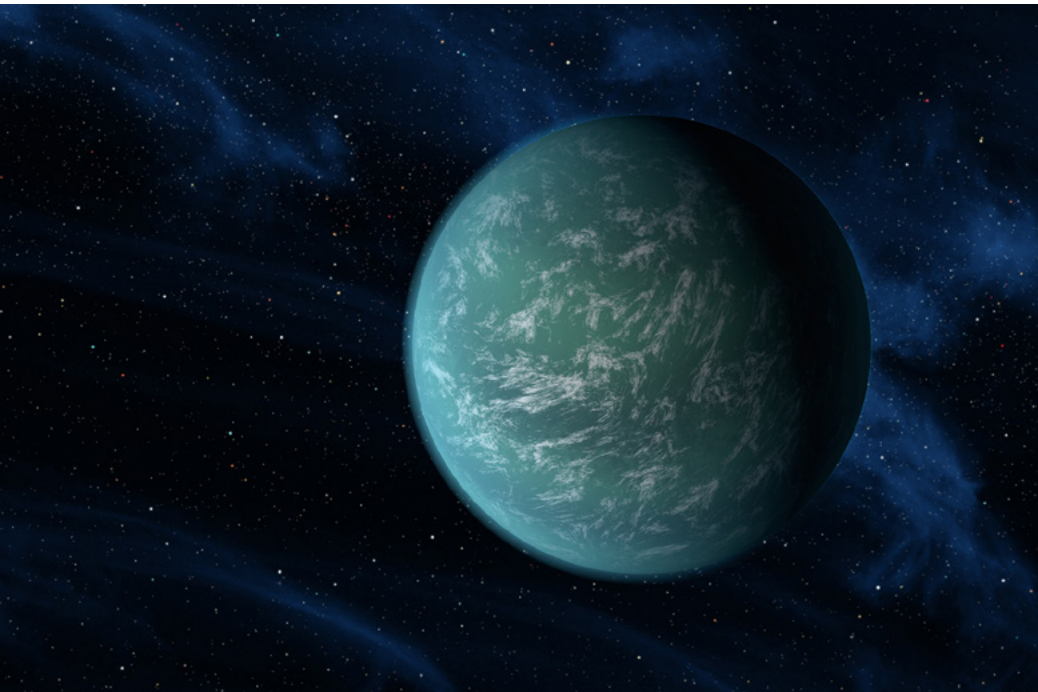


## UNIVERSE DISCOVERY GUIDES

August

# THE SEARCH FOR HABITABLE WORLDS



Artist's conception of Kepler-22b, the first planet NASA's Kepler mission confirmed to orbit in a Sun-like star's habitable zone. Credit: NASA/Ames/JPL-Caltech

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The universe is a place of change. NASA missions advance our understanding of the changing universe.

[www.nasa.gov](http://www.nasa.gov)

## ARE WE ALONE?

When we look out into the night sky and see so many stars, we can't help but think that at least one of those stars might have a planet like Earth orbiting it where other beings are looking out into their night sky. Both of us are thinking, "Is there anyone else out there?"

In the ever-changing universe, it took Earth billions of years to develop complex life. Are the changes that led to life on our planet happening elsewhere in our Galaxy and in other galaxies of the universe?

Scientists used to be skeptical of finding other planets, let alone other life, in the universe. But our advancing technological capabilities have allowed us to begin the search.

So where do we start?

There is only one planet we know of that harbors life: Earth. As our only model of a planet where life developed, we ask ourselves:

What is special about Earth?

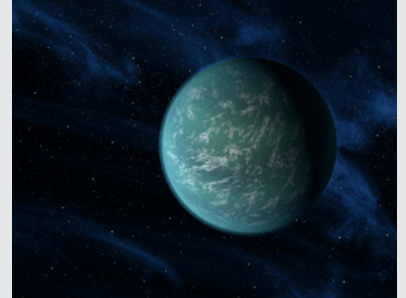
Besides life, what does an "Earth-like" planet have?

Well, let's see:

- Our star, the Sun, has lived long enough to allow life to develop on Earth
- Earth is the right size so it has enough gravity to hold an atmosphere in place. Earth has an atmosphere that protects us, but does not suffocate us.
- We orbit the right distance from our star to have liquid water year-round

For several years, NASA's Kepler Mission has been monitoring more than 150,000 stars for evidence of planets about the *size* of Earth orbiting stars that are *like* our Sun. And guess what? Kepler's discoveries include planets over a wide range of sizes, and some of those planets are about the size of Earth!

