National Aeronautics and Space Administration

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Tatooine-like Star System

Kepler 47 is a binary star system with two planets, one in the habital zone.

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April 2018

A Star

A star is type of astronomical object consisting of a luminous spheroid of plasma held together by its own gravity.

Image credit: ESA/Hubble & NASA

A Star Cluster

A star cluster is a group of stars that share a common origin and are gravitationally bound for some length of time.

Image credit: X-ray: NASA/CXC/PSU/L. Townsley et al; Optical: UKIRT; Infrared: NASA/JPL-Caltech

Binary Star Systems: Classification and Evolution

By Space.com | Staff | January 17, 2018

More than four-fifths of the single points of light we observe in the night sky are actually two or more stars orbiting together. The most common of the multiple star systems are binary stars, systems of only two stars together. These pairs come in an array of configurations that help scientists to classify stars, and could have impacts on the development of life. Some people even think that the sun is part of a binary system.

Binary classifications

Binary stars are two stars orbiting a common center of mass. The brighter star is officially classified as the primary star, while the dimmer of the two is the secondary (classified as A and B respectively). In cases where the stars are of equal brightness, the designation given by the discoverer is respected.

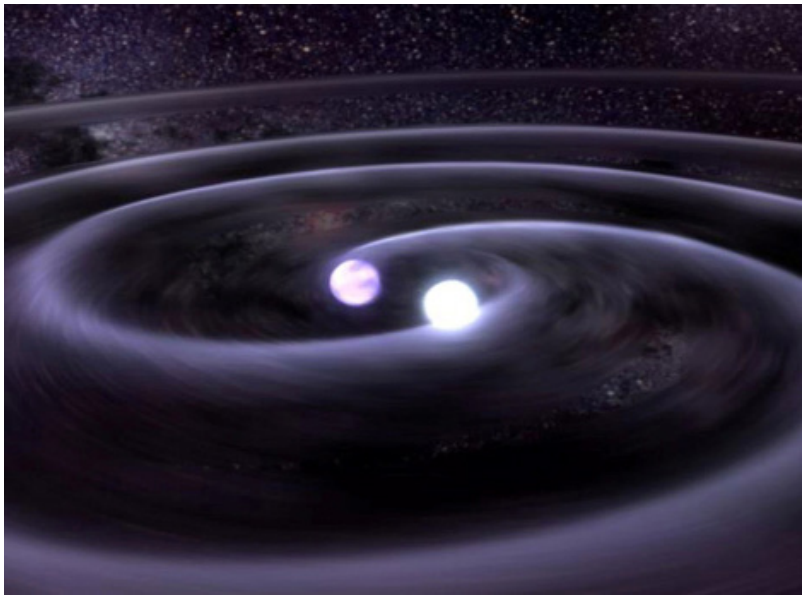
Binary pairs can be classified based on their orbit. Wide binaries are stars that have orbits that keep them spread apart from one another. These stars evolve separately, with very little impact from their companions. They may have once contained a third star, which booted the distant companion outward while eventually having been ejected themselves.

Close binaries, on the other hand, evolve nearby, able to transfer their mass from one to the other. The primaries of some close binaries consume the material from their companion, sometimes exerting a gravitational force strong enough to pull the smaller star in completely. [Infographic: How 'Tatooine' Planets Orbit Twin Stars of Kepler-47]

The pairs can also be classified based on how they are observed, a system that has overlapping categories. Visual binaries are two stars with a wide enough separation that both can be viewed through a telescope, or even with a pair of binoculars. Five to 10 percent of visible stars are visual binaries.

Spectroscopic binaries appear close even when viewed through a telescope. Scientists must measure the wavelengths of the light the stars emit and determine their binary nature based on features of those measurements.

Eclipsing binaries are two stars whose orbits are at an angle so that, from Earth, one passes in front of the other, causing an eclipse. This feature is based on the line of sight rather than any particular feature of the pair.



In the binary system J0806, two white dwarf stars orbit one another every 321 seconds. Scientists think the stars, about 1,600 light-years away, are spiraling in toward one another and will eventually merge.

Credit: NASA/Tod Strohmayer (GSFC)/Dana Berry (Chandra X-Ray Observatory)

Astrometric binaries are stars that seem to dance around an empty space; that is, their companions cannot be identified but only inferred. Such a companion may be too dim to be seen, or could be hidden in the glare from the primary star.

Stars referred to as double stars are two that appear close together in the sky visually, but are not necessarily anywhere near one another in space.

Discovery and evolution

The first binary stars seen were visual binaries. In 1617, at the request of a fellow scientist, Galileo Galilei turned his telescope toward the second star from the end of the handle of the Big Dipper, discovering that one star seemed to be two; ultimately it turned out to be six. In 1802, Sir William Herschel, who cataloged about 700 pairs of stars, first used the term "binary" in reference to these double stars.

