaxies. Called LHA 120-N 44, this star-forming region is found toward the southern constellation of Dorado, located in the Large Magellanic Cloud, about 160,000 light-years away from Earth. It features a giant bubble, called a superbubble, that is blowing outward due to high winds flowing off young stars, clustered in the middle of the image. In this composite image, data from NASA's Chandra X-ray Observatory (purple and pink) reveals the superbubble of hot gas, while data from the Hubble Space Telescope (orange and light blue) shows the gas and dust in the system. **Image and text credit:** Enhanced image by Judy Schmidt (CC BY-NC-SA) based on images provided courtesy of NASA/Chandra X-ray Center/Smithsonian Astrophysical Observatory, NASA/Space Telescope Science Institute

https://chandra.harvard.edu/photo/2019/archives

E. Margaret Burbidge (1919–2020) was a British American astronomer who was one of the first to demonstrate how almost all elements are fabricated from hydrogen within stars. She helped develop and utilize the Faint Object Spectrograph for the Hubble Space Telescope. She was elected the first female president of the American Astronomical Society in 1976 and held several other leadership positions, including Director of the Royal Greenwich Observatory, and she was the first Director of the University of California, San Diego's Center for Astrophysics and Space Science. She received several prestigious awards, including the Henry Norris Russell Lectureship and the National Medal of Science. Asteroid 5490 Burbidge was named in her honor, as was the Margaret Burbidge Award of the American Physical Society. Photo credit: Annie Gracy/Wikipedia, CC BY-SA

October 2021

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

December 2021

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	1	2 Election Day	3	4 New Moon	5	6
7 Daylight Saving Time Ends	8	9	10	11 First Quarter Veterans Day	12	13
14	15	16	17	18	19 Full Moon	20
21	22	23	24	25 Thanksgiving Day	26	27 Last Quarter
28	29	30				

December 2021

Mount St. Helens. Satellite observations over the past 40 years have helped scientists understand how the area around Washington state's Mount St. Helens has recovered since it was the site of the deadliest volcanic eruption in U.S. history on May 18, 1980. The above image was captured nearly 40 years after the blast, on April 17, 2020, by the Operational Land Imager (OLI) on Landsat 8, launched in February 2013. Landsat 8 is part of the joint NASA/U.S. Geological Survey (USGS) Landsat program, which began in July 1972. Landsat satellites have been acquiring images of Mount St. Helens for nearly five decades. Over time, researchers have watched green plants and trees on the edge of the volcano move closer to the mountain as the land recovers. **Image and text credit:** NASA Earth Observatory image by Joshua Stevens, using Landsat data from USGS

https://earthobservatory.nasa.gov/images/146735/mount-st-helens

Born in 1940, **John A. Baross** is a professor of oceanography at the University of Washington and Fellow of the American Academy of Microbiology. Baross was one of the first to apply the microbiology of extremophiles to expand our view of habitability in the universe on non-Earth-like planets. His research on thermophilic microorganisms and viruses at volcanic vents, including Mount St. Helens, the Juan de Fuca Ridge, and the Lost City Hydrothermal Field, revealed immense microbial diversity in environments previously thought to be too extreme for life. He wrote one of the first papers that outlined the case for life's origins at submarine hydrothermal vents. He served on numerous national and international planetary protection committees and chaired the NASA-sponsored study by the National Academy of Sciences that examined the possibility of "weird life" based on alternative options for building blocks, solvents, and chemistry necessary for life as we know it. He was one of the founding members of the University of Washington Astrobiology program, one of the top-ranked programs in the world. He mentored eleven doctoral students and trained many other graduates, undergraduates, and postdoctoral trainees, many of whom are now the next generation of leaders in astrobiology. Photo credit: National Geographic/John Marshall

