PlanetQuest the search for another Earth

Outreach ToolKit Manual

Distributed for members of the NASA Night Sky Network

The Night Sky Network is sponsored and supported by JPL's PlanetQuest public engagement program. PlanetQuest is a part of JPL's Navigator Program, which encompasses several of NASA's extra-solar planet-finding missions, including the Keck Interferometer, the Space Interferometry Mission (SIM), the Terrestrial Planet Finder (TPF), the Large Binocular Telescope Interferometer (LBTI), and the Michelson Science Center.

NASA Night Sky Network: ***http://nightsky.jpl.nasa.gov/***

PlanetQuest: ***http://planetquest.jpl.nasa.gov/***

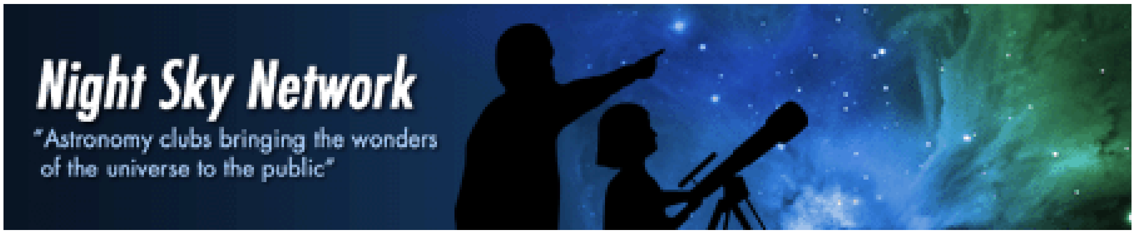
Contacts

The non-profit Astronomical Society of the Pacific (ASP), one of the nation's leading organizations devoted to astronomy and space science education, is managing the Night Sky Network in cooperation with JPL. Learn more about the ASP at http://www.astrosociety.org.

For support contact:

Astronomical Society of the Pacific (ASP)
390 Ashton Avenue
San Francisco, CA 94112
415-337-1100 ext. 116
nightskyinfo@astrosociety.org

CREDITS: All photos and images in the ToolKit Manual unless otherwise noted are provided courtesy of Marni Berendsen and Rich Berendsen.



Your Club's Membership in the NASA Night Sky Network

Welcome to the NASA Night Sky Network! Your membership in the Night Sky Network will provide many opportunities for your club to expand its public education and outreach.

Your club has at least two members who are the Night Sky Network Club Coordinators. These members will assist with introducing the club to the Night Sky Network and the Outreach ToolKits.

What does the Night Sky Network Club Coordinator do?

Your club assigns a primary and at least one backup Night Sky Network Club Coordinator. Up to four club members can be assigned as Club Coordinators. In case the primary Club Coordinator is unavailable, the backup can take over. Use the "**Change Coordinators**" selection under **"Club Coordinator Functions"** on the Night Sky Network to manage who are the Club Coordinators.

The Night Sky Network Club Coordinator:

- Receives any new Outreach ToolKits
- Maintains and manages the Outreach ToolKits
- Maintains the list of your club members who are participants in the Night Sky Network.
- Confirms and approves outreach events logged by club members on the Night Sky Network
- Maintains accurate club contact information for publishing on the public site
- And most importantly, introduces the Night Sky Network program and the Outreach ToolKits to your astronomy club

What does the Night Sky Network provide for the club?

The Night Sky Network is an opportunity for your club to:

- Enhance the public outreach you already do
- Encourage more of your members to participate in outreach
- Increase the confidence of those who are interested in outreach
- Earn national recognition for your outreach efforts
- Network with other amateurs doing outreach

- Keep up-to-date on the latest NASA discoveries via members-only teleconferences with NASA scientists
- Attract more members to your club by providing your visitors with engaging, memorable experiences

This is the hub where amateur astronomy club members involved in public outreach can have discussions, ask questions of NASA scientists, log your events and feedback on the kits, get news on outreach, and exchange your ideas for use of the ToolKits and new outreach materials. This is a combination of a public site and a "participants-only" site.

To access the Night Sky Network, use this link: http://nightsky.jpl.nasa.gov/.
You should already have received an email with your username and password when your Club Coordinator added you as a participant.

PROGRAM PARTICIPATION GUIDELINES

The following "terms and conditions," and "standards of conduct" apply to any individual or club participating in the Night Sky Network and working as a volunteer. Please review this information carefully with all club members prior to their participation in any volunteer work in connection with the Night Sky Network.

1. ***Club members understand and agree that in consideration for being allowed to participate in the Night Sky Network, you and your club acknowledge that for any and all program activities you engage in, you are doing so at your own risk, and you assume all risk of injury, illness, death, or damage to you, and your personal or club property that might result from your participation in any such activities.***

2. ***Club members agree to conduct themselves appropriately and to avoid any actions that would reflect negatively upon the ASP, JPL or NASA, while engaging in program activities.***

3. ***As a club member you are volunteering your efforts and are free to use Outreach ToolKit materials at times and events of your own choosing.***

4. ***There is no obligation on ASP's, NASA's, or JPL's part to compensate you or your club or offer any employment in the future.***

5. ***You agree to not represent yourself as an employee or agent (e.g. you may not enter into contracts) of the ASP, JPL or NASA, or to use your affiliation with these organizations for private gain for yourself or your club.***

6. ***Your club may choose to cease being a member of Night Sky Network at any time by marking your club as inactive on the Night Sky Network website or by sending a letter or email to the ASP. Individual club members may also terminate their volunteer activities in connection with this program at any time. Likewise, the ASP, JPL, or NASA may terminate your club's membership or any individual club member's participation in the program at any time.***

How do we involve our club members?

Photo Credit: James Scala

The Night Sky Network program and the Outreach ToolKits can be a catalyst to getting more of your club members to participate in outreach.

Share the fun! The Club Coordinator introduces the Outreach ToolKit to the club. Astronomy clubs like yours have found that the most successful way to involve more of your club members in outreach is for the Club Coordinator to follow these steps:

1) Take a little time to become familiar with the Outreach ToolKit and the suggested activities – watch the training video and review the *PlanetQuestManual.pdf* on the PLANETQUEST OUTREACH TOOLKIT MANUAL AND RESOURCES CD. Try out one of the activities on your friends or family.
2) Set aside 30-45 minutes at a club meeting to introduce the Outreach ToolKit and the Night Sky Network program to your club using selected parts of the Training Video and the Outreach ToolKit. Here are some suggestions:
   a) Show selected Training Video segments
   b) Show the PowerPoint to introduce your club to the program (See the *ClubIntro.ppt* on the PLANETQUEST OUTREACH TOOLKIT MANUAL AND RESOURCES CD in the *PowerPoints* folder)
   c) Demonstrate one or two of the activities
   d) Let your members inspect and play with the materials in the ToolKit
   e) Pass around a signup sheet for interested club members to sign up
3) Schedule follow-up outreach training meetings for the interested members
   a) This provides an opportunity for members to ask questions and try out new demonstrations in a supportive environment,
   b) Benefit 1: Increases the confidence of those who are interested in outreach.
   c) Benefit 2: Provides a forum for more experienced outreachers to share their tips and tricks.
4) Make a plan to use one or more of the activities at your next star party or other event.
5) You now have an outreach team of interested club members
6) Enter them as participants in the Night Sky Network website using "**Add Participants**" under "**Club Coordinator Functions"**.
   a) When you add a Participant, the person will receive an email with his or her username and default password. After the member logs in the first time, he or she can change his/her own password.
7) You may want to make copies of the PLANETQUEST OUTREACH TOOLKIT MANUAL AND RESOURCES CD and copies of the training DVD for each participant
8) **Log Events:** Make sure your participating members understand how to log events in the Night Sky Network website

9) **IMPORTANT:** Encourage your members to bookmark the Night Sky Network (or put it in their "Favorites") on their own browsers for easy access.
10) You can schedule regular outreach meetings or plan to meet for a few minutes before each public night or other scheduled club event.
11) **Mentors:** To increase confidence in doing more kinds of outreach, create a "buddy system" – seasoned outreachers should be encouraged to take along at least one other interested club member for school events, presentations, youth groups, or other community events. This sets up a mentoring system within your club.

How does the club gain recognition for outreach and maintain membership in the Night Sky Network?

Night Sky Network Logo

On the PLANETQUEST OUTREACH TOOLKIT MANUAL AND RESOURCES CD the *LOGOs* folder contains Night Sky Network logos you may post to your website and use on club correspondence to identify your club as a Night Sky Network member.

IMPORTANT: The logos with the word "NASA" in the file name and the NASA logo on the image cannot be used on personal business cards, name badges, or in any way that might be interpreted as indicating that an individual is an employee of NASA. The other logos (without "NASA" in the file name) may be used in any way you wish to identify your club and its members as Night Sky Network participants.

Earning Recognition and Maintaining Membership

To make sure your club remains a star in the Night Sky Network and to gain recognition for your outreach events, your club members are expected to use the Outreach ToolKits in at least **five events each year** and **log your experiences with those events online** on the NSN website.

The Club Coordinator is in the position to ensure that club members who use the ToolKit in outreach events log the events on the Night Sky Network website.

The Club Coordinator confirms and approves outreach events logged by club members on the Night Sky Network.

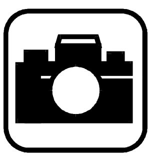
Here are the steps:

1. The Club Coordinator loans out the Outreach ToolKit or one or more of the activities in it to a Club Member. **TIP:** It may be helpful to include a printed copy of the Log Event form and one or two copies of the Authorization and Release form for photos.

2. The Club Member conducts the event and notes the event information on the Log Event form. You are encouraged to have digital photos taken of the event.
3. The Club Member logs into the Night Sky Network and chooses "**Log an Event**" from the Participant Home Page.
4. The Club Member completes the online event form. When you log an Event, you may attach up to two photos, each of which can be up to 100 KB in size. See below under "Event Photos".
5. Periodically, one of the Club Coordinators reviews events logged by their Club Members on the Night Sky Network. To do this, the Club Coordinator logs into the Night Sky Network and chooses "**Review Logged Events**" from the Club Coordinator Functions.
6. The Club Coordinator approves the event and the event will then appear on the list of events when Night Sky Network members choose "**Find Events**".

Your event may become a featured news story on the Night Sky Network.

EVENT PHOTOS



You may attach up to 2 digital photos (GIF or JPG format, no larger than 100 KB each) to your logged events. Be sure to note who the photographer was so proper credit can be given. These photos may be used in News Features on the Night Sky Network or by NASA/JPL in publicity if we have an Authorization and Release from each recognizable person, especially children, whose face appears in your attached photos. Please have each person complete a space on the "Authorization and Release" form and mail the forms back to the ASP in the envelope provided with the kit, or to the address at the top of the form.

Return to:
Night Sky Network
Astronomical Society of the Pacific
390 Ashton Avenue
San Francisco, CA 94112

AUTHORIZATION AND RELEASE

FOR VIDEO TAPE/STILL PHOTOGRAPHY RECORDING

CLUB NAME: ______________________________________

EVENT DATE: _____________________

PHOTO TAKEN BY (First, Last Name): ______________________________

I hereby grant to the California Institute of Technology the right, without fee, to make and use video tape recordings/still photographs of me in connection with the subject event in any manner or form and for any lawful purpose at any time. I waive any right that I may have to review or approve the finished product, or the use to which it may be applied. I release and discharge the California Institute of Technology and its employees, and its subcontractor(s) and employees from any liability to me by virtue of any representation that may occur in the making or editing of said video tape recordings or still photographs.

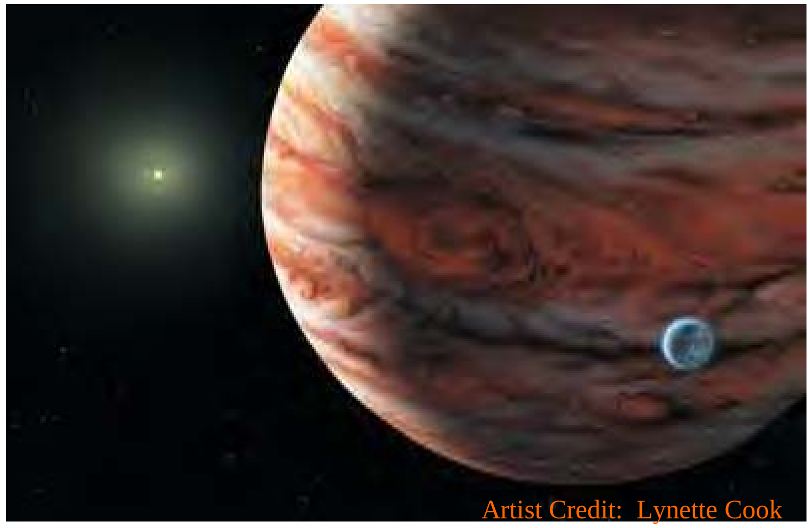
I have read this agreement before signing below and warrant that I fully understand its contents.