Stars travel around the galaxy, and sometimes a massive star captures a passing one, creating a new binary pair. But this is a rare event. More commonly, the envelope of gas and dust that collapses in on itself to form a star splits and forms two or more stars instead. These stars evolve together, though not necessarily identically.

How a pair of stars evolve depends on their distance from each other. Wide binaries have very little effect on each other, and so they often evolve much like single stars. Close binaries, however, impact each other's evolution, with mass transfers changing the composition of the stars. If one star in a close binary system explodes in a supernova or sheds its outer layers and forms a pulsar, often the companion is destroyed. If it survives, it continues to orbit the newly formed body, perhaps passing on more of its material.

Binary star systems provide the best means for scientists to determine the mass of a star. As the pair pulls on each other, astronomers can calculate the size, and from there determine characteristics such as temperature and radius. These factors help characterize single main sequence stars in the universe.

In 2015, astrophysicist Paul Sutter — a research fellow with the Astronomical Observatory of Trieste — wrote on Space.com that it seems unlikely that life could exist in most binary systems.

"While binary systems certainly have a habitable zone, where liquid water could potentially exist on the surface of a planet, life might find it difficult to gain a foothold. Orbiting two stars at once, as our friend Kepler-47c does, makes life very elliptical, occasionally bringing the planet out of the zone. Life doesn't take too kindly to frequently freezing over," he wrote.

"Orbiting just one star in a binary system? Well, sometimes you'll have two stars in your sky at once, which can be a tad toasty. And sometimes you'll have a star on each face of the planet, ruining the night. And don't forget the double-doses of UV radiation and solar flares. With that kind of instability, erraticism and irradiation, it's hard to imagine complex life evolving with the kind of regularity it needs."

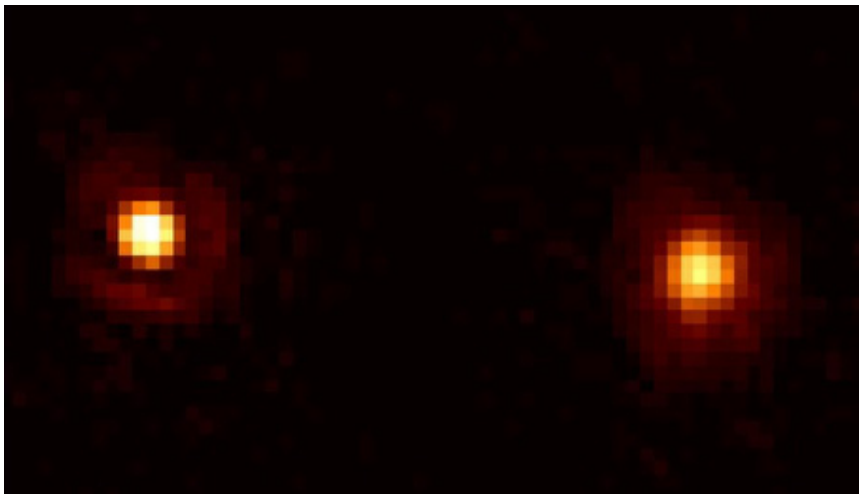
The closest star system to Earth — Alpha Centauri — includes a binary pair of stars, Alpha Centauri A and Alpha Centauri B. The third star, Proxima Centauri, is roughly one-fifth of a light-year away (roughly 13,000 sun-Earth distances; some astronomers debate whether Proxima Centauri should be considered part of the same system.) While no stars in the habitable zone have been found in the binary star part of Alpha Centauri, the planet Proxima Centauri b was announced in 2016 in the habitable region of its star. However, scientists are divided as to whether a red dwarf star such as Proxima Centauri has stable enough "space weather" to prevent radiation or heat surges diminishing the chance for life on a nearby planet.

Stars in multiple systems can have a direct impact on life. A host of planets have already been found orbiting multiple stars. The orbit of these stars can affect the evolution of life, which needs a relatively stable system to develop in. Though binary and multiple systems appear initially daunting, given that one or more stars are constantly moving closer and farther from the planets and changing the amount of light, heat and radiation they receive, systems such as wide binaries or close binaries could actually produce conditions where life could eventually evolve. [9 Exoplanets That Could Host Alien Life]

Is the sun a binary star?

In the 1980s, scientists suggested the presence of Nemesis, a second star — either a brown dwarf, dim red dwarf or white dwarf — in the sun's system as a reason behind the periodic mass extinctions that occurred in Earth's history, which some paleontologists suggest have occurred in 26-million-year cycles, though the cyclical nature is under debate.