November 2021

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

January 2022

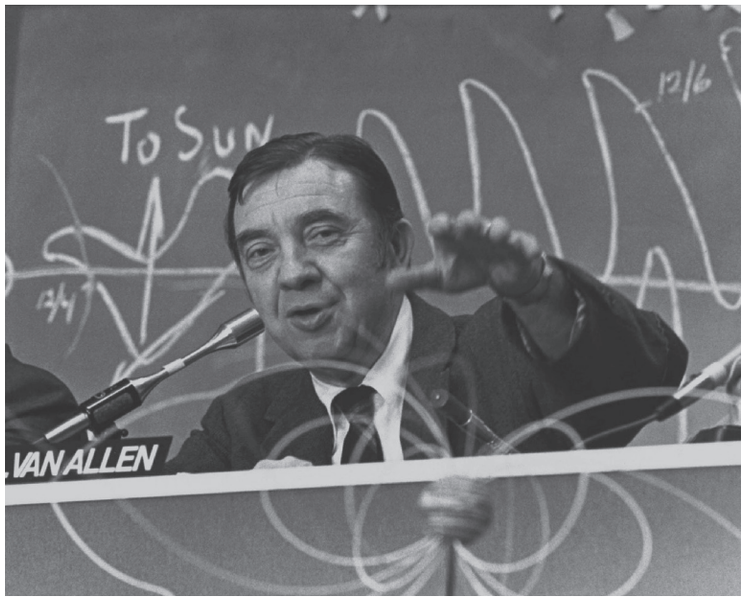
S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			1	2	3	4 New Moon
5	6	7	8	9	10	11 First Quarter
12	13	14	15	16	17	18
19 Full Moon	20	21	22	23	24 Christmas Day (observed date)	25
26	27 Last Quarter	28	29	30	31 New Year's Day 2022 (observed date)	

January 2022

Solar Orbiter Launch Takes Solar Science to New Heights. Pictured above, the Solar Orbiter—an international collaboration between the European Space Agency (ESA) and NASA to study our closest star, the Sun—launched on February 9, 2020, at 11:03 p.m. local time on a United Launch Alliance Atlas V rocket from Cape Canaveral Air Force Station in Florida. The mission uses Venus's and Earth's gravity to swing itself out of the ecliptic plane—the swath of space, roughly aligned with the Sun's equator, where all planets orbit. From there, Solar Orbiter's bird's-eye view will give us the first-ever look at the Sun's poles. Like Earth's own North and South poles, the Sun's poles are extreme regions quite different from the rest of the Sun. They can be covered in coronal holes, cooler stretches of the solar atmosphere, which spawn a flow of fast solar wind. There, scientists hope to find the footprints of knotted magnetic fields that are key to understanding the waxing and waning of solar activity—periods of time when explosions of light, energy, and giant clouds of solar material can erupt from the Sun out into space. Studying the activity around the Sun's poles will help scientists better understand the behavior of the Sun's magnetic field, which in turn affects the environment of the entire solar system. **Image and text credit:** Jared Frankle, NASA Solar Orbiter Social Participant

https://www.nasa.gov/press-release/solar-orbiter-launch-takes-solar-science-to-new-heights



James A. Van Allen (1914–2006) is most widely known for his contribution to the discovery of the radiation belts that circle Earth, now known as the Van Allen Belts. He graduated with a Ph.D. in nuclear physics from the University of Iowa in 1936 and was the principal investigator for 24 missions. A cosmic ray–detecting device developed by Van Allen and his colleagues was launched into space on the very first satellite ever put into space by the United States—Explorer 1. Explorer 1 discovered the radiation belts in the upper atmosphere that were later named for Van Allen. Photo credit: NASA