Name (Please Print)	Address/Phone
Signature(Parent/Guardian if under 18)	

Name (Please Print)	Address/Phone
Signature(Parent/Guardian if under 18)	

Name (Please Print)	Address/Phone
Signature(Parent/Guardian if under 18)	

The PlanetQuest Outreach ToolKit



The search continues for planets around distant stars.

None of these newly discovered worlds has actually been seen. All are massive, Jupiter-class planets, considered unlikely to harbor life as we know it. Many have short orbital periods. If planets like Earth exist, with smaller masses and longer orbital periods, their discovery will require more sensitive instruments and years of precise, sustained observations.

Nonetheless, the dream of other worlds waiting to be explored -- and the idea that our solar system is not unique -- has moved from philosophical speculation into reality. These discoveries harbor the potential to shift human thinking on a scale comparable to the Copernican revolution.

The next chapter in the brief history of extrasolar planet discoveries is already being written. New tools and visionary technologies currently in development will soon enable us to learn more about these nearby planetary systems. The Keck Interferometer will capture the first images of gas giants outside our solar system, while the Space Interferometry Mission will be capable of detecting evidence of planets slightly larger than Earth. Meanwhile, other ground-based planet search programs continue to yield new discoveries, giving scientists a broader view of the diversity of planets in our galaxy.

To become familiar with some of NASA's exciting missions we suggest you review *The Search for Another Earth.ppt* (PowerPoint presentation) included on the PLANETQUEST OUTREACH TOOLKIT MANUAL AND RESOURCES CD in the *PowerPoints* folder. In addition, browse through the PlanetQuest web site: http://planetquest.jpl.nasa.gov/

We hope you and the audiences you reach enjoy this ToolKit of materials and activities featuring topics on planet-finding provided to you by NASA, the Jet Propulsion Lab, and the Astronomical Society of the Pacific.

Summary of Activities in the PlanetQuest Outreach ToolKit

Studies have shown that science is best learned by doing, not just by listening or reading. Each of these activities has opportunities to involve your audience in a hands-on, participatory experience, allowing the presenter to discuss questions and ideas with the audience instead of being limited to a lecture format.

All activities can be done outside. Activities 1 and 4 can be done in a classroom or other indoor event setting and are suitable for outdoors in daylight or early evening. Activities 2, 3, and 4 are uniquely designed to be used or adapted for use outside under the night sky.

1. **HOW DO WE FIND PLANETS AROUND OTHER STARS?**
   Manipulate various demonstration materials to simulate star wobble (astrometry and radial velocity), transits (photometry), direct imaging of planets.

2. **TELESCOPE TREASURE HUNT: HOW DO STARS AND PLANETS FORM?**
   Tour the telescopes at a star party to view different objects that contribute to stellar and planetary formation, place stickers on a "Telescope Treasure List."

3. **WHERE ARE THE DISTANT WORLDS?**
   Use a star map to find constellations and to identify stars with extrasolar planets.

4. **WHY DO WE PUT TELESCOPES IN SPACE?**
   Investigate simulated atmospheric conditions through a mock telescope

Multimedia Resources

Additional materials allow the presenters to include multimedia in the activities, such as Powerpoints, video clips, and animations. These can also be used in stand-alone presentations.

Go to the section labeled "Multimedia Gallery" in the *PlanetQuestManual.pdf* for instructions on its use.

Approach to designing the materials in the Outreach ToolKit

The principles we followed in designing the materials for this kit were:

1. Allow you as the presenter to decide how many items you need for any given event and to adapt the activities to your audience.
2. The physical materials should be items that can be easily found, copied, or made, or that can be acquired at a low cost.
3. Make the kit so that the materials can be adapted to large or small audiences.
4. Materials need to be able to withstand handling, dew, and wind.
5. Most astronomy events are outside and access to electrical power is limited. Activities are designed to not require plug-in electrical power, except for video clips and Powerpoints.

In keeping with these principles, a number of items are on the PLANETQUEST OUTREACH TOOLKIT MANUAL AND RESOURCES CD in the *PlanetQuestManual.pdf* and can be easily printed out. These kinds of items include the Treasure Hunt lists for the "Telescope Treasure Hunt" and the star maps for the "Where are the Distant Worlds" activity. We encourage you to personalize these handouts with your club's contact and/or schedule information.

How to get more of the Materials Provided with the Kit

Each Activity chapter in the *PlanetQuestManual.pdf* has details on how to acquire more materials.

Night Sky Network

Log Event Form

Starred fields are required.

***Name of Event:**	
***Submitted By (Person):**	
***Club:**	
***Name of Primary Presenter/Organizer:**	
Presenter's Profession:	

***Event Type: (Check ONE)**

- ☐ Star Party (Astronomy Night):School/Public/Other Group
- ☐ Star Party for club members
- ☐ Classroom Presentation
- ☐ Club Meeting
- ☐ Astronomy Convention/Conference
- ☐ Family/Friends Event
- ☐ Girl Scout Event/Meeting
- ☐ Other Youth Group Event/Meeting
- ☐ Other organization's mtng/convention/conference
- ☐ Club newsletter article
- ☐ Newspaper/magazine article
- ☐ Television/radio show
- ☐ Other (please specify):

Name of Group the Event was for:	
*** Event Date:**	
*** Length of Event:**	(specify # of mins,hrs, or days - or approx # of words if an article):
*** Event Location:**	*City: *State: Zip:

***Facility Type (Check ONE):**

- ☐ K-12 School
- ☐ College/University
- ☐ Museum/planetarium/observatory
- ☐ Community/Gov't Facility (e.g. Library, Park, Sidewalk)
- ☐ Private Facility (e.g. hotel, private home)
- ☐ Media (newspaper, newsletter, magazine, TV)
- ☐ Other (please specify):

*** Number of your club members participating as presenters:** ☐

*** Toolkit Activities Used:** (Check all that apply)

From PlanetQuest Kit:

- ☐ Telescope Treasure Hunt
- ☐ Where are the Distant Worlds (Star maps)
- ☐ How do we find planets around other stars?
- ☐ Why do we Put Telescopes in Space?
- ☐ Used ToolKit materials, media, or information not related to specific activities

(Continue to Page 2)

	***Total Number of Visitors or Audience Members (if unknown, please estimate)**

Demographics of audience members are requested by government agencies. If exact numbers are unknown, please try to estimate. Otherwise, leave the space blank.

Estimated #	**How many visitors or audience members were...**		
	Minority?		Adults?
	Female?		Teens?
			Children?

IF A SCHOOL EVENT:

Estimated #	**How many audience members were...**		
	Non-teacher adults?		
	K-8th Grade Teachers?		K-8th Grade Students?
	High School Teachers?		High School Students?
	Community College Instructors?		Community College Students?
	Other College or University Instructors?		Other College or University Students?

What materials (and how many) did you hand out at the event, if any?

Provide a few comments or interesting anecdotes about the event:

- **PHOTOS:** If you wish to include electronic photos, you will need to log your event online.
- **Please use this form as a reference to log your event online on the Night Sky Network:** http://nightsky.jpl.nasa.gov
- **OR send the form to your Night Sky Network Club Coordinator**
- **OR mail this form to:**
  Night Sky Network
  Astronomical Society of the Pacific, 390 Ashton Avenue, San Francisco, CA 94112
- **OR FAX this form to:** 415-337-5205

HOW DO WE FIND PLANETS AROUND OTHER STARS?

Quick Links

About the Activity
- What's this activity about?
- Helpful Hints
- Background Information:
- Detailed Activity Description

Materials:
- What materials from the Tool Kit do I need?
- What do I need to prepare?
- What must I supply?
- Where do I get additional materials?

What's this activity about?

SUGGESTIONS:
- ***View the Training video for suggested ways to demonstrate this.***
- ***Review "Four Ways to Find a Planet" video*** on the PlanetQuest web site or in the *Multimedia Gallery* folder on the PLANETQUEST OUTREACH TOOLKIT MANUAL AND RESOURCES CD (go to the Interactive_Gallery folder and double-click on "index.html")

Big Question: How do we find planets around other stars?

Big Activity: Spin "stars" to simulate star wobble (astrometry and radial velocity). Briefly explain transit method and direct imaging of planets.
Participants: One to six participants (per set of materials)

Duration: 5 - 30 minutes

Topics Covered:
- Four ways we are (or will be) detecting planets around a star
- Reasons why we need many ways to detect planets (Optional Activity)
- Upcoming NASA missions to find Earth-like planets

Activities:
Spin "stars" to differentiate between stars with planets and stars without planets and show techniques for discovering planets around other stars.
Venue:
- The full activity can be done inside or outside with at least some light.

Helpful Hints

If you are doing this for more than about 10 people at once, you may want to acquire more foam balls and attached planets, and break the group into smaller groups of 5 or 6 each.

- You will need to acquire at least two more foam balls for stars and make at least one more planet on a golf tee.

FOR LARGE AUDIENCES: If you have a large seated group of people and have access to an overhead projector, you can also show the wobbling star by spinning the foam balls on the projection surface of the overhead.

To simplify/shorten:

Reduce to 5 minutes: Show just the wobbling vs non-wobbling star and do the Part 1: The Wobble.

Background Information:

- *Radial Velocity* (or *Doppler Shift)* involves measuring the redshift or blueshift of a star's *spectral lines* as it moves toward and away from us along our line-of-sight ("radial" movement). The light is stretched out (longer wavelengths toward the red) when the star is moving away and gets bunched up (shorter wavelengths toward the blue) when the star is coming toward us.
  - *Spectral Lines* are lines in the star's spectrum caused by the presence of certain elements in the star's atmosphere.

- *Astrometry* measures a star's position relative to some reference point, like another star. Over time, its position changes. If a body is orbiting the star, it will wobble somewhat in its path. Other changes to a star's position are caused by parallax and its proper motion.
  - *Parallax* is the apparent change in the star's position caused by the Earth's annual motion around the Sun.
  - The star's *proper motion* is the actual path it takes in space as it moves through the Galaxy.

On the scale where our Sun is the size of the foam ball (approx 3"), one light year is about 330 miles. Jupiter would be about 150 feet away (halfway down a football field). The nearest star (Alpha Centauri – at roughly 4 light years) is about 1300 miles away (about halfway across the USA). The distance of a star 10 light years away would be similar to the distance from Los Angeles to New York. A star 35 light years away would be halfway to the Moon. This demonstration uses shorter distances in the examples.

- For more information: http://planetquest.jpl.nasa.gov/science/finding_planets.html

<u>Detailed Activity Description</u>

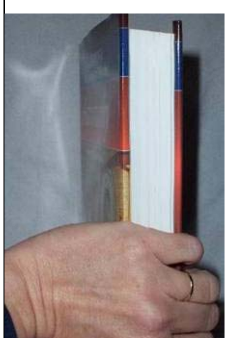
How do we determine if a star has planets?

PART 1: The "Wobble"

Leader's Role	**Participants' Roles (Anticipated)**
INTRODUCTION: *<u>To Say:</u>* How many people have heard that scientists have found planets around other stars? How do you think we can tell the difference between stars that have planets and stars that don't? *<u>To Do:</u>* Put the Star balls on a smooth surface like a tabletop with at least an area 2 feet by 2 feet clear of obstacles. Direct the participants to spin and observe the motion of the Star without a planet.  *<u>To Ask:</u>* What motion does it take? *<u>To Say</u>:* This is the motion a star without a planet has against the sky.	Listen and respond. Participants spin the Star without a planet and observe its motion.
<u>To Do:</u> Direct participants to spin the Star with a planet connected by the golf tee ("gravi-tee") and observe its motion. *<u>To Ask:</u>* What's different about the motion of this star? How do we know a star might have planets?	Spin the Star with a planet connected by the golf tee and observe its motion. Answer: Its wobble; How it moves … etc.

To Say: Most methods for finding stars that have planets are dependent on detecting in some manner this movement (wobble) of a star caused by an orbiting planet. These methods cannot detect the planet itself, just the movement of the star as a result of its having one (or more!) planets in orbit around it.	Listen
Do you suppose our star, the Sun, wobbles? (To go into more detail, see discussion under "Astrometry" on page 5).	Discuss the possibility that our Sun wobbles.
Which is our biggest planet? Which planet do you think makes the Sun wobble the most?	Give answers. Jupiter
Methods we use today to detect the wobble are only sensitive enough to see the big Jupiter-sized planets. So do you think we've found any Earth-sized planets around other stars yet?	
Smaller planets like Earth do not move their stars around enough for the motion of the star to be detected by methods we use today. We've found big planets like Jupiter around other stars, do you suppose there might be small planets like Earth too?	Discuss.
The next generation of NASA missions, are expected to be much more sensitive and be able to detect Earth-sized planets. Terrestrial Planet Finder (TPF) and the Space Interferometry Mission (SIM).	