In 2010, NASA's Wide-field Infrared Survey Explorer (WISE) began searching for brown dwarfs, though it isn't searching specifically for one in the solar system. But if a companion exists, WISE should turn it up. Neither WISE nor the Two Micron All Sky Survey has turned up signs of a companion, and on NASA's "Ask an Astrobiologist," David Morrison, an astrobiology senior scientist, stated that such an object would have been clearly detected by these sensitive telescopes.



The red giant star Mira A (right) and its companion, a close binary pair.

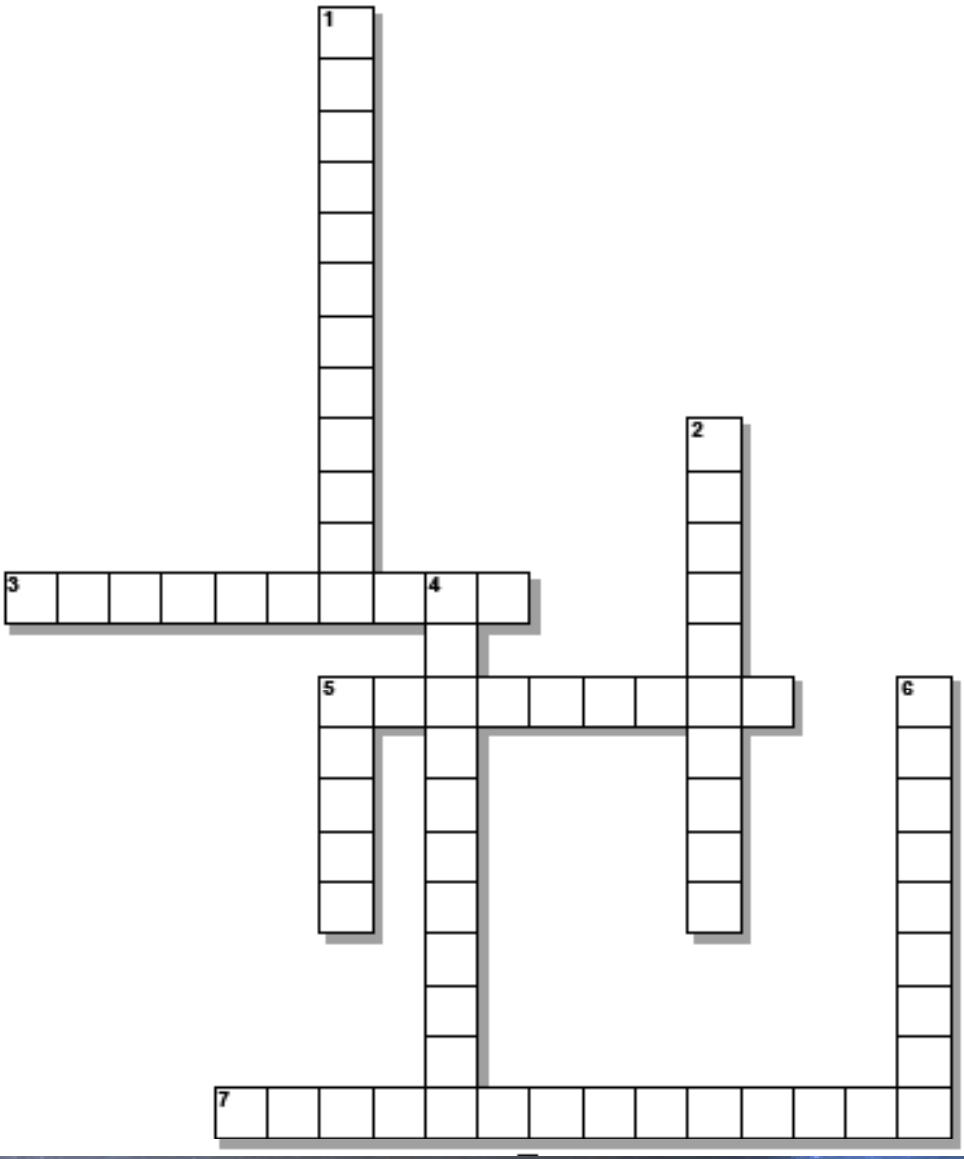
Credit: Margarita Karovska (Harvard-Smithsonian Center for Astrophysics) and NASA

In 2017, a study showed that almost every star like the sun likely had a companion when they were born. A survey using the Very Large Array in New Mexico and the James Clerk Maxwell Telescope in Hawaii examined dozens of systems and found that the younger ones generally had a wide separation, and the older ones had a narrow separation.

Modeling suggested that most stars would form with a distance between them, and then either move closer together or drift apart, breaking gravitational bonds. In the case of the sun, it's still unclear if Nemesis did exist. If it had, the sun's sibling likely moved away billions of years ago.