Look out into the night sky. How many stars do you see? From Kepler's discoveries, scientists now estimate that at least one of every six stars has an Earth-size planet. That means there are at the very least 15 billion planets about the size of Earth just in our own Milky Way Galaxy! If we used birdseed to represent planets, we would need about four semi-truck trailers full of birdseed to hold them all. For the whole story, visit: [http://www.nasa.gov/mission\\_pages/kepler/news/17-percent-of-stars-have-earth-size-planets.html](http://www.nasa.gov/mission_pages/kepler/news/17-percent-of-stars-have-earth-size-planets.html)



Artist's conception of Kepler-22b, the first planet NASA's Kepler mission confirmed to orbit in a Sun-like star's habitable zone. Credit: NASA/Ames/JPL-Caltech

The next step is to determine which ones have liquid water. Why do scientists think it is important for the planet to have liquid water?

Researchers explored the most extreme environments on Earth to find what conditions life tolerates. What an enormous variety they found! But all life on Earth seems to have one condition in common: it all requires liquid water to thrive, grow, or reproduce. How about you: do you need water? So a planet that orbits its star in a zone where liquid water could exist might be a good candidate. This zone, where it is not too hot and not too cold for liquid water to exist, is called the “habitable zone.”

How many Earth-size planets orbit in the habitable zone of their star and actually have liquid water? Is life rare or common on these planets?



Artist's conception of planet in the habitable zone of a Sun-like star. Image copyright Dan Durda, FIAA

These are the next questions NASA scientists want to answer.

Today we know our planet orbits a star in a vast galaxy full of billions of other stars — many with planets of their own orbiting them. Yet NASA's search for *life* on a planet other than our own continues.

Soon we may be able to answer our question, “Is there anyone else out there?”

## SKY FEATURE: KEPLER MISSION FIELD

### How to Find it

**Distance:** Almost all the stars being monitored are between 600 and 3,000 light-years distant

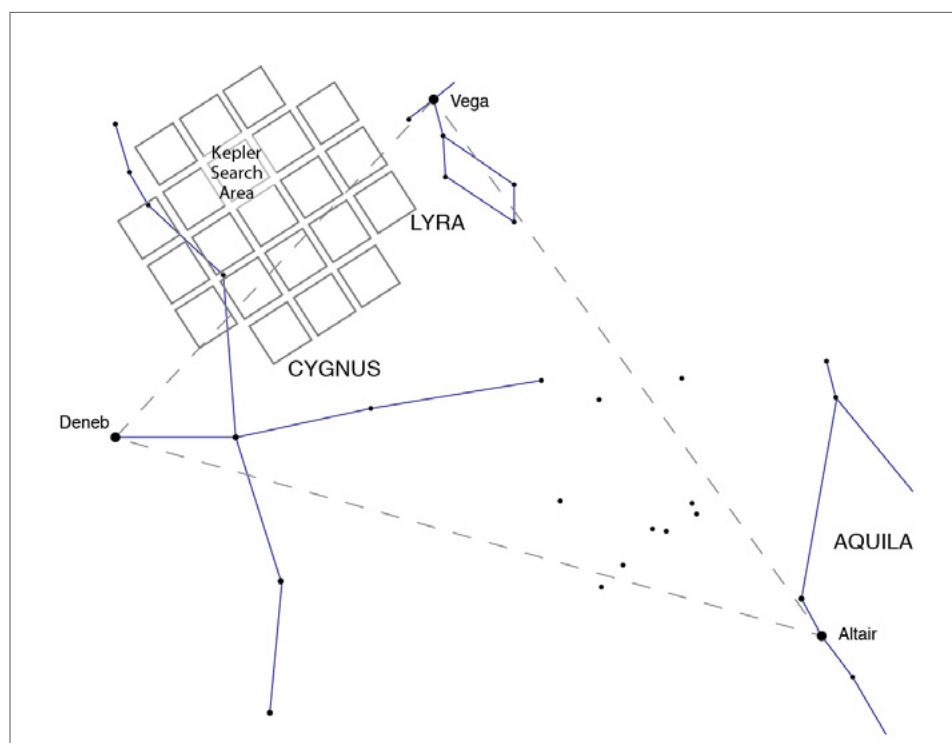
**Dimension:** 10 degrees (about the size of your fist held at arm's length)

**To view:** Just your eyes

[Click here to jump to the full-sky August Star Map.](#)



Kepler Spacecraft. Credit: NASA



You can see the area of the sky where the Kepler Mission searched for Earth-size planets orbiting Sun-like stars.