PART 2: ASTROMETRY

Leader's Role	**Participants' Roles (Anticipated)**
<u>*To Say:*</u> *Astrometry* involves measuring a star's position related to some reference point, like another star. Over time, its position changes. If a body is orbiting the star, it will wobble somewhat in its path. From the distance of about 35 light years, Jupiter would cause the Sun's position to change by $1/1000^{th}$ of an arc second (0.001 arcsec) over a 12 year period. But how much is that?! <u>*To Do:*</u> Spin the star with the big planet again. <u>*To Say:*</u> This is approximately equal to detecting the change in position of this ball as it wobbles from a distance of 3300 miles or if you were in Los Angeles and the ball (star) was in New York.  (Another way of explaining it): If you were in Los Angeles and I was in New York, this is like you being able to see me hold up my finger and wiggle it side to side. (Yet another way): This is approximately equal to detecting a change in position as small as the thickness of a one-inch thick book from a distance of 3300 miles or about from Los Angeles to New York.	Listen. Spin the star ball with a planet and the one without a planet. Observe their paths.

To Say: SIM: Space Interferometry Mission will be able to detect this kind of movement. In fact, it will be able to detect a change in the star's position 1000 times smaller than that over a 5-year period. This means that from about 35 light years away, we would be able to detect the movement induced in the star by an Earth-sized planet orbiting at the distance of Jupiter. Or a planet 3 times the size of Earth at the distance of Earth's orbit. *To Do:* Spin the star with the toothpick and tiny clay planet.  *To Say:* This is approximately equal to detecting the change in position of this ball as it wobbles from a distance of 3300 miles or if you were in Los Angeles and the ball (star) was in New York. (NOTE: You will not likely be able to visually detect the wobble as you watch the star spin.) Can anyone see the wobble in the star? How sensitive is the new SIM telescope NASA is developing? (Another way of explaining it):  This is approximately equal to detecting a change in position as small as the thickness of one page of a book from a distance of 3300 miles or about from Los Angeles to New York. SIM is scheduled for launch in 2009.	Listen. Discuss and spin star with tiny planet.

PART 3: PHOTOMETRY or TRANSIT METHOD

Leader's Role	Participants' Roles (Anticipated)
To Say: *Photometry* is measuring the brightness of a star. The brightness of the star changes when a planet passes in front of the star from our perspective. This is also known as the Transit method – because the planet transits the star from our perspective.	Listen.
To Do: Put the star with a planet (foam ball with tee and ball) onto a skewer. Hold the star with a planet at eye level and orbit the planet in front of the star from the participant's perspective. 	Watch.
To Say: Imagine this star being bright like the Sun. As the planet orbits in front of the star, the planet blocks a little of the star's light. Now, imagine this star as being a few hundred miles away in __(pick a city at least 300 miles away)___. We can't see the planet, just the change in the amount of light coming from the star. OPTIONAL MULTIMEDIA: o Show movie of the November 15, 1999 transit of the Sun by the planet Mercury – MercuryTransit.mpeg o Show Kepler Mission movie These movies can be found in the *Multimedia Gallery* folder on the PLANETQUEST OUTREACH TOOLKIT MANUAL AND RESOURCES CD in the *Movies* sub-folder.	

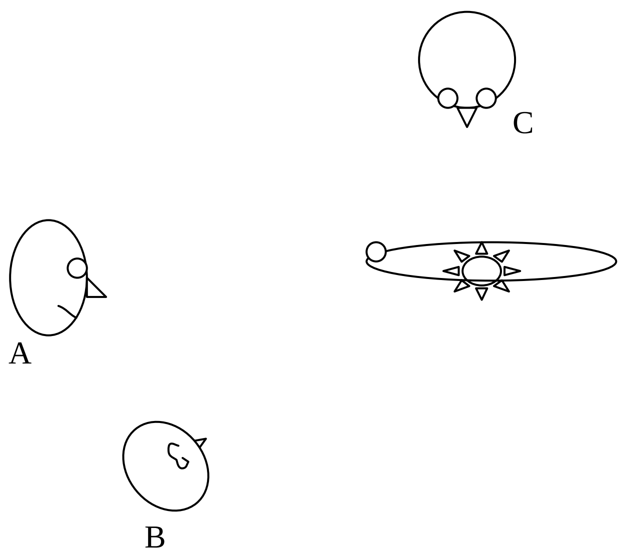
PART 4: DIRECT IMAGING: Through Starlight Nulling

Leader's Role	**Participants' Roles (Anticipated)**
<u>To Say:</u> All the other methods we've looked at detect some kind of a change in the star. Why do you suppose we can't see the planets directly? Direct Imaging will allow us to detect the actual light from the star reflected off the planet. So we can detect the planets themselves. *<u>To Do:</u>* Hold up the yellow foam ball with a planet on the skewer stick *<u>To Say:</u>* Imagine this star being bright like the Sun. And located several hundred miles away, like in __(pick a city at least 300 miles away)___ . Do you think it would be easy to see the planet next to the star?  NASA is developing ways to block out some of the light from the star, this is called starlight nulling. Hold out one or two fingers to cover just the bright star but not the planet. Do you think it might be easier to see the planet now? If we can find a method to reduce the amount of light coming just from the star, we have a better chance of seeing the planets directly.	Discuss (typical answers): too dim, too far away, too small, star is too bright (TIP: Many people do not understand how small planets are compared to a star – <u>Example:</u> if our sun was the size of the foam ball (about 3"), Earth would be the size of a poppy seed. Jupiter would be a bit smaller than the eraser on a pencil) Participants hold up fingers to block "light" from star.

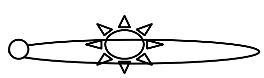
To Say: TPF: NASA's Terrestrial Planet Finder is being designed to block out almost all the light from the star so the planets can be seen directly (using a technique called interferometry). It is expected to launch within the next 15 years. This method is in development and is expected to allow us to see planets as small as Earth. We can then take a "picture" of the planet's atmosphere – and if we can see what's in the atmosphere, what do you think that will tell us? What might you look for in the atmosphere to find signs of life?	Possible life? Oxygen, water, methane

OPTIONAL: Planetary System Orientation One reason why we use multiple methods to Detect Planets

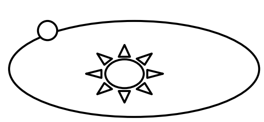
Leader's Role	Participants' Roles (Anticipated)
To Say: Planetary orbits around different stars have different orientations to us. Imagine people living on planets around other stars looking at our Solar System. *To Do:* Invite participants to look at their spinning star and planet from different perspectives. See the illustration below of people on planets around 3 other stars looking at the Sun-Jupiter orbit.	



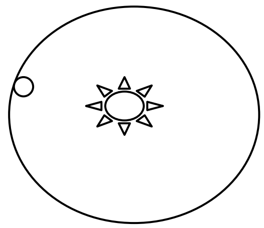
A sees it edge-on.



B sees it at an angle.



C sees it face on.



To Do: Remind participants of the different methods, discussed and modeled, used to discover planets: Radial Velocity, Astrometry, Photometry, Direct Imaging *To Ask:* Which techniques would be best to detect the planet for each of these perspectives shown (assume a near circular orbit)? A: Edge on (all methods) B: From an angle (radial velocity, astrometry, direct imaging) C: Face on (astrometry, direct imaging)	
To Ask: For which view(s) would the radial velocity technique be useless? (Which views do not have the star moving toward, then away from us? C.)	
To Ask: For which view(s) would the photometry/transit method technique be useless? (Which views do not allow the planet to pass in front of the star from your point of view? B and C)	
To Say: We need different techniques to find stars with planets depending on how they are oriented to our point of view.	

Materials

What materials from the ToolKit do I need?

- 3 Foam balls ("stars"): one will have a planet (you must insert the planet into the star – see *Prepare Ahead* below), one will be without a planet
- 1 Large "Planet" (small ball) attached to a golf tee
- 1 Toothpick
- Tiny ball of clay (1 mm) – pinch this off the block of clay.
- Alternate Material for large planet on the golf tee:
    - Clay

From *Multimedia Gallery* folder on the PLANETQUEST OUTREACH TOOLKIT MANUAL AND RESOURCES CD:

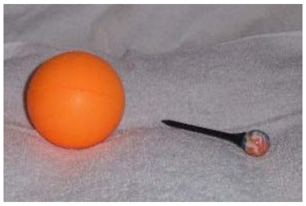
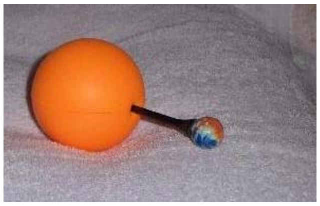
- (Optional) MercuryTransit.mov (QuickTime movie) or MercuryTransit.mpeg (MPEG movie): This is a movie of the November 15, 1999 transit of the Sun by the planet Mercury. The movie was taken by the TRACE spacecraft (for more info on TRACE: http://sunland.gsfc.nasa.gov/smex/trace/)
- (Optional) Video clip of the Kepler mission

What must I supply?

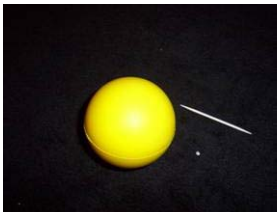
- A book approximately one inch thick

What do I need to prepare?

- Insert the Golf tee with the small ball ("gravi-tee" and "planet") into one of the foam balls.

- Make a very small ball of clay (about 1 mm in diameter). Place it on the end of the toothpick and insert the other end of the toothpick into one of the other foam balls.




Where do I get additional materials?

- Foam balls: The ones you received in the kit are "stress balls". You may be able to find them at a local craft store, but generally, these can only be ordered in large quantities. Quantum Promotions will sell as few as 10 stress balls at once. They refer to these as "sample" shipments. You can order them by any of these methods:
    EMAIL: sales@quantumpromotions.com or contact the sales rep, Steve Tallman, at: stallman@quantumpromotions.com.
    FAX: 510-420-1930.

CALL toll free at: 1-877-776-6674.
For 10 stress balls, the quoted price as of June 2003 is $1.54/ea, plus shipping.

Project Adventure (www.pa.org) carries acceptable foam balls:
http://www.pa.org/description.asp?title=Foam+Balls

Toledo Physical Education Supply (www.tpesonline.com) has some acceptable foam balls that are about the right size and weight. Acceptable products are:
Product ID 4317 Super Foam No Bounce Balls
OR Product ID PSB Super Pinky Play Ball

- Golf Tees: golfing supply store
- Attached planet: Glue a small rubber ball or marble with super glue to a golf tee. Using super glue is the most effective and secure method. You don't want the ball flying off the tee and hitting someone. Alternatively, you can wrap a small ball of clay around the end of the golf tee.
- Clay: Craft store, toy store

TELESCOPE TREASURE HUNT:
HOW DO STARS AND PLANETS FORM?

Quick Links

About the Activity:

- What's this activity about?
- Helpful Hints
- Background Information
- Detailed Activity Description

Materials:

- What materials from the tool kit do I need?
- What do I need to prepare?
- What must I supply?
- Where do I get additional materials?

What's this activity about?

Big Question: How do stars and planets form?

Big Activity: Tour the telescopes to hunt for different objects that contribute to stellar and planetary formation, using a set of stickers and a Treasure List.

Participants: Adults, teens, families with children 5 years and up
If a school/youth group, 5th grade and higher
No minimum or maximum number of participants
Minimum of 3 presenters

Duration: 30 to 90 minutes

Topics Covered:

- An overview of how stars and their planets form

Activities:

Participants tour the telescopes to hunt for different objects that contribute to stellar and planetary formation, using a set of stickers and a Treasure List. Participants place one of their stickers next to each type of object they view. Alternatively, if no stickers are available, the participants can mark each item with a pen or pencil. When all the items on the Treasure List are found, one of the astronomers signs off on it.

Helpful Hints

To simplify/shorten: Carry out Telescope Treasure Hunt activity without using stickers. Participants mark items they find with pen or pencil. Kids really enjoy the stickers, though.

Background Information

A description of how each type of object contributes to star and planet formation is on the Treasure List. For more information: http://planetquest.jpl.nasa.gov/science/origins.html

Please Note: Not all objects needed for the Treasure Hunt are visible in the sky all year around (see **NOTE**s below).