Some scientists suggest that there is evidence out there for a Nemesis. Evidence they cite includes the distant orbit of dwarf planet Sedna, the well-defined edge of the Kuiper Belt (a debris disk in our solar system), and the orbits of objects in the Oort Cloud (icy rocks beyond Pluto's orbit).

Separately, there are research teams pursuing the track of a purported "Planet Nine" ice giant planet that is at the edge of our solar system. In 2016, Konstantin Batygin and Mike Brown (both researchers at the California Institute of Technology) stated that Planet Nine may be altering the orbits of objects in the Kuiper Belt.



Across:

3 the name of our galaxy "cluster
5 another word for moon
7 patterns of several stars that form a shape in the night sky

Down:

1 scientific equipment used to detect various wavelenghts of light from the electromagnetic spectrum
2 on type of galaxy system
4 a type of electromagnetic wave that is emitted by our Sun
5 how galaxies are classified
6 the shortest frequency and hightest electromagnetic waves - very dangerous to living things

Look Skywatcher! Twin Suns of Real-Life 'Tatooine' Planet Visible in Binoculars

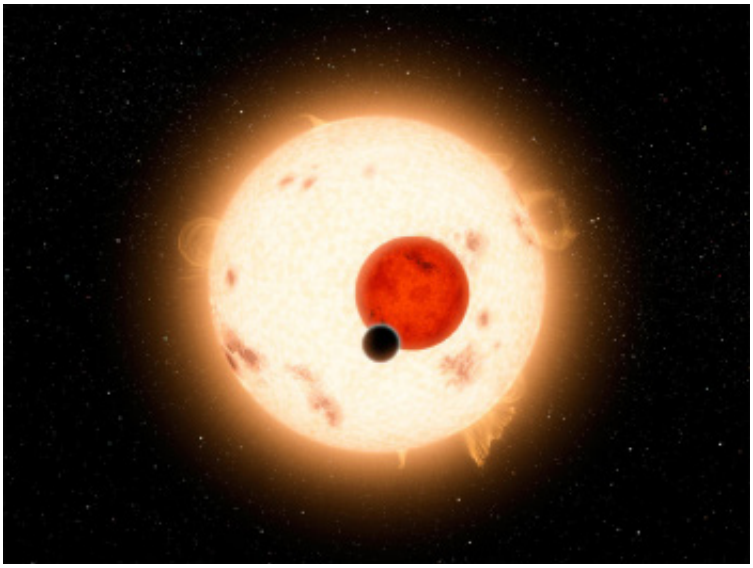
By Mike Wall, Space.com | Senior Writer | September 15, 2011

Scientists have spotted a real-life Tatooine — a world with two suns, like Luke Skywalker's home planet in the "Star Wars" films — and you should be able to see this alien star system, too, using a good pair of binoculars.

Astronomers announced the discovery of the alien planet, called Kepler-16b, today (Sept. 15). The Saturn-mass planet orbits a pair of stars known as Kepler-16A and Kepler-16B. Someone on Kepler-16b would see two suns hanging near each other in the sky, just as Luke did on Tatooine.

The Kepler-16 star system is just 200 light-years from Earth, in the constellation Cygnus (the Swan). Because it's so close, it should be visible to many amateur skywatchers, researchers said.

The sky map of Cygnus here shows the constellation as it currently appears high overhead at night.



NASA's Kepler mission has discovered a world where two suns set over the horizon instead of just one. The planet, called Kepler-16b, is not thought to be habitable. It is a cold world, with a gaseous surface, and it circles two stars, just like "Star Wars" Tatooine.

Credit: NASA/JPL-Caltechsunstar.jpg

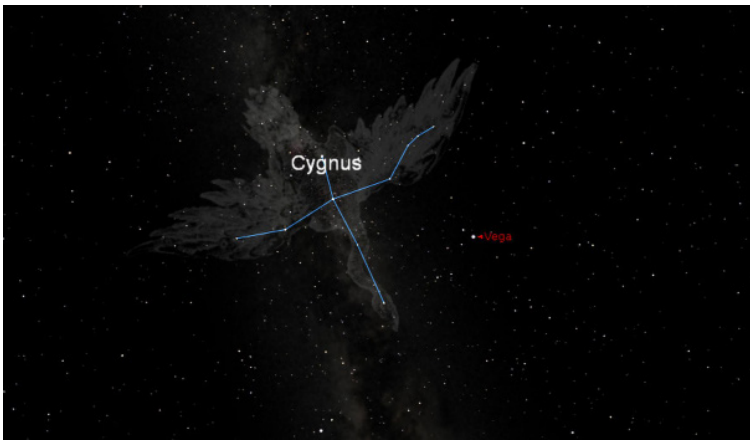
"If you want to find Kepler-16, it's 11 1/2 -magnitude," Laurance Doyle of the Search for Extraterrestrial Intelligence (SETI) Institute, lead author of the paper announcing the discovery of Kepler-16b, told reporters today. "You could probably squint and see it through binoculars." (On an astronomer's scale, lower magnitudes represent brighter objects.)