On an August evening before midnight, the Summer Triangle, marked by the stars of Vega, Deneb, and Altair is almost directly overhead.

Find the stars Deneb and Vega. Hold your fist out at arm's length and place it between those two stars. This marks the area of the sky the Kepler spacecraft monitored, searching for Earth-size planets. It is an area just a little larger than your fist. In this small area of the sky, the Kepler Spacecraft has found evidence for hundreds of Earth-size planets.

## TRY THIS!

### How much of our Galaxy does the Kepler Mission include?

Imagine if you could shrink our Solar System, the Sun and all its planets, so it fits into the palm of your hand. The diagram (right) is about the correct size. On this scale, the orbits of Mercury, Venus, and Earth are so small that they are not shown in the diagram. The orbits of Mercury, Venus, Earth are so small on this scale, they are not shown in the diagram.

Our Sun is just one star among the hundreds of billions of stars in our Milky Way Galaxy.

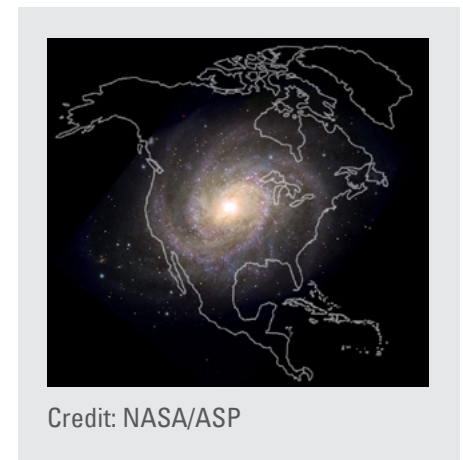
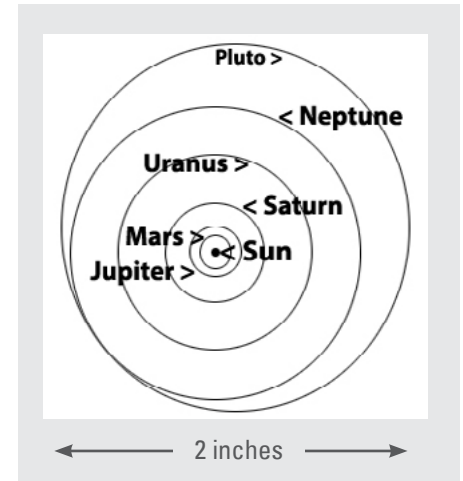
With the Solar System sitting in the palm of your hand, the Milky Way Galaxy, with its 200–400 billion stars, would span North America — about 2,500 miles (4,000 km) across.

#### *How much of our Galaxy does the Kepler Mission include?*

On this scale, the stars in the Kepler Field would be 15–75 miles (24–120 km) away from the Solar System in the palm of your hand. What cities are 15 to 75 miles away from you? This corresponds to about 150,000 stars searched by Kepler for extra-solar planets, out of the hundreds of billions of stars in our galaxy.

It may seem like a small part of the Milky Way, but this sample of stars allows scientists to estimate how many Earth-size planets are likely to exist in our Galaxy.

For more about how and where the Kepler Mission identifies Earth-size planets, visit <http://kepler.nasa.gov/Mission/faq>



## Make a Star Wheel!

Make a star wheel to find the Kepler Mission Field and find other stars known to have planets orbiting them:

<http://kepler.nasa.gov/education/starwheel/>

For more Kepler education and public outreach activities, see here:

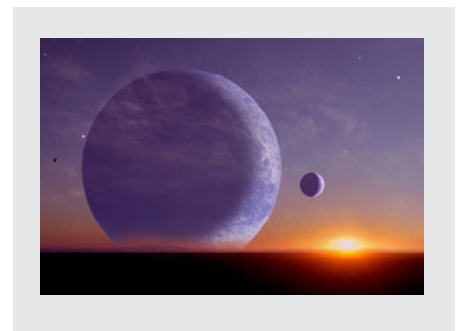
<http://kepler.nasa.gov/education/>



## Do It Yourself Planet Search

Detect an exoplanet passing in front of its home star! This NASA portal to the MicroObservatory Network allows you to control a telescope, get images of stars known to have orbiting planets, and to analyze those images to discover the tell-tale dip in the light of the star as the planet transits in front of it.