Examples of objects in each category on the Treasure List:

Supernova Remnant:

M1: Crab Nebula
NGC 6960 & NGC 6992: Veil Nebula

NOTE: There are **no "Supernova Remnants"** visible through amateur telescopes from about **mid-April to the end of June** in the early evening (before 11 p.m.). The Crab Nebula is no longer visible after mid-April and the Veil Nebula does not get high enough to be seen (and only under very dark skies) until the beginning of July.

Planetary Nebula:

M57: Ring Nebula
M27: Dumbbell Nebula
NGC 2392: Eskimo or Clown Nebula

Clouds of Gas and Dust (star forming regions):

M8: Lagoon Nebula
M20: Trifid Nebula
NGC 7000: North American Nebula
M42: Orion Nebula

NOTE: There are **no "Clouds of Gas and Dust"** visible through amateur telescopes from **May to the end of June** in the early evening (before 11 p.m.). The Orion Nebula is no longer visible after the end of April and the Lagoon (M8), the Trifid (M20), and the North American Nebula (NGC 7000) all start coming into view toward the end of June.

Open Star Clusters:

M11: Wild Duck
M45: Pleiades
NGC 869 and 884: Perseus Double Cluster

A Star with Planets:

See the star maps in the Activity: "Where are the Distant Worlds?"

A Planet Orbiting our Sun:

Check your favorite astronomy reference or magazine for star maps that show planets visible at the time you are observing

Detailed Activity Description

<table>
<tr><th>Leader's Role</th><th>Participants' Roles (Anticipated)</th></tr>
<tr><td>Preparation:

<u>To Do:</u>
1. Each participating amateur astronomer may pick any object(s) he or she wishes to show and that his or her telescope is capable of viewing.
2. Prepare the astronomers by giving each person a copy of the Treasure List. Explain that your visitors will have these and be on a "treasure hunt" to look at these objects. The information on the back of the Treasure List may give each astronomer some talking points about their object. (Of course, there may be objects that some of the astronomers will be viewing that are not on the Treasure List – like the Moon, globular clusters, or another galaxy – you can refer to these as "bonus" or "surprise" items).
3. Optional: Hand out ASK ME ABOUT OTHER WORLDS badges to the astronomers.</td><td rowspan="2"></td></tr>
<tr><td><u>Note:</u>
If examples of one or more of the objects on the Treasure List are not accessible (sky too bright, out of range of the telescopes, no examples far enough above the horizon) of the items on the Treasure List, you can have someone explaining about the object (e.g. supernova remnant Crab Nebula) and indicating its position in the sky if it was dark enough to see it, or when you would be able to see it.</td></tr>
<tr><td>Introduction:
Introduce the activity and explain to the participants what to expect. You can use the following script, if you wish:

<u>To Say:</u>
Tonight, you will be on a treasure hunt as you tour the telescopes. You can find many different and exotic objects found in our Galaxy that contribute to the formation of stars and planets. Travel from telescope to telescope and hunt for these amazing objects. You will receive a Treasure List and set of stickers. For each object on the Treasure List that you see through a telescope, place one of your stickers next to that object. (Hold up the Treasure List)</td><td>Participants tour from one telescope to another to view different objects in the night sky.

At each telescope, participants can place a sticker on their Treasure List next to the object they viewed.</td></tr>
</table>

To Say (continued): When you have found all the items on the Treasure List, take the List to any one of the astronomers and he or she will sign off on your Treasure List. Look up at all the stars. Where do you think they come from? Have they always been there? How many of these do you think we will find planets around – like the planet you are standing on? Tonight, you will see a star, other than our own Sun, that actually has been found to have planets orbiting around it. You won't be able to see the planets themselves, but as you gaze at the star, imagine the kinds of planets orbiting the star – does it have any planets like ours? Any with life? Over the next 25 years, NASA will be sponsoring a series of missions that will answer those questions. So enjoy your treasure hunt and discover the secrets of the sky! You may pick up your Treasure Lists and stickers…<indicate how you are distributing the Treasure Lists and stickers>. *Or, even more simply:* Did you know that the calcium in your bones and the oxygen you breathe were formed inside of a star? Here's a Treasure List to take on a treasure hunt through the telescopes to view objects in the sky that make stars like our Sun and planets like the Earth we're standing on. Place one of these stickers next to each object you see.	 Discuss questions

Materials

What materials from the tool kit do I need?

- Sheets of stickers
- Treasure Lists
- Optional: 6 Badge Holders

If you have used up what was provided with the ToolKit, you can print these from the PLANETQUEST OUTREACH TOOLKIT MANUAL *(See "What do I need to prepare" section below):*

- Treasure List: Pages for the 2-sided Treasure List "How do stars and planets form?" (see next page) to hand out to the participants. A place is reserved at the bottom of the second page of the Treasure List for your club contact information and club logo. (Back side of the Treasure List)
- **Ask Me About Other Worlds Badges:** These can be worn at any of your events. These are designed to fit on Avery Name Badges (style number 5392). Or you may print them to plain paper and cut them out. **INSTRUCTIONS FOR PRINTING:** Adobe Acrobat Reader has a default printing feature that shrinks oversized documents to fit the page. Even though Ask Me About Other Worlds Badges page is not oversized, Acrobat will automatically shrink it, which will cause the badges to not print properly. The way to avoid this is to deselect the shrink option in the File>Print box. It is called different things depending on which version of Acrobat you are using and whether you are on a PC or a Mac. It can be called "fit to page", "fit to paper", "page scaling", "shrink large pages", or "shrink oversized pages to fit paper size". Whatever it is called, the option needs to be unchecked or deselected in order for the badges to print properly. It is recommended that you print the file on plain paper first to make sure it looks okay before printing to the badge paper.

What must I supply?

- Telescopes

What do I need to prepare?

- Make as many copies of the Treasure Lists as you might need for your visitors. These are designed to be a two-sided sheet. **NOTE**: You may want to add your club contact information and club logo on the bottom of the second page in the reserved space.
- You may want to cut the stickers into strips of 6 to 8 stickers each to pass out to the participants.
- Insert "Ask Me About Other Worlds" badges into the badge holders.

Where do I get additional materials?

- Badge Holders: These are 3" x 4" pin style name badges. Many suppliers are on the Internet or try your local computer or office supply store.
- Stickers for the participants to place on their Treasure Lists: You can purchase a variety of stickers from your local office supply store. Also try Teacher-Created Materials at http://www.teachercreated.com/ . The stickers in the ToolKit are Item #1816.


ASK ME ABOUT
OTHER
WORLDS
Art Credit: Lynette Cook
PLANETQUEST
the search for another Earth

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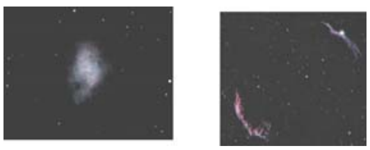
How do stars and planets form?

For over 400 years astronomers have been asking this question and we still only have some of the answers.

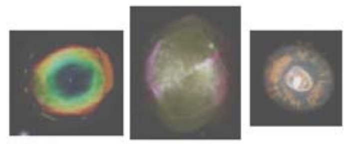
Visit the telescopes to hunt for these objects that contribute to building planets like the Earth you are standing on. Place a sticker next to each type of object you see.

1



Type: Supernova Remnant – The remains of an exploded star

2

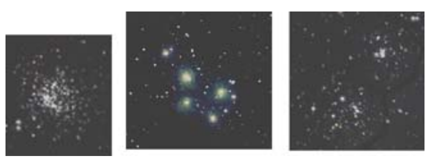


Type: Planetary Nebula – a Dying Star

3

Type: Cloud of Gas and Dust – Star Nursery

4



Type: Open Star Cluster – Young Stars

5

Venus Mars Jupiter Saturn

A Planet Orbiting our Sun

6 **A Star with Planets**

Find a star where planets formed

Treasure Hunt Completed! ______________________________________ Date ______________

Images courtesy of Starry Night Pro™ SPACE.com www.starrynight.com . Extrasolar planet image by Lynette Cook.

1. Supernova Remnant

A massive star ends its life in a spectacular supernova explosion with the brilliance of 100 million Suns. A rapidly expanding, glowing shell of material called a supernova remnant contains silicon, iron, and carbon formed inside the star during its life, as well as heavier elements like copper and lead forged in the explosion.

Space is enriched with the ingredients to make new stars and planets. And life. The iron in your blood originated inside of a star.

2. Planetary Nebula – A Dying Star

After living for billions of years, a star like our Sun dies, slowly ejecting its outer layers and enriching space with a variety of elements essential for life as we know it.

One of these elements, oxygen, can combine with the hydrogen gas in space to make water for future planetary systems and the life that might evolve on them.

3. Clouds of Gas and Dust

Huge clouds of gas and dust hundreds of light years across reside between the stars. Denser areas of the cloud collapse under the force of gravity to form new stars, recycling the material ejected from supernovae and dying stars.

4. Open Star Cluster

Born together from the same cloud of gas and dust, open clusters of stars eventually overcome their mutual gravitational attraction and drift apart. Many remain linked as double or triple star systems. Others live alone, like our Sun. There may be planets around some of these stars!

5. A Planet Orbiting our Sun

Our Sun is a star that has planets. From a few light years away, our Sun would look like any other star. Do you suppose a civilization living on a planet around another star can see one of the Sun's planets?

6. A Star with Planets

Astronomers have discovered over 100 planets around other stars. These are called extrasolar planets. Do you suppose the star you saw might have a planet with life, like our Solar System does?

Find out more about upcoming NASA missions to study stars and their planets:
http://planetquest.jpl.nasa.gov/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Art Credit: Lynette Cook
PLANETQUEST
the search for another Earth


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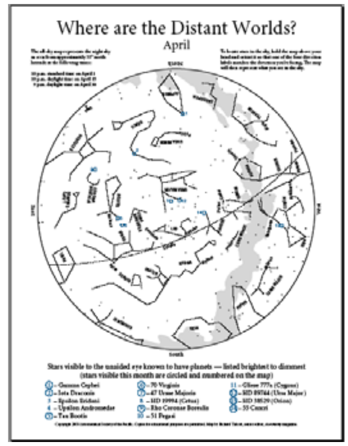
WHERE ARE THE DISTANT WORLDS?

Quick Links



What's this activity about?

Big Question: Where are the distant worlds in the night sky?

Big Activity: Use a star map to find constellations and to identify stars with extrasolar planets.

Participants: Adults, teens, families with children 8 years and up
If a school/youth group, 5th grade and higher
1 to 4 participants per map

Duration: Varies (however long you choose to observe constellations)

Topics Covered:

- How to find Constellations
- Where we have found planets around other stars

Activities:

1. At a star party, pass out to your visitors a monthly star map marked with stars with extrasolar planets - Northern Hemisphere only, and naked eye only.
2. Discuss information included on the Planetary PostCards about the star and its planetary system.
3. Discuss upcoming NASA missions to discover more about these and other planetary systems

Helpful Hints:

- TO PROMOTE YOUR CLUB: You may want to copy your club's information and schedule on the back side of the star map which you hand out.

- Emphasize that the stars marked on the star maps have planetary systems of their own, just like our star, the Sun, does.

- When you discuss other stars that have planets, some people may think you mean that some of OUR planets (like Jupiter or Saturn) are near other stars. A common misconception is that the stars are sprinkled among the planets of our Solar System. A discussion of stellar distances is instructive. The visible part of our Milky Way Galaxy is about 100,000 light years across and where we are it is about 1000 light years thick. You can use an example where the distance across our Solar System is a bit bigger than a quarter (with the Sun as a grain of sand in the center of the quarter) and the NEAREST star (4 light years away) is 2 football-field lengths away. The Milky Way Galaxy would span the United States (about 2500 miles) and be about 25 miles thick – about the same relative dimensions as a CD (100 to 1). To imagine the 200 billion stars in our Galaxy, think of building a four-foot high wall all around a football field and then filling it with birdseed. That's roughly 200 billion bird seeds. Now imagine distributing those seeds (stars) over the entire USA, 25 miles deep. The stars are VERY far apart!

Milky Way Galaxy dimensions are like a CD

- If the participant has heard of the Voyager missions from the 1970's, these spacecraft have passed well beyond the orbit of Pluto. Many people think these spacecraft are now "among the stars". On the slightly-larger-than-quarter-sized model of our Solar System, The Voyager spacecraft are only about 2-3 inches beyond the edge of the quarter – still VERY far from even the nearest star.

- You may want to begin this activity with the "wobble" demonstration from the "How Do We Find Planets Around Other Stars" activity.