Cygnus has three stars in its right wing, Doyle said. The key is to find the bright star in the middle, called Iota 2 Cygni, which shines with a magnitude of about 3.

"If you can find that, you're within 1 1/2 degrees of Kepler-16b," Doyle said. The width of your clenched fist held at arm's length covers about 10 degrees. [The Strangest Alien Planets]

Seeing the point of light representing the Kepler-16 system would be neat enough. But next year, amateur astronomers may actually get to spot the newfound alien planet Kepler-16b — or, at least, see some evidence of the existence of this circumbinary planet.

NASA's Kepler space telescope detected the exoplanet by noticing the telltale dips in brightness caused when Kepler-16b passed in front of its parent stars. It will make another transit on June 28, 2012, dimming the star Kepler-16A by about 1.7 percent, according to Doyle.



This sky map shows the configuration of stars in the constellation Cygnus (the Swan), which currently appears overhead in the night sky. The bright star Vega is identified as a reference star. The binary Kepler-16 star system, which is home to the Tatooine-like planet Kepler-16b, can be found with telescopes and binoculars within the constellation.

Credit: Starry Night Software

The transit will occur during daylight hours in the United States and Europe — but much of Asia will be invitingly dark.

"That will be visible from China, India, Russia, Korea and Japan and so on," Doyle said. "So if you're an amateur and you want to detect the first transit since the discovery of a circumbinary planet, you can go to the northeastern hemisphere of Earth."

A 1.7 percent drop in a star's brightness is something amateurs with a decent telescope and CCD (charge-coupled device) imager can pick up, Doyle said. Off-the-shelf versions of this equipment would be fine, he added.

You can follow SPACE.com senior writer Mike Wall on Twitter: @michaeldwall. Follow SPACE.com for the latest in space science and exploration news on Twitter @Spacedotcom and on Facebook.

Star Quiz: Test Your Stellar Smarts

The closest star to the sun is:
A. Alpha Centauri A
B. Star Light, Star Bright
C. Proxima Centauri

2. Stars are made primarily of:
A. The will to succeed
B. Helium and Carbon
C. Hydrogen and helium

3. Which of the following is NOT a known type of star:
A. Green dwarf
B. Red giant
C. White dwarf

4. The sun is currently categorized as a:
A. Main-sequence star
B. Shooting star
C. Red giant star

5. Which quality determines whether a star will become a black hole when it dies:
A. Its attitude
B. Its temperature
C. Its mass

6. When a star runs out of fuel for nuclear fusion and dies in an explosion, it's called a:
A. Supernova
B. Tantrum
C. Standard Candle

7. The class of stars that lose mass rapidly as it flies off in a stellar wind is called:
A. Wolf-Rayet Stars
B. Cepheid Stars
C. Dieting Stars

8. How many stars are in our Milky Way galaxy?
A. 300 million
B. 300 billion
C. Too many

9. What is a globular cluster?
A. A venereal disease
B. A spherical group of stars bound together by gravity
C. A condensation of heavy metal elements in a star's core

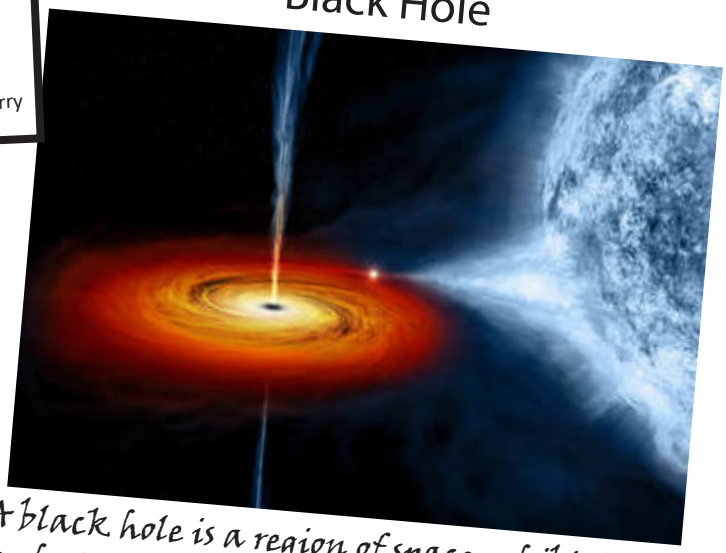
10. The brightest star in the night sky is:
A. The North Star
B. Star Trek
C. Sirius

Neutron star

Neutron stars are created when giant stars die in supernovas and their cores collapse, with the protons and electrons essentially melting into each other to form neutrons.