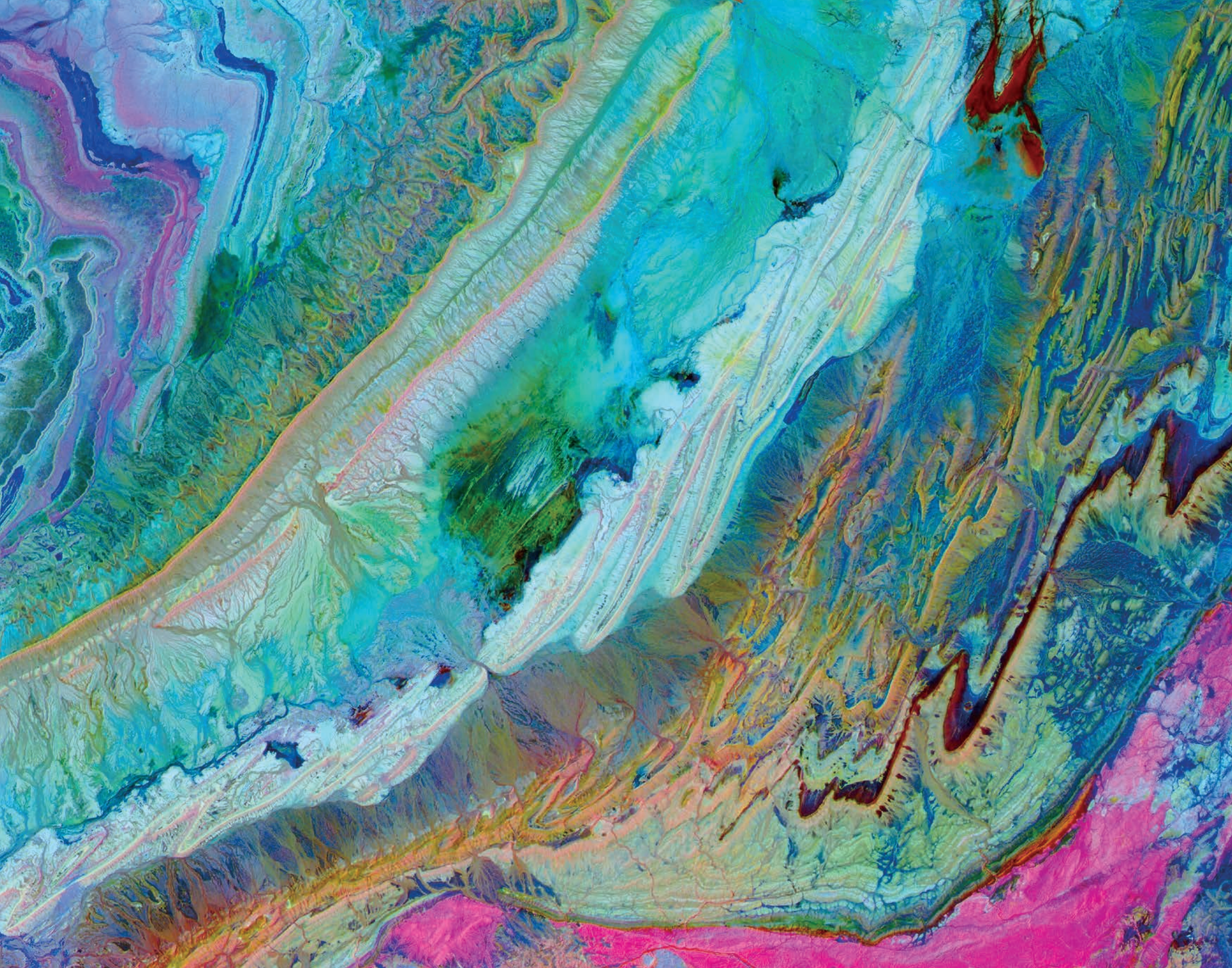
December 2021

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

February 2022

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28					

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
						1 New Year's Day (observed date)
2 New Moon	3	4	5	6	7	8
9 First Quarter	10	11	12	13	14	15
16	17 Full Moon Birthday of Martin Luther King, Jr. (observed date)	18	19	20	21	22
23 30	24 31	25 Last Quarter	26	27	28	29



February 2022

Morocco's Anti-Atlas Mountains. When the African and Eurasian tectonic plates collided about 80 million years ago, the Tethys Ocean was destroyed. The ocean bed's limestone, sandstone, claystone, and gypsum layers were folded and crumpled together to form the Anti-Atlas Mountains in Northwest Africa. In this false-color image of southwest Morocco from November 5, 2007, the different rock types are highlighted by combining the visible, near-infrared, and short-wave infrared bands collected by the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) instrument on NASA's Terra satellite, one of the oldest satellites in the Earth Science Division's fleet, launched in December 1999. In 2019, Terra, designed to operate for six years, marked 20 years of Earth observations from space. **Image and text credit:** NASA/Ministry of Economy, Trade, and Industry (METI)/Advanced Information Systems Technology (AIST)/Japan Space Systems; and U.S./Japan ASTER Science Team