Background Information:

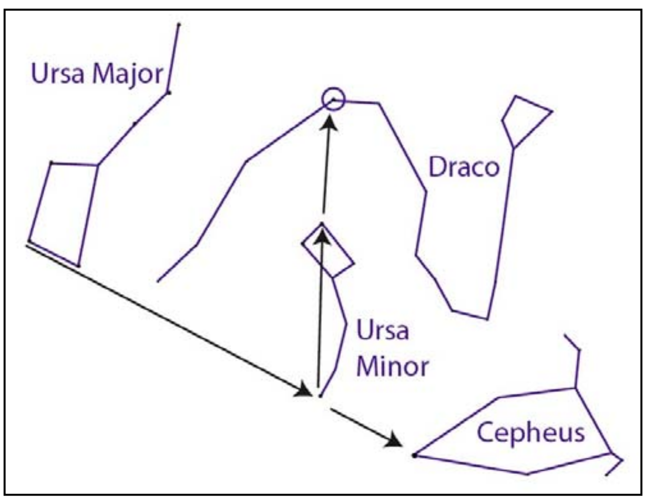
- **Planet Naming Conventions**:

  You may have noticed that the planets around a star are named b, c, d, as in gamma Cephei b, or Upsilon Andromeda b, Upsilon Andromeda c, and so on.

  You may have wondered why there is no "a" planet. As premier extra-solar planet hunter Debra Fisher explains it:
  "The "A" component is reserved for the star. The default naming convention (since the IAU hasn't jumped in) is that the first detected planet is "b" continuing alphabetically. Usually, the first detected planet is the inner one (Keplerian biases) but in one case, GJ 876, the outer planet was discovered first. So GJ 876 b is the outer planet, and GJ 876 c is the inner planet."
  (The IAU is the Internal Astronomical Union and is the organization that performs such tasks as setting naming conventions of astronomical objects.)

  Note also that when there is a binary star, the two stars are called, for example, Sirius A and Sirius B. The upper case A or B refers to stars. Lower case b, c, etc. refers to the planets.

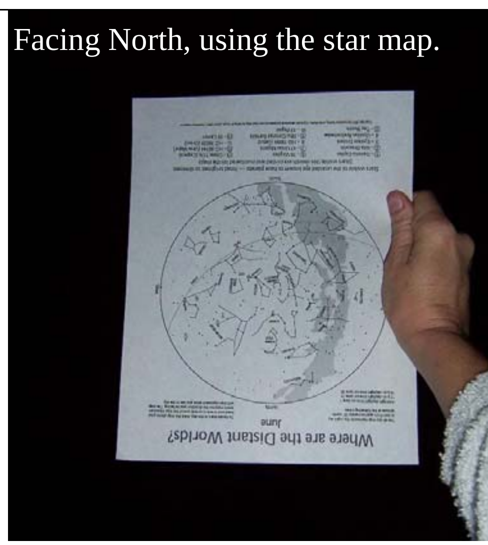
- **Finding the brightest stars with planets**



The two brightest Northern Hemisphere stars with planets are gamma Cephei and iota Draconis. Fortunately they are visible almost all year and are fairly easy to find, even though they are only about 3rd magnitude. Note in the figure that you can use the pointer stars from the Big Dipper to point to the North Star (Polaris) and then just continue on another 20 degrees or so to gamma Cephei. Iota Draconis is found by starting at the North Star, drawing a line through the star at the "bottom" of the Little Dipper and continuing on to iota Draconis.

For more information on locations of distant worlds and for a 3-D interactive of where the distant worlds are: http://planetquest1.jpl.nasa.gov/atlas/atlas_index.cfm
Or look in the *Multimedia_Gallery* folder on the PLANETQUEST OUTREACH TOOLKIT MANUAL AND RESOURCES CD and go into the Interactive_Gallery > index.html > 3D New Worlds Atlas.

ACTIVITY DESCRIPTION

Leader's Role	**Participants' Roles (Anticipated)**
Introduction: *To Ask:* Who has heard that scientists have found planets around stars other than our own Sun? How many of these stars might you think have been found? Anyone ever see a star that has planets around it? (our own Sun, some may know of other stars) We can't see the planets around other stars, but we can see the star. We can also show you a picture of what the system might look like. *To Say:* We're going to look at a map that will show us where to find these stars in the sky. NASA missions are being designed right now to find more stars with planets and to find out which planets might have life! We'll use the star map to find the constellations the stars are in and then find the stars with planets.	Participants begin to think about and respond to questions about extrasolar planets beyond our Solar System.
To Ask: What's a constellation? (make sure the participants understand)	Participants share, learn, or are reminded of what constitutes a constellation.
To Do: Demonstrate how to use the star map to find a constellation and one of the stars. Assist participants in finding other constellations and stars with planets. **To demonstrate how to use a star map:** If facing North, hold the map up against the sky and orient the star map so that North on the map is down - toward the northern horizon (see photo to the right). If facing East, orient the map so that East on the star map is down toward the eastern horizon.  Facing North, using the star map.	Participants practice using a star map to find constellations and stars with planets.

<table>
<tr><td><u>To Do:</u>
Show participants the Planetary PostCard for the star they found in the sky. You will need a small flashlight.</td><td></td></tr>
<tr><td><u>To Ask:</u>
Using the Planetary PostCard you can ask questions to stimulate discussion:
• That star is hotter/colder than our Sun. How do you think that might affect its planets?
• Here is where one of the planets orbits that star. What would it be like to live on this planet (or one of its moons)?
• If Earth was orbiting that star, what might be different?
• How big do you suppose this planet is compared to the planets in our Solar System?
• Do you think we have found all the planets in this system?</td><td>Think about and discuss another planetary system</td></tr>
<tr><td><u>Additional Discussion on Epsilon Eridani – the nearest star we know of with planets (besides the Sun!)</u>
<u>To Say:</u>
The fastest speed recorded for a spacecraft was 150,000 miles per hour, reached by the Helios satellite that is in orbit around the Sun. That's 42 miles per second.
<u>To Ask:</u>
How long do you would it take to for someone living on Epsilon Eridani's planet about 10 light years away, to get into our Solar System if they were traveling at the speed of our fastest spacecraft (light travels at 186,000 miles per second and our fastest spacecraft travels at about 42 miles per second)? Or for us to reach them?

The spacecraft would travel at 2/10,000th the speed of light (42 divided by 186,000 = 0.00022). So 1 light year would take 5,000 years. Epsilon Eridani is about 10 light years from us. So . . . 10 years X 5,000 = 50,000 YEARS to get there.

<u>To Discuss:</u>
• What would we have to do to take such a trip?
• How would we stay in communication with the spacecraft?
• Would a manned or unmanned spacecraft be a better idea? Why?
• How long would it take for us to know the spacecraft had arrived?
• How different do you think Earth will be in 50,000 years?</td><td></td></tr>
</table>

Materials:

What materials from the ToolKit do I need?

- Planetary PostCards – the ToolKit included printed sets of some of them. All of the available Planetary PostCards are in this Outreach ToolKit Manual in the Planetary PostCards section. You may print out and assemble as many copies as you need.

- Star map for the current month marked with stars that are known to have planetary systems. These maps are in the Distant Worlds Star Maps section in this Outreach ToolKit Manual. These maps are generic for any year. There are no planets or deep sky objects on these maps.

- For more detailed information about each star's planetary system, print out the Visible Stars with Planets page

What do I need to prepare?

- You may want to prepare a page to photocopy onto the reverse side of the star maps that has your club information on it, e.g. logo, name, contact information, schedules.
- As many copies of star maps as you need for the participants
- Print out (or photocopy) a set of Planetary PostCards, if desired, for each participating amateur astronomer.

What must I supply?

- Small flashlight if using the Planetary PostCards

Copyright Notice:

The artist's conception images of the planetary systems on the front of the Planetary PostCards are copyrighted by Lynette Cook. You have permission to make photocopies of these cards or print out and copy the images from this Manual. You may not reproduce the images in any other manner. You may only use the images in your education and public outreach events. Permission of the artist, Lynette Cook, must be obtained for any additional use of the artwork.

The reverse side of the Planetary PostCards can be copied and used for any education and public outreach use.

You may want to change the reverse side of the cards to include your club's information if you want to use them as handouts at star parties.

Where do I get additional materials?

- Photocopy as needed or print from this manual:
  - Planetary PostCards
  - Distant Worlds Star Maps

Visible Stars with Planets (Brightest to Dimmest)

	Constell-ation	Host Star	Distance from Earth (light-years)	Appar-ent Mag.	Star data / Spec Type	Star Surface Temp (K) est.	Solar Masses / Solar Radii	Planets	Planet Mass (Jupiter=1)	Eccent ricity	Avg Dist from Star (AU)	Orbital Period
1	Cepheus	gamma Cephei	38.5	3.225	Binary 12 AU apart – 40 yr period / K1 IV RedGiant	4900	1.6 / 4.7	b	1.76	0.2	2	2.5 yrs
2	Draco	Iota Draconis	100	3.3	K2III RedGiant	4420	1.05 / 13	b	8.7	0.71	1.3	550.651 days
3	Eridanus	Epsilon Eridani	10.4	3.73	K2V	5180	0.85 / ?	b	0.86	0.6	3.3	2502.1 dys (6.85 yrs)
			10.4	3.73	K2V	5180	0.85 / ?	c	0.1	0.3	40	260 yrs
4	Andromeda	Upsilon Andromedae	43.9	4.09	F8V	6200	1.3 / 1.6	b	0.71	0.04	0.06	4.6 days
								c	2.11	0.23	0.83	242 days
								d	4.61	0.36	2.5	1266.6 dys
5	Bootes	tau Bootes	49	4.5	F7V	6300	1.2 / 1.2	**b**	3.87	0.018	0.046	3.3 days
6	Virgo	70 Virginis	72	5	G5V	5200	0.95 / 1.9	b	6.6	0.4	0.43	116.6 days
7	Cetus	HD 19994	73	5.07	F8V	6160	1.35 / ?	b	2	0.2	1.3	454 days
8	Ursa Major	47 Ursae Majoris	43	5.1	G0V	5600	1.03 / 1	b	2.41	0.096	2.1	1095 days
								c	0.76	0.1	3.73	2594 days

	Constell-ation	Host Star	Distance from Earth (light-years)	Appar-ent Mag.	Star data / Spec Type	Star Surface Temp (K) est.	Solar Masses / Solar Radii	Planets	Planet Mass (Jupiter=1)	Eccentricity	Avg Dist from Star (AU)	Orbital Period
9	Corona Borealis	rho Coronae Borealis	55	5.4	G2V	5700	1 / ?	b	1.1	0.028	0.23	39.65 dys
10	Pegasus	51 Pegasi	48	5.5	G2.5V	5770	1.05 / 1.4	b	0.47	0	0.05	4.23 dys
11	Ursa Major	HD 89744	130	5.7	F7V	6166	1.4 / ?	b	7.2	0.7	0.88	256 dys
12	Cygnus	Gliese 777A	51.8	5.71				b	1.15			
13	Orion	HD 38529	138	5.94	G4	5800	1.39 ?	b	0.77	0.312	0.12	14.3 dys
								c	11.3	0.34	3.51	2189 dys
14	Cancer	55 Cancri	44	5.95	G8V	5570	1.03 / ?	b	0.84	0.03	0.115	14.65 dys
								c	0.21	0.34	0.24	44.26 dys
								d	4	0.16	5.9	2785 dys

References:
http://planetquest.jpl.nasa.gov/
http://www.extrasolar.net/mainframes.html
http://www.solstation.com/stars2/ups-and.htm