Credit: NASA/Dana Berry

Black Hole



A black hole is a region of space exhibiting such strong gravitational effects that nothing—not even particles and electromagnetic radiation such as light—can escape.

Credits: NASA/CXC/M.Weiss

Quasar

A quasar is an active galactic nucleus of very high luminosity. A quasar consists of a supermassive black hole surrounded by an orbiting accretion disk of gas.

Credit: ESO/M. Kornmesser

2 TRILLION AND COUNTING

NASA/ESA/S. Beckwith(STScI) and The HUDF Team

Hubble shows our observable universe contains 10 times more galaxies than previously thought.

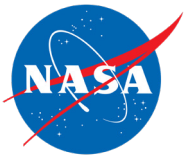
The universe suddenly looks a lot more crowded, thanks to observations from NASA's Hubble Space Telescope and other observatories. Astronomers have found that there are at least 10 times more galaxies in the observable universe than they once thought! Most of these galaxies were relatively small and faint in the early universe. They had masses similar to those of the **satellite galaxies** surrounding our Milky Way. As they merged to form larger galaxies, **the population densities of galaxies** in space decreased. So just how many galaxies does our universe contain? That's one of the most fundamental questions in astronomy! The Hubble Deep Field images, such as the Ultra-Deep Field image above, gave us the first real understanding of just how many galaxies exist in the universe. These observations revealed a number of faint galaxies. This led astronomers to estimate that the **observable universe** contained about 200 billion galaxies. This new finding shows this estimate is at least 10 times too low! Space telescopes, such as Hubble, NASA's James Webb Space Telescope (set to launch in 2018) and other observatories, allow us to peer into our universe's past and piece together what it once looked like billions of years ago.

Words To Know

Satellite galaxy: a galaxy that orbits a larger galaxy due to gravitational forces.

Population density of galaxies: The number of galaxies in a particular volume.

Observable universe: Region of the universe that may be observed from Earth at the present time.



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Misson: TESS Target: Exoplanets

NASA's search for planets outside of our solar system has mostly involved very distant, faint stars. Because they are so dim, planets around faint stars are harder to study more closely because they require a lot of telescope time to get a good measurement. However, NASA's upcoming Transiting Exoplanet Survey Satellite (TESS) mission will solve this problem by looking at the brightest stars in our own solar neighborhood.

TESS is scheduled to launch no earlier than March 2018. After launch, it will quickly start discovering new exoplanets that groundbased observatories, the Hubble Space Telescope and, later, the James Webb Space Telescope, will target for follow-up studies. Planets around closer, brighter stars are ideal for follow-up study because they'll produce stronger signals than planets around more distant stars.

By surveying the entire sky over two years, TESS will do the initial roundup of nearby exoplanets, with the potential to identify thousands during its prime mission. One of TESS' main science goals is to identify 50 rocky worlds, like Earth or Venus, whose masses can be measured through follow-up observations.

Follow-up observations from space- and ground-based telescopes will study what the exoplanets' atmospheres are like.

Using a technique known as spectroscopy, the telescopes will look at the chemical signatures of the light passing through an exoplanet's atmosphere.

These signatures can tell scientists what chemicals are in the planetary atmosphere, and how abundant they are. Knowing this information, scientists can then compare the atmospheres of distant rocky worlds with the atmospheres of the rocky worlds in our own solar system: Earth, Venus and Mars. Together, these observations will help scientists determine whether some planets could potentially support life.

Image credit: Mark Garlick, markgarlick.com

Interview with Chief Scientist, Dr. Ellen Stofan

NASA Chief Scientist…pretty cool title, right? The office represents all the scientific endeavors at NASA, ensuring they're aligned with and fulfilling the administration's science goals. After more than three years as Chief Scientist, Ellen Stofan is departing for new adventures. We caught up with her to ask 10 questions about her role and what she will miss most after she leaves the agency. Take a look…

1) What were some of your expectations coming in as NASA's chief scientist?

When I started as Chief Scientist, all I knew is that I would be science advisor to the Administrator, Charlie Bolden, overseeing the agency's science portfolio. What I did not realize at the time was the degree that I would be impressed by him.

Charlie is an amazing leader who deeply cares about each and every person at this agency. He makes everyone feel valued. That is why NASA has just been voted by our employees for the fifth straight year as the Best Place to Work in the federal government!

2) What do you think it the next big thing for NASA science?

Looking across our science portfolio, I think the most exciting area, which actually connects everything we do, is the search for life beyond Earth. People have long wondered if we are alone, and we are now actually going to answer that question in the next few decades. We are exploring Mars, where it is very likely that life evolved at around the same time life evolved here on Earth. Conditions on Mars deteriorated after about a billion years, so life either went underground, or became extinct. It will likely take future Mars astronauts to find the best evidence of Mars life.