<http://www.cfa.harvard.edu/smgphp/otherworlds/OE/>



## ACTIVITY: WHAT'S THE "HABITABLE ZONE" AROUND A STAR?

Time: 15 minutes

Age: 8 and up

Why is there life on Earth and not on Venus or Mars?

What about life on planets around other stars?

Imagining a campfire to represent a star, this activity involves thinking how comfortable you'd be standing at different distances from that campfire. The activity models how a planet's distance from the star and its atmosphere influences the habitability of the planet.

Find the activity here:

[http://nightsky.jpl.nasa.gov/download-view.cfm?Doc\\_ID=394](http://nightsky.jpl.nasa.gov/download-view.cfm?Doc_ID=394)



**Candle**  
**(Cool, Red star)**

**Campfire**  
**(Yellow/White Star)**

**Bonfire**  
**(Hot, Blue Star)**

Credit: Astronomical Society of the Pacific

## Go Deeper: Are we alone in the universe?

### Astrobiology: Science Learning Activities for Afterschool

Time: Each of the eight activities is about one hour

Age: Adapted to ages 5 and up

Explore topics related to astrobiology, which is the search for life beyond our own planet Earth. As you complete the activities in the guide, you will use some of the same strategies that astrobiologists use.

Find these activities here:

[http://www.nasa.gov/pdf/145916main\\_Astrobiology.Guide.pdf](http://www.nasa.gov/pdf/145916main_Astrobiology.Guide.pdf)



Origin of Life on Earth. From left to right, starting from a volcanic primitive Earth and simple molecules in the ocean to complex life forms on land. Credit: NASA

Topics explored:

- Do you think aliens exist?
- How do we recognize life?
- What does life need to live?
- What are the most extreme environments on Earth where life actually exists?
- Would planets orbiting other stars have those same environments?
- Do you think we are alone in the universe?

For more education and public outreach activities from NASA.gov, visit

<http://www.nasa.gov/audience/foreducators/index.html>

Looking for more Earth and Space Science formal and informal education activities?

Try out NASA's digital collection of resources at NASA Wavelength:

<http://nasawavelength.org>





## CONNECT TO NASA SCIENCE

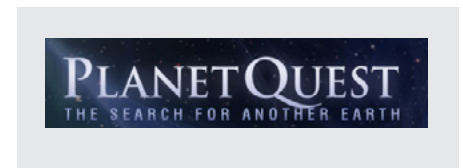
### How do we know?

What are scientists looking for in the atmospheres of distant planets?  
How does that help us find evidence of life on other worlds?

<http://amazing-space.stsci.edu/resources/tales/huntforlife.php>

Scientists use a variety of methods to confirm that it is a planet. NASA's PlanetQuest tells all:

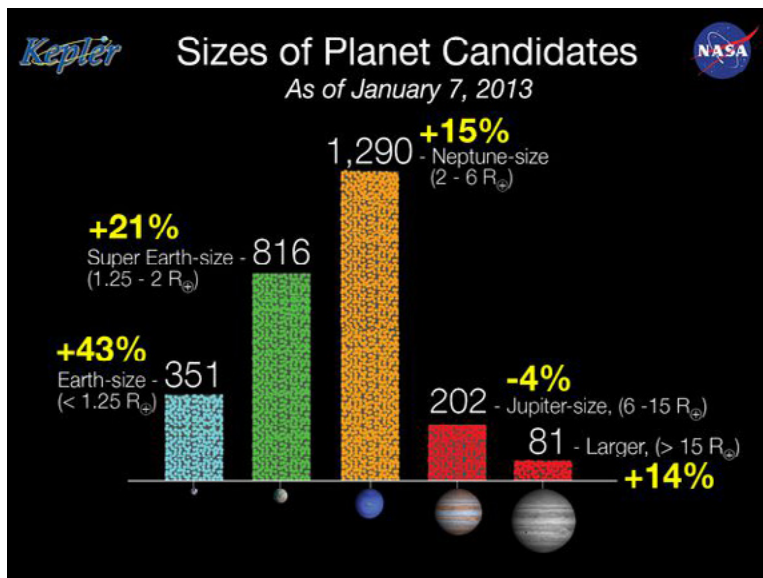
<http://planetquest.jpl.nasa.gov/page/methods>