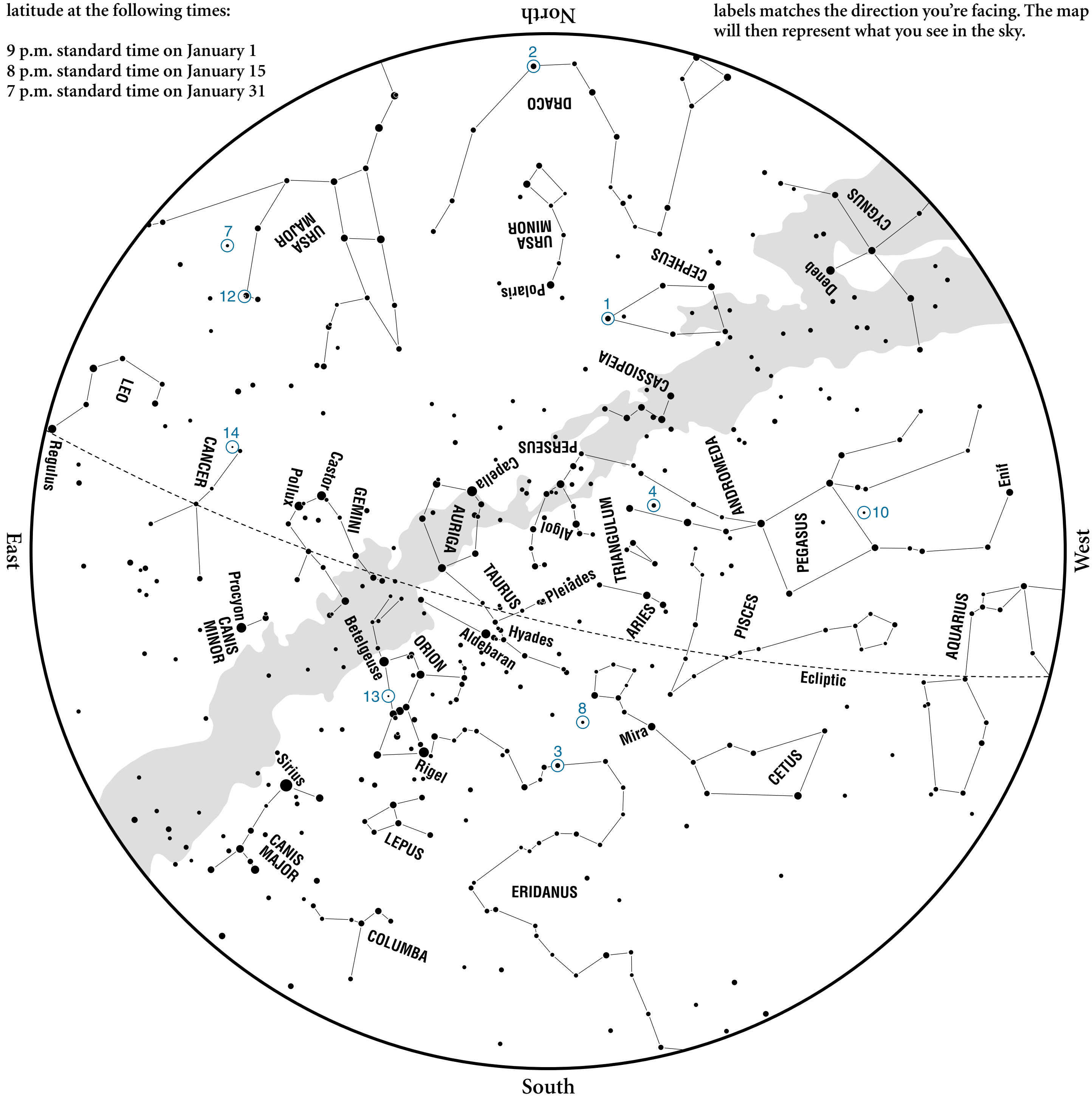
Where are the Distant Worlds?

January

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

9 p.m. standard time on January 1
8 p.m. standard time on January 15
7 p.m. standard time on January 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.



Stars visible to the unaided eye known to have planets — listed brightest to dimmest
(stars visible this month are circled and numbered on the map)

1 – Gamma Cephei
2 – Iota Draconis
3 – Epsilon Eridani
4 – Upsilon Andromedae
5 – Tau Bootis
6 – 70 Virginis
7 – 47 Ursae Majoris
8 – HD 19994 (Cetus)
9 – Rho Coronae Borealis
10 – 51 Pegasi
11 – Gliese 777a (Cygnus)
12 – HD 89744 (Ursa Major)
13 – HD 38529 (Orion)
14 – 55 Cancri

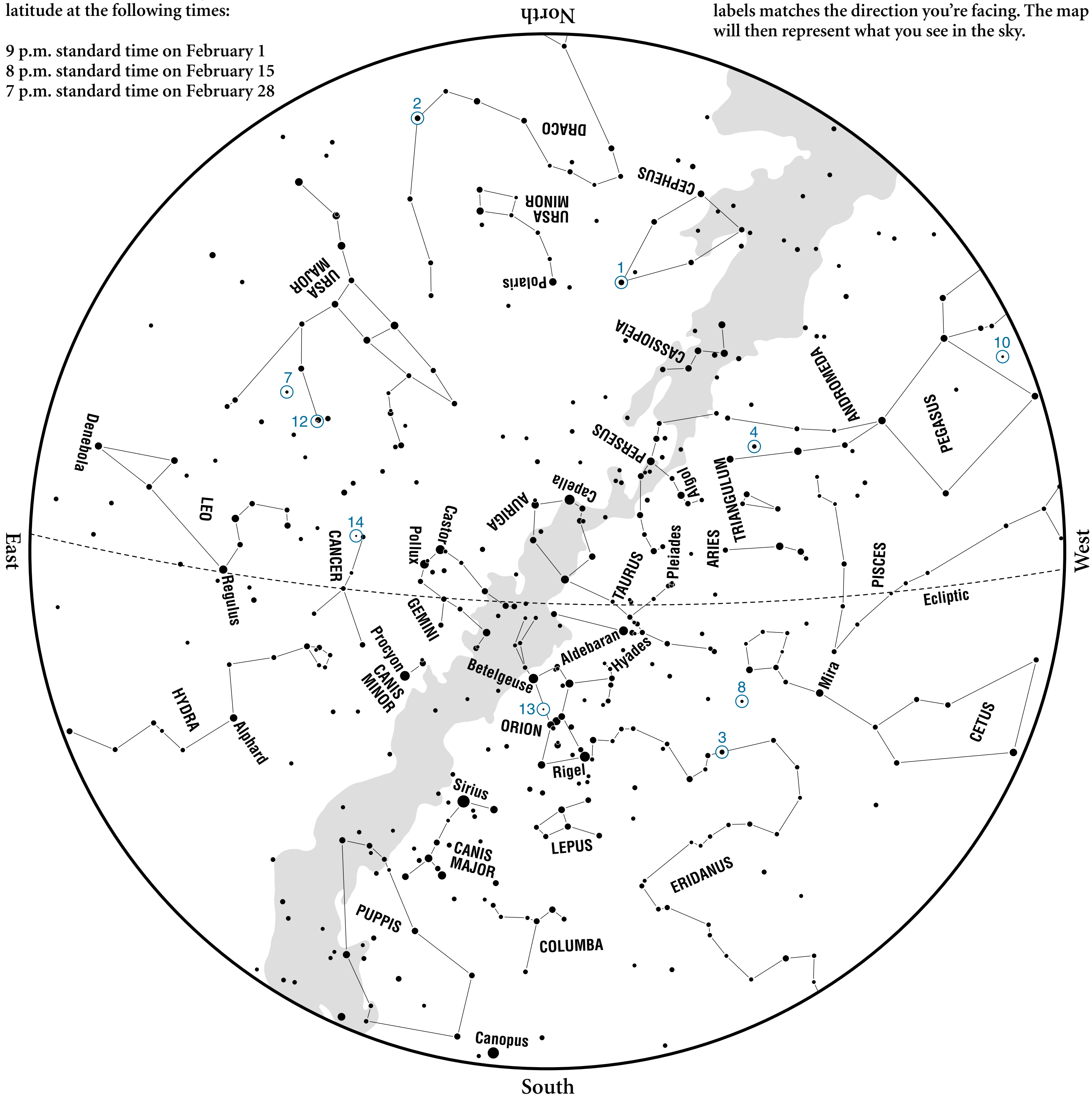
Where are the Distant Worlds?

February

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

9 p.m. standard time on February 1
8 p.m. standard time on February 15
7 p.m. standard time on February 28

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.



Stars visible to the unaided eye known to have planets — listed brightest to dimmest (stars visible this month are circled and numbered on the map)

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11 – Gliese 777a (Cygnus)
12 – HD 89744 (Ursa Major)
13 – HD 38529 (Orion)
14 – 55 Cancri

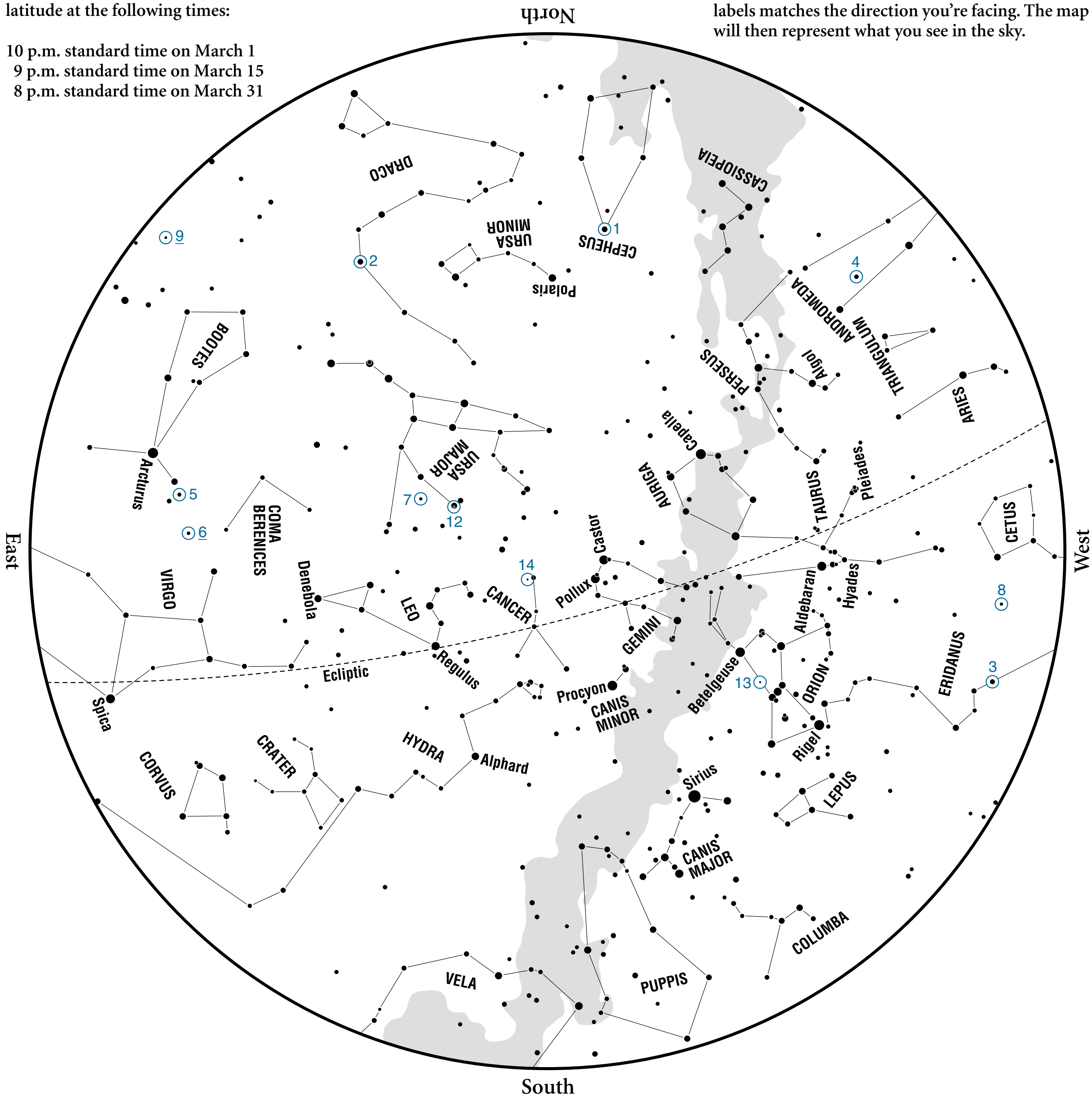
Where are the Distant Worlds?

March

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

10 p.m. standard time on March 1
9 p.m. standard time on March 15
8 p.m. standard time on March 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.