We also are planning to explore the ocean worlds of the outer solar system, like Europa, where we might find life in subsurface oceans. Beyond our solar system, the thousands of planets discovered by the Kepler Space Telescope have made me very optimistic that we are close to finding an Earth 2.0—though that will take us a little longer.

3) NASA science rewrites textbooks all the time. What is something you've seen here that has the potential to occur in the future that will change the textbooks for kids of tomorrow?

For kids 16 and under today, for every day of their life, we have been living and working in space on board the International Space Station. Now we are ready to take that next step in the coming decade, to move humans beyond low-Earth orbit where we have been for such a long time, out to the vicinity of the moon and then on to Mars.

These kids are the "Mars generation," and the exploration of Mars will change our outlook in profound ways, from looking back at Earth – that will just look like another star – to finding evidence of life beyond Earth. So it will not just change science textbooks, it will change how we look at ourselves when we become a multi-planetary species.

4) Behind every pretty space image is a team of scientists who analyze all the data to make the discovery happen. What do you wish the public knew about the people and work that goes into each of those pretty pictures?

It really does take a team. When I go out and talk to school kids, I tell them learning how to be a good member of a team is so important in life. You need to learn to be a leader and a follower, and above all a listener. Our teams at NASA are becoming more and more diverse, which is incredibly important. If everyone looks the same and comes from the same background, they are likely to approach problems the same way. And when you are trying to do tough things – from addressing climate change to sending humans to Mars – you need the best team, which means a diverse team.

5) We have a lot of opportunities for citizen science. What's one opportunity you wish everyone knew about that they could get involved with at NASA?

Go to www.nasa.gov/solve where you can find all kinds of great opportunities to join us at NASA in searching for planets around other stars, exploring Mars, helping us gather data about this planet, and tackling technology challenges. We really are stronger together, and getting the public involved in what we do is helping us get more good science every day. Even more importantly, it lets people know that science is fun!

6) What changes did you make at the agency while you were there?

As Chief Scientist, I got to work on a lot of fun challenges, from our strategy on how to get humans to Mars, to learning about and promoting the research we do every day on the International Space Station. But one of the things that I am most proud of is that, working with my team, NASA now collects voluntary demographic data on all of our grant proposals. Implicit or unconscious bias is all around us; we may act on deep-seated biases that we don't even know we have. The first step in dealing with bias is seeing if you have a problem, and that is what the data collection will tell us.

7) You worked a lot with kids as the agency's Chief Scientist. How important do you feel STEM education is for NASA?

We need the next generation of scientists, doctors, computer programmers, technologists and engineers, and NASA provides the inspiration and hands-on activities that help get kids interested in science. Because of climate change, we are facing rising sea levels, changing patterns of agriculture, and changing weather. We need good engineers and scientists to help us mitigate the effects of climate change and reduce carbon emissions.

On top of that, we live in a society that is dependent on technology; I don't think most of us can go very long without checking our smartphones. But as technology becomes more complex, we need everyone in society to have at least a basic understanding of it, and that's where the importance of STEM education comes in. We are ALL consumers of science and technology. We all need to be informed consumers.

8) What solar system destination are you still most excited/eager for NASA to still go explore?

As a planetary geologist, I am most excited by one of the ocean worlds of the outer solar system. Titan, one of Saturn's moons, is an amazing little world where it rains, and the liquid forms rivers, lakes and seas. But this liquid is actually liquid methane and ethane –basically gasoline, rather than water – due to the extremely cold temperatures out by Saturn.

Titan is an excellent place to explore to help us better understand how oceans and atmospheres interact, and maybe even understand more about the limits of life. We think water is critical to the evolution of life, but Titan may tell us that having a liquid is the most important factor.

9) What will you miss most?

It's the people of NASA whom I will miss the most. Everyone I work with is so committed to the mission of this agency—pushing back the frontiers of science and technology to accomplish great things for the nation. NASA represents the best of this country. We demonstrate that with hard work and determination, we can explore the universe, our galaxy, our solar system and our home planet.