### Taking a Census

The Kepler space telescope is doing the first large-scale census of planets around other stars. The goals of the program include an understanding of how common planets are in our galaxy, including Earth-size planets. For an up-to-date count of the total number of planets discovered around other stars, including those found by Kepler, visit

<http://planetquest.jpl.nasa.gov/>



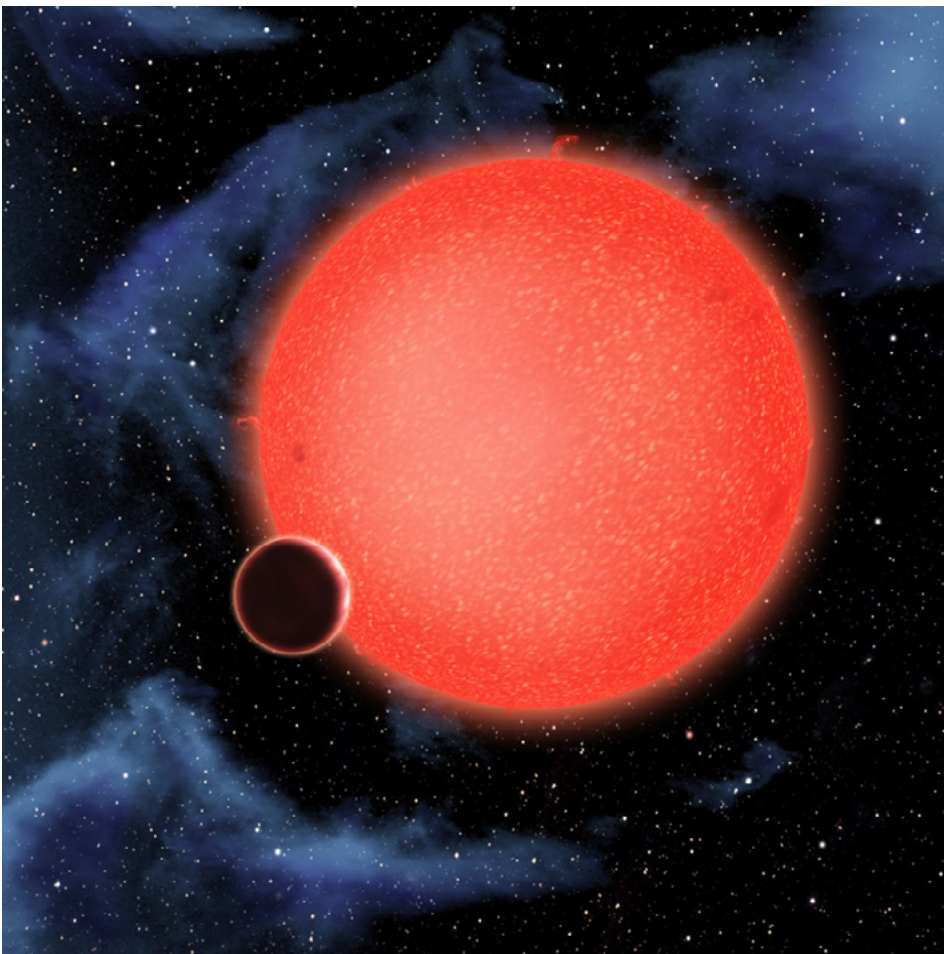
Story: <http://kepler.nasa.gov/news/nasakeplernews/index.cfm?FuseAction=ShowNews&NewsID=244> Credit: NASA/Kepler mission

For the latest news from the Kepler Mission, visit  
<http://kepler.nasa.gov/news/nasakeplernews/>

## Shrouded Water World

The Hubble Space Telescope confirmed the detection of a new type of planet, a water world shrouded with a thick, steamy atmosphere. Hot, sticky, and wet.