Stars visible to the unaided eye known to have planets — listed brightest to dimmest (stars visible this month are circled and numbered on the map)

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10 – 51 Pegasi
11 – Gliese 777a (Cygnus)
12 – HD 89744 (Ursa Major)
13 – HD 38529 (Orion)
14 – 55 Cancri

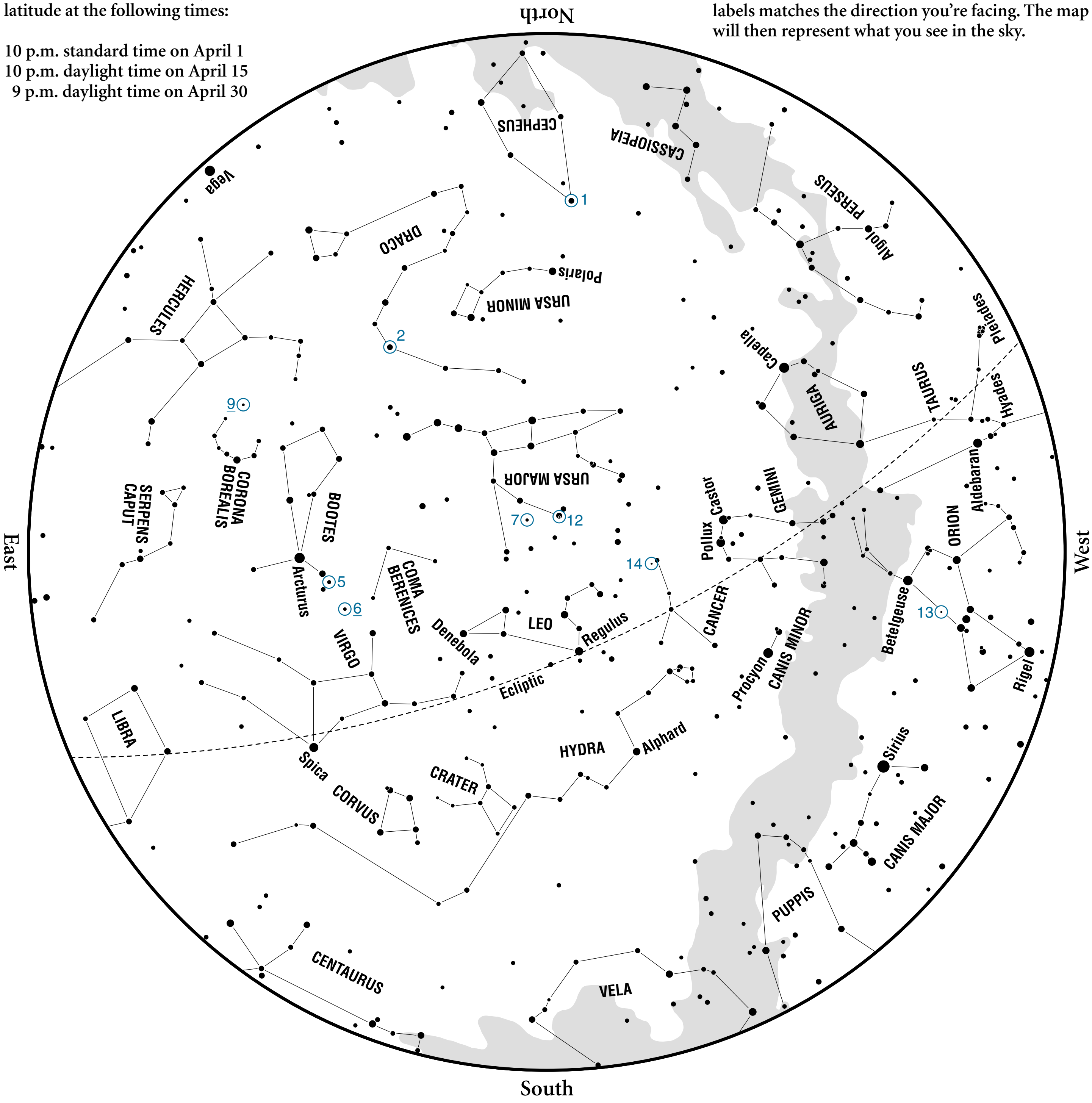
Where are the Distant Worlds?

April

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

10 p.m. standard time on April 1
10 p.m. daylight time on April 15
9 p.m. daylight time on April 30

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.



Stars visible to the unaided eye known to have planets — listed brightest to dimmest (stars visible this month are circled and numbered on the map)

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11 – Gliese 777a (Cygnus)
12 – HD 89744 (Ursa Major)
13 – HD 38529 (Orion)
14 – 55 Cancri

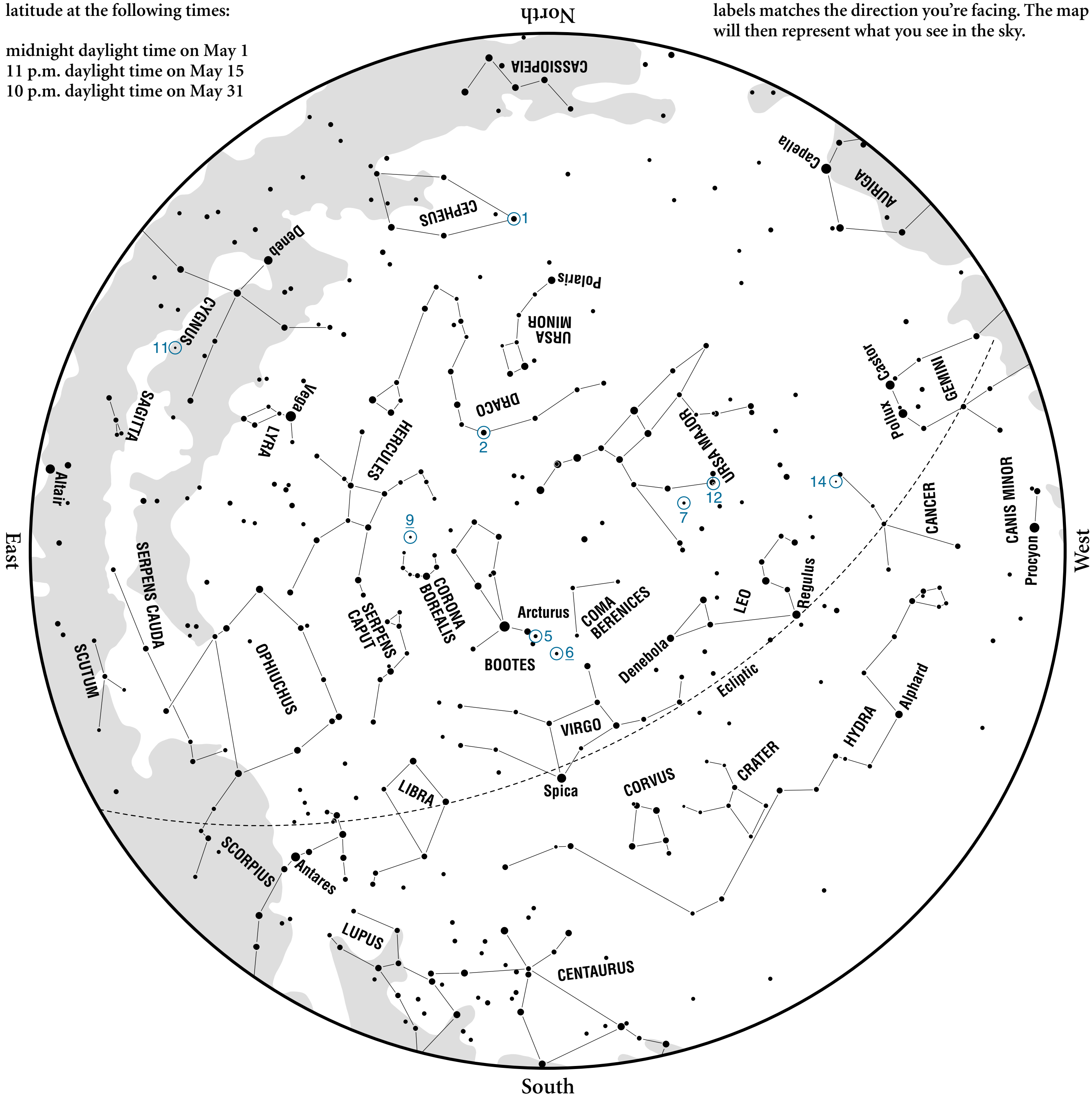
Where are the Distant Worlds?

May

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

midnight daylight time on May 1
11 p.m. daylight time on May 15
10 p.m. daylight time on May 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.



Stars visible to the unaided eye known to have planets — listed brightest to dimmest (stars visible this month are circled and numbered on the map)

(1) – Gamma Cephei	(6) – 70 Virginis	(11) – Gliese 777a (Cygnus)
(2) – Iota Draconis	(7) – 47 Ursae Majoris	(12) – HD 89744 (Ursa Major)
3 – Epsilon Eridani	8 – HD 19994 (Cetus)	13 – HD 38529 (Orion)
4 – Upsilon Andromedae	(9) – Rho Coronae Borealis	(14) – 55 Cancri
(5) – Tau Bootis	10 – 51 Pegasi	

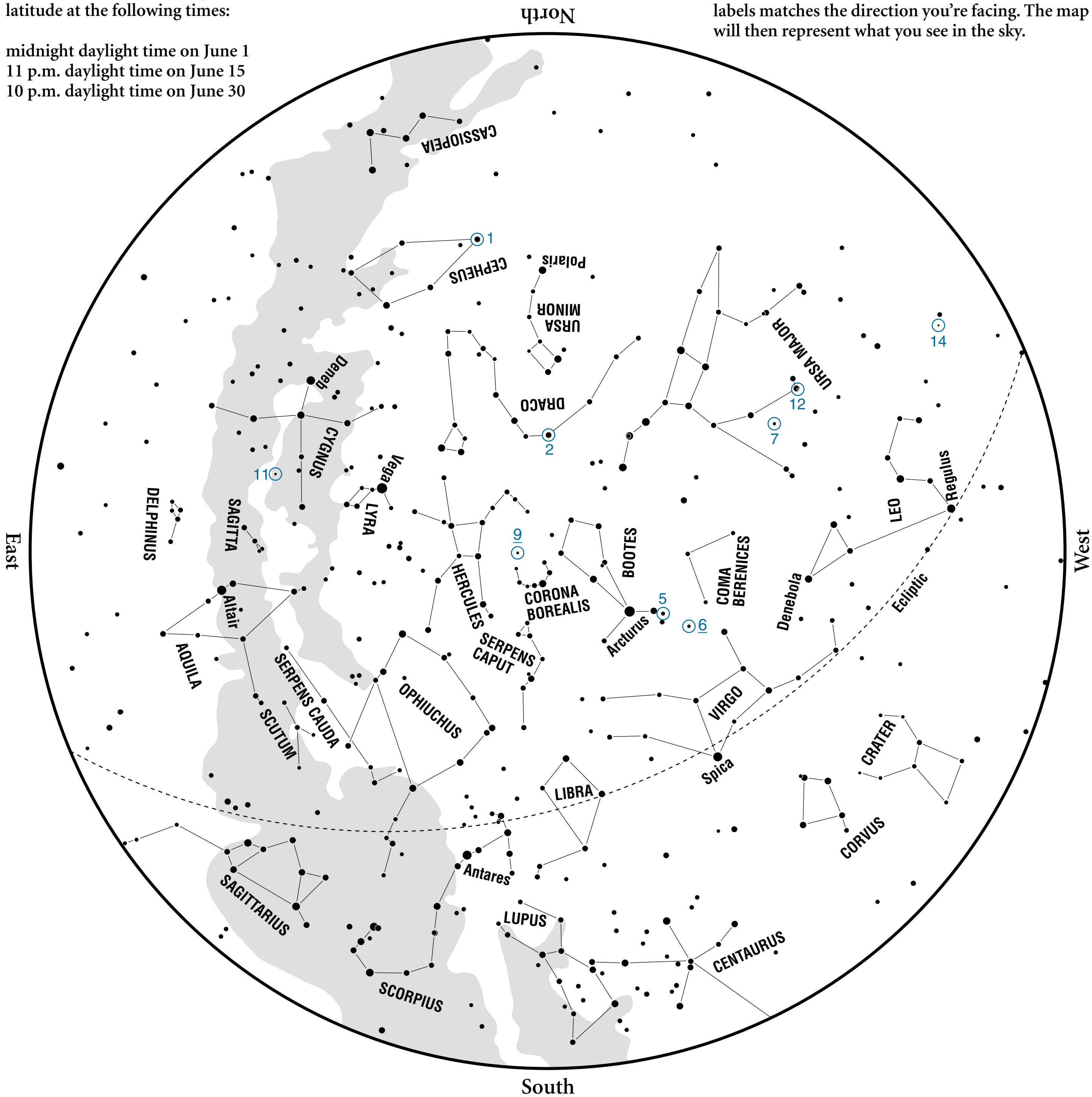
Where are the Distant Worlds?

June

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

midnight daylight time on June 1
11 p.m. daylight time on June 15
10 p.m. daylight time on June 30

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.