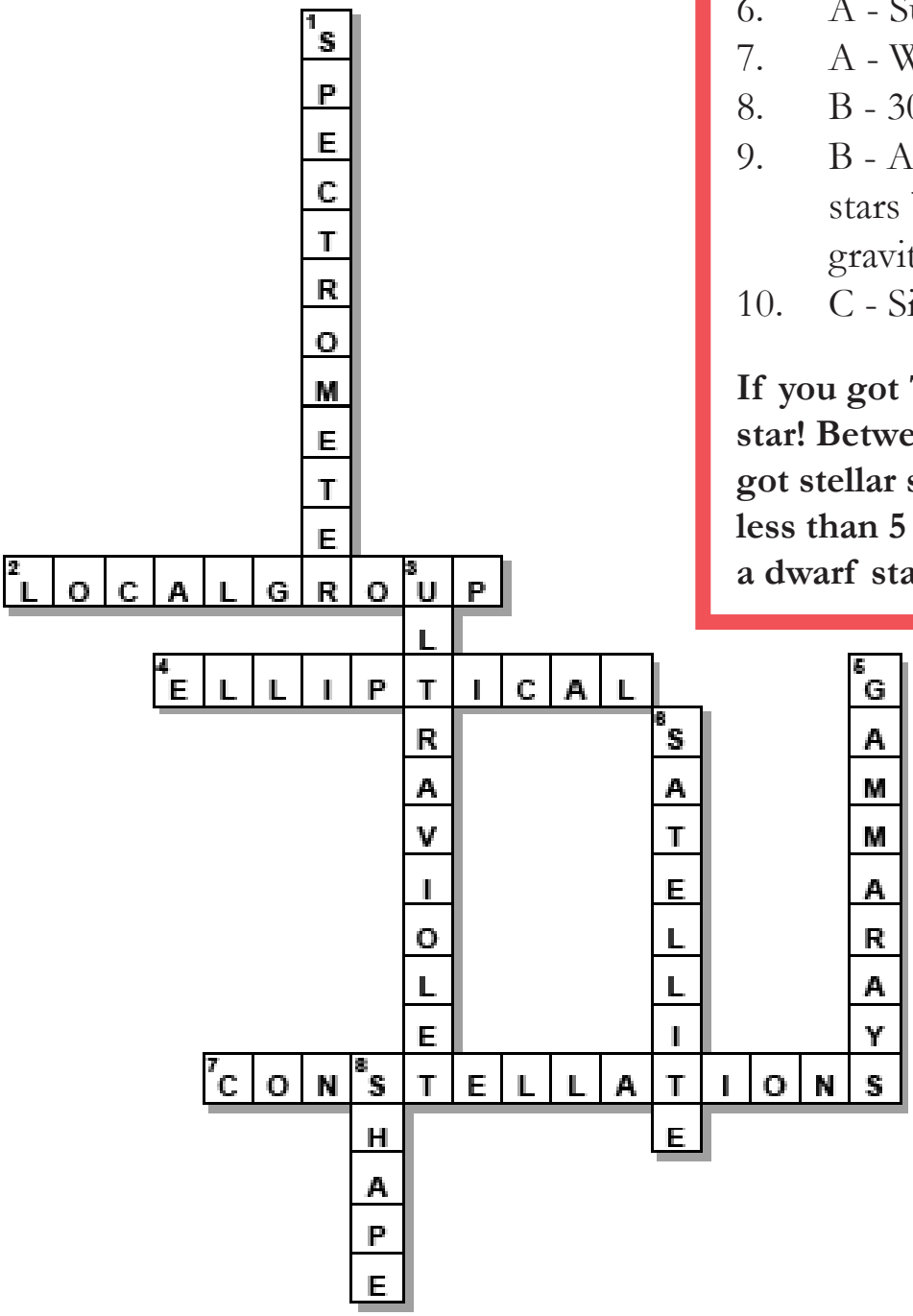
Our partnerships with other space agencies from around the world and with the private sector here have shown me that great teams accomplish great things. I like to say that NASA is the keeper of the future—we don't just wait for the future to happen. We work to create it every day.

10) In your opinion, after seeing everything you've seen here, why should people care about the science at NASA?

At NASA, we gather the data to help answer the most fundamental and profound questions: Where did we come from? How does our planet and our universe work? What is the fate of our planet? It is only by exploring, by making measurements, by answering scientific questions that we can move forward as a society. And in doing so, we push technology and engineering in ways that benefit us every day right here on Earth.

NASA makes measurements that show how the sea level is rising, how Arctic ice is melting, and how weather patterns are changing. We also gather data to help farmers grow more crops using less water, help understand our water resources, and do the research to improve forecasting. These data keep us secure and improve the quality of life on Earth every day.

Universe Crossword Answers



Star Quiz Answers

1. C - Proxima Centauri
2. C - Hydrogen and helium
3. A - Green dwarf
4. A - Main-sequence star
5. C - Its mass
6. A - Supernova
7. A - Wolf-Rayet Stars
8. B - 300 billion
9. B - A spherical group of stars bound together by gravity
10. C - Sirius

If you got 7-10 correct, you're a star! Between 5-7 right? You've got stellar smarts. If you got less than 5 correct, we'll call you a dwarf star.

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