<http://www.hubblesite.org/newscenter/archive/releases/star/extrasolar-planets/2012/13/>

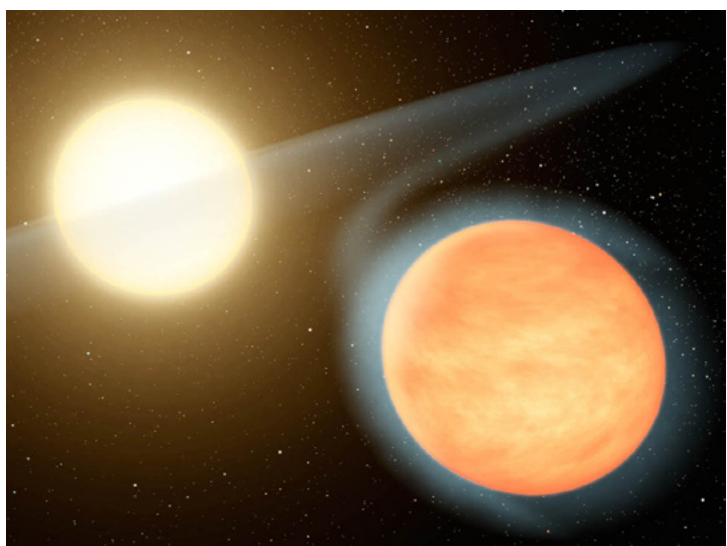


Artist's Concept of planet orbiting the red dwarf star, GJ1214. Credit: NASA, ESA, and D. Aguilar (Harvard-Smithsonian Center for Astrophysics)

For the latest news from Hubble, visit  
<http://hubblesite.org/newscenter/>

## Planet in the Sky with Diamonds?

The Spitzer Space Telescope helped discover the first carbon-rich planet ever observed. This planet, WASP-12b, is a clue that planets come in very diverse forms. WASP-12b may harbor carbon in a variety of forms, including graphite and diamond: <http://www.spitzer.caltech.edu/news/1231-ssc2010-10-NASA-s-Spitzer-Reveals-First-Carbon-Rich-Planet>



Credit: NASA/JPL-Caltech/R. Hurt (SSC)

## Detections of Life-friendly Molecules on Alien Planets Take a Step Forward

Using the Spitzer Space Telescope and the Hubble Space Telescope, astronomers discovered water, methane, and carbon dioxide in a gas giant planet, known as HD 209458b. As of October 2009, this is only the second planet known to contain these molecules, called organics. This discovery offers hope that we can discover the same organics around smaller rocky worlds, where the chemistry of these organics may indicate the presence of life.

For the latest news from Hubble, visit <http://hubblesite.org/newscenter/>

For the latest news from Spitzer, visit <http://www.spitzer.caltech.edu/news>

To learn more about NASA Astrophysics Missions, visit: <http://science.nasa.gov/astrophysics/>

## ACKNOWLEDGEMENTS

The Universe Discovery Guides are a collaborative effort between members of the NASA Astrophysics education and public outreach (E/PO) community and the NASA Astrophysics Science Education and Public Outreach Forum. We also gratefully acknowledge the informal educators from the Astronomy from the Ground Up (AFGU) and the Sky Rangers communities who field-tested the guides.