https://www.nasa.gov/image-feature/moroccos-anti-atlas-mountains

Born in 1969, **J. Marshall Shepherd** is the Georgia Athletic Association Distinguished Professor of Geography and Atmospheric Sciences at the University of Georgia (UGA). Shepherd is Director of the UGA Atmospheric Sciences Program and a full professor in the Department of Geography, in which he earlier was Associate Department Head. Host of The Weather Channel's award-winning *Weather Geeks* show and podcast, Shepherd is also a senior contributor to *Forbes* magazine and is called upon frequently as a climate and weather expert by national media and government officials. Shepherd is a past president of the American Meteorological Society and the recipient of myriad awards recognizing his achievements in research and teaching, including the Presidential Early Career Award, presented to him in 2004 by President George W. Bush; the 2020 Mani L. Bhaumik Award for Public Engagement with Science from the American Association for the Advancement of Science; and the Climate Communications Prize from the American Geophysical Union. For 12 years before joining UGA, Shepherd was a research meteorologist at NASA's Goddard Space Flight Center and served as Deputy Project Scientist for the Global Precipitation Measurement (GPM) mission. He has leadership and membership roles on the boards and advisory committees of government agencies, nonprofits, and professional organizations. In addition to being past editor of the *Journal of Applied Meteorology and Climatology* and *Geography Compass*, Shepherd co-authored *Dr. Fred's Weather Watch,* a children's book about weather and weather instruments. Shepherd received a B.S., M.S., and Ph.D. in physical meteorology from Florida State University, where he was the first African American to earn a doctorate from the Department of Meteorology. Photo credit: UGA Photographic Services

January 2022

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

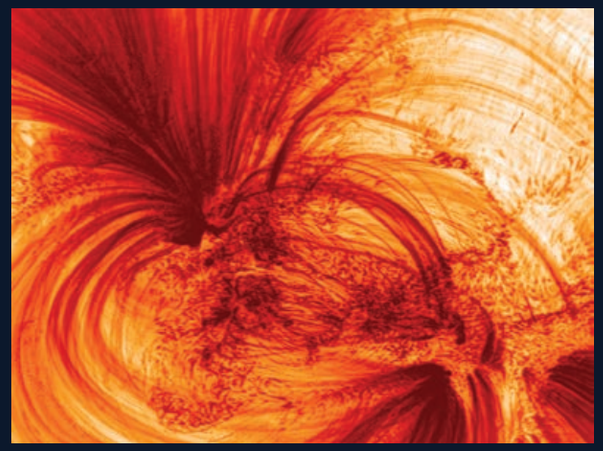
March 2022

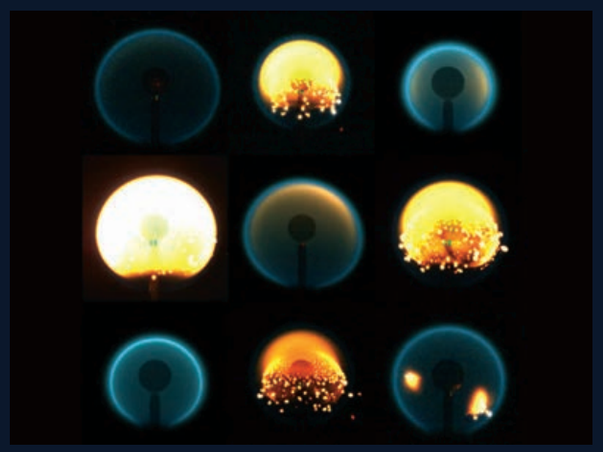
S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

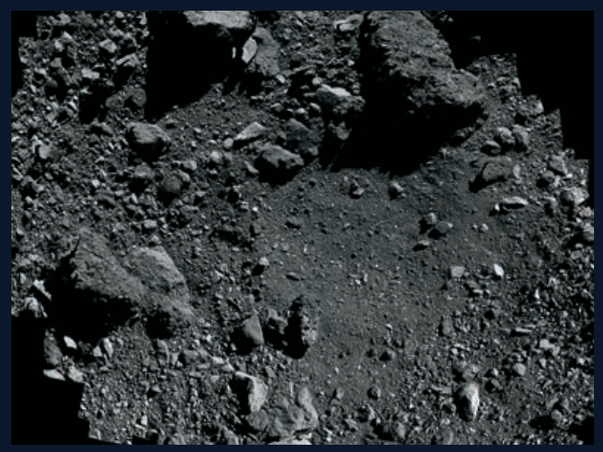
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
		1 New Moon	2	3	4	5
6	7	8 First Quarter	9	10	11	12
13	14	15	16 Full Moon	17	18	19
20	21 Washington's Birthday (observed date)	22	23 Last Quarter	24	25	26
27	28					

National Aeronautics and
Space Administration














EXPLORE SCIENCE

NP-2020-08-2890-HQ