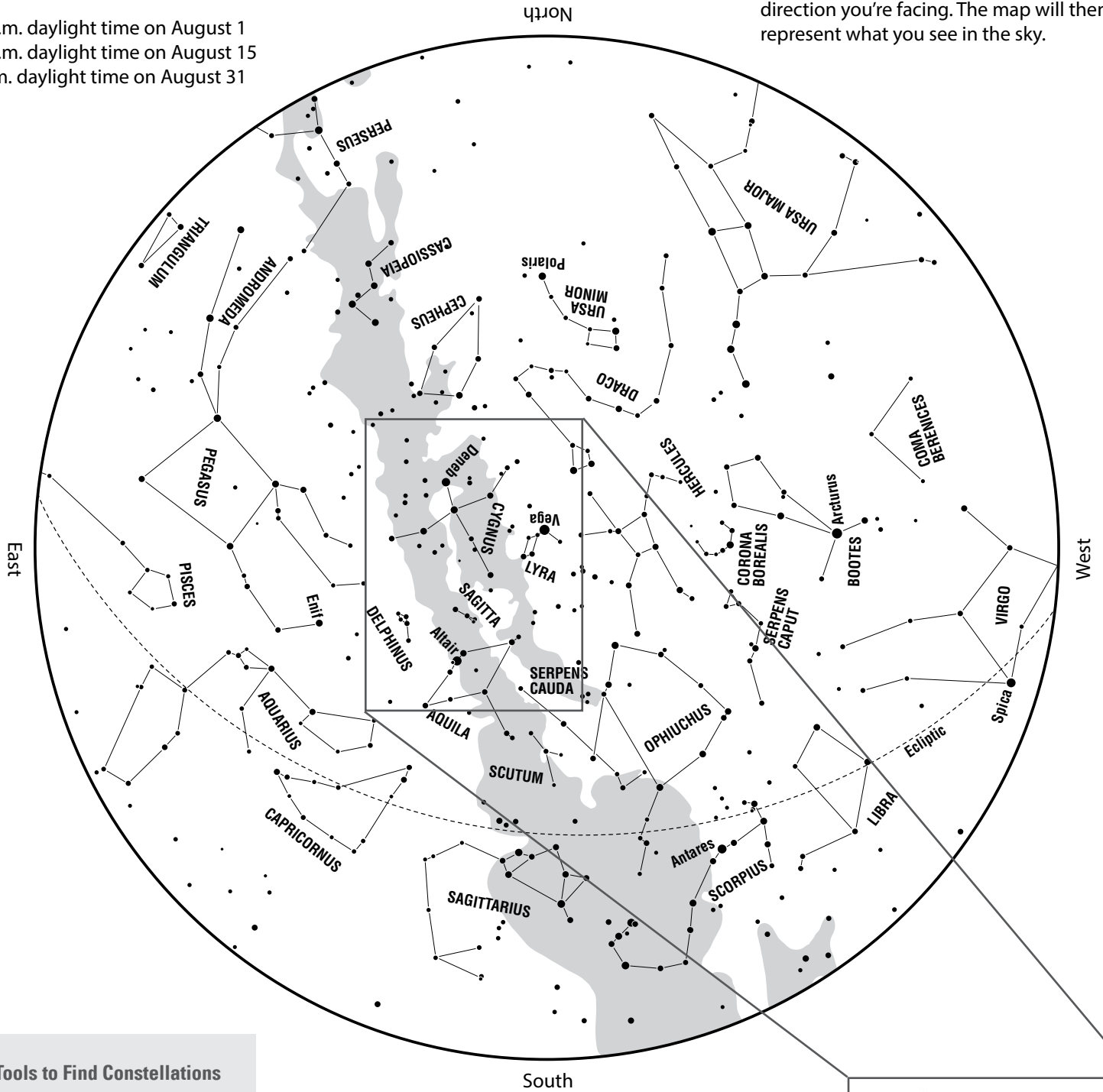
Contributing NASA Astrophysics E/PO programs include: Afterschool Universe, Alien Earths, Astronomy Picture of the Day (APOD), the Chandra X-ray Observatory, the Cosmic Background Explorer (COBE), Cosmic Questions, the Euclid mission, Exoplanet Exploration, the Fermi Gamma-ray Space Telescope, the Galaxy Evolution Explorer (GALEX), the Herschel Space Observatory, the High Energy Astrophysics Science Archive Research Center (HEASARC), the Hubble Space Telescope, Imagine the Universe, the Infrared Processing and Analysis Center (IPAC), the James Webb Space Telescope, the Kepler Mission, the Milky Way Project, the Night Sky Network (NSN), the Nuclear Spectroscopic Telescope Array (Nu-STAR), Observing with NASA (OwN), Other Worlds, the Planck mission, PlanetQuest, Planet Hunters, the Spitzer Space Telescope, StarChild, the Stratospheric Observatory for Infrared Astronomy (SOFIA), the Swift mission, the Two Micron All-Sky Survey (2MASS), the Wide-Field Infrared Survey Explorer (WISE), the Wilkinson Microwave Anisotropy Probe (WMAP), the X-ray Multi-Mirror Mission (XMM-Newton), and Zooniverse.

The Astrophysics Forum is supported by NASA's Science Mission Directorate under Cooperative Agreement NNX09AQ11A to the Space Telescope Science Institute, Astronomical Society of the Pacific, Adler Planetarium and Astronomy Museum, and Johns Hopkins University.

The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

- 11 p.m. daylight time on August 1
- 10 p.m. daylight time on August 15
- 9 p.m. daylight time on August 31

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



### Tools to Find Constellations

#### For mobile device users:

Search your app store for “planetarium” or “sky map” to find free or low-cost apps. These help you more easily locate constellations.

[View a video on how to read a star map.](#)

### August Sky Feature: Kepler Mission Field

[Jump to Sky Feature to find out about the Kepler Mission Field](#)