Stars visible to the unaided eye known to have planets — listed brightest to dimmest (stars visible this month are circled and numbered on the map)

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12 – HD 89744 (Ursa Major)
13 – HD 38529 (Orion)
14 – 55 Cancri

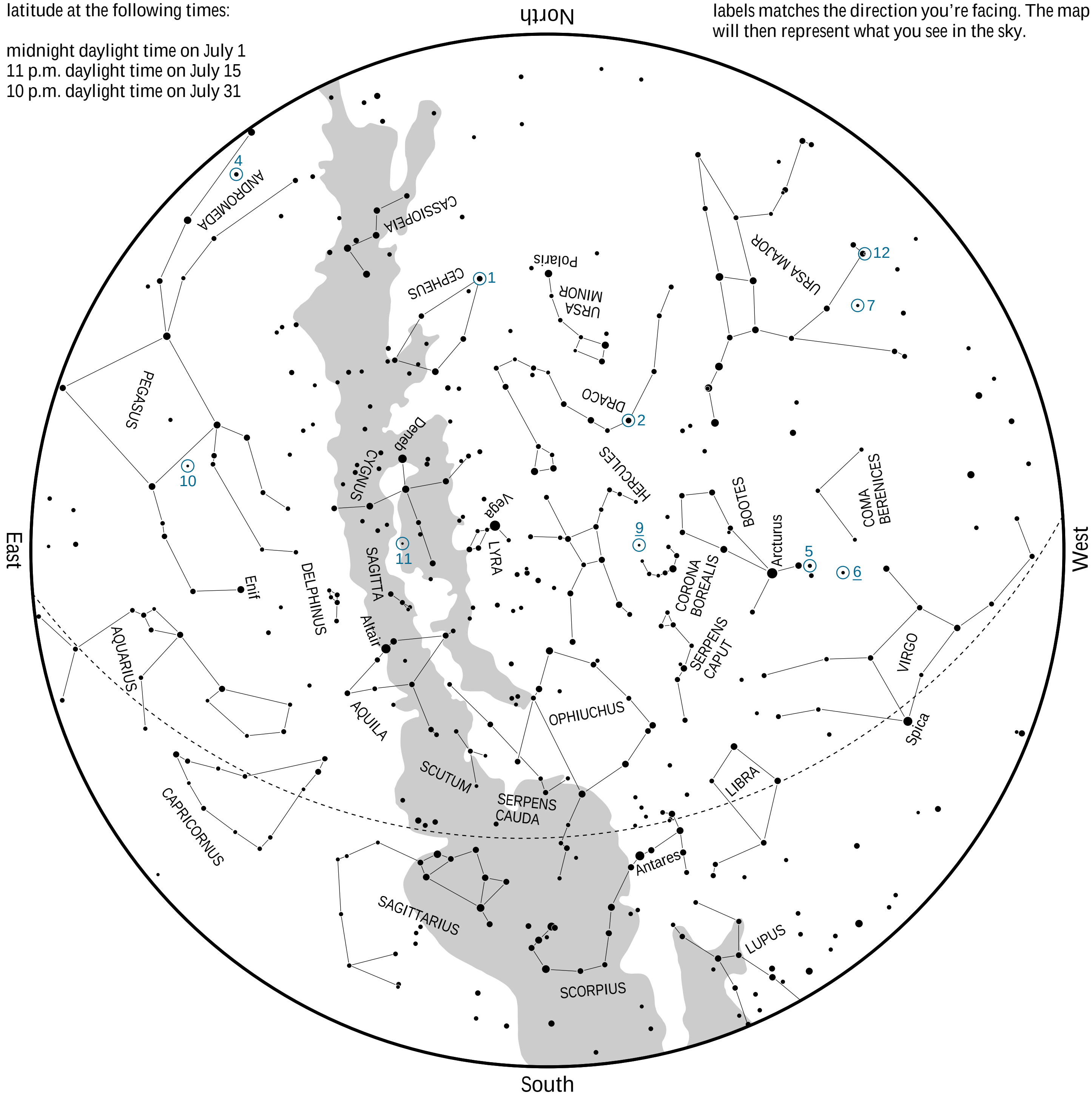
Where are the Distant Worlds?

July

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

midnight daylight time on July 1
11 p.m. daylight time on July 15
10 p.m. daylight time on July 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.



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11 – Gliese 777a (Cygnus)
12 – HD 89744 (Ursa Major)
13 – HD 38529 (Orion)
14 – 55 Cancri

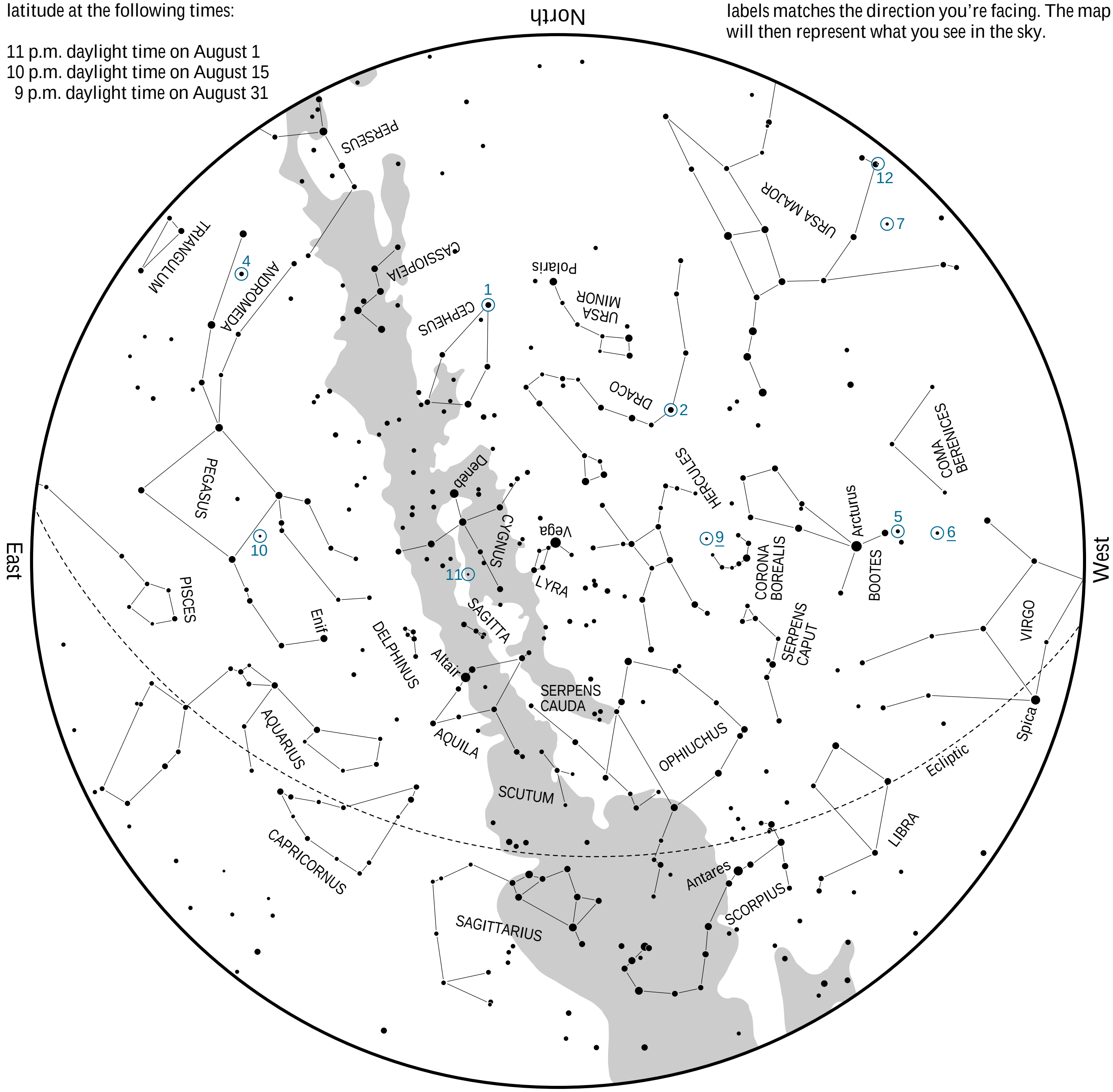
Where are the Distant Worlds?

August

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.



Stars visible to the unaided eye known to have planets — listed brightest to dimmest (stars visible this month are circled and numbered on the map)

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14 – 55 Cancri

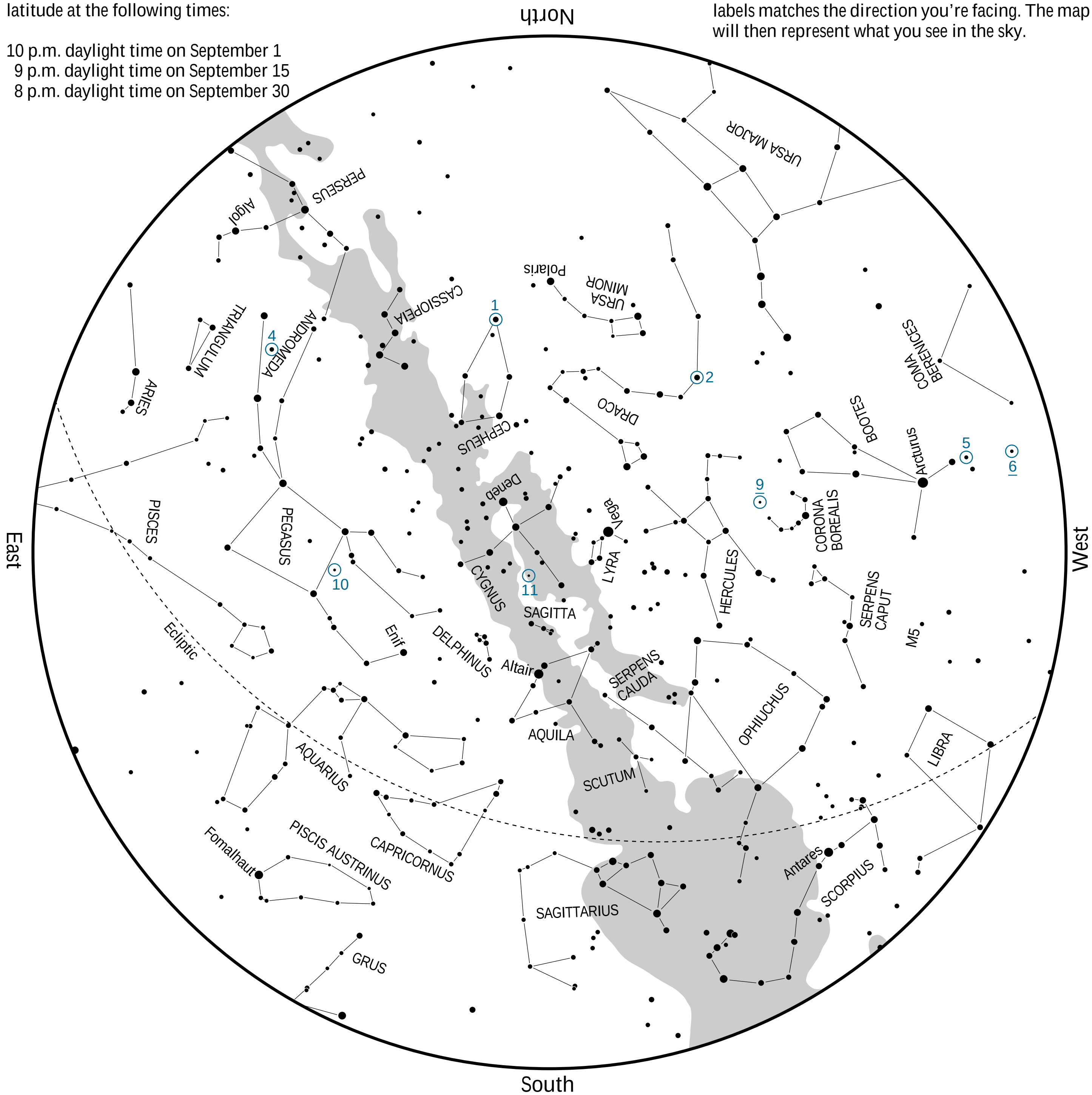
Where are the Distant Worlds?

September

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

10 p.m. daylight time on September 1
9 p.m. daylight time on September 15
8 p.m. daylight time on September 30

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.



Stars visible to the unaided eye known to have planets — listed brightest to dimmest
(stars visible this month are circled and numbered on the map)

1 – Gamma Cephei	6 – 70 Virginis	11 – Gliese 777a (Cygnus)
2 – Iota Draconis	7 – 47 Ursae Majoris	12 – HD 89744 (Ursa Major)
3 – Epsilon Eridani	8 – HD 19994 (Cetus)	13 – HD 38529 (Orion)
4 – Upsilon Andromedae	9 – Rho Coronae Borealis	14 – 55 Cancri
5 – Tau Bootis	10 – 51 Pegasi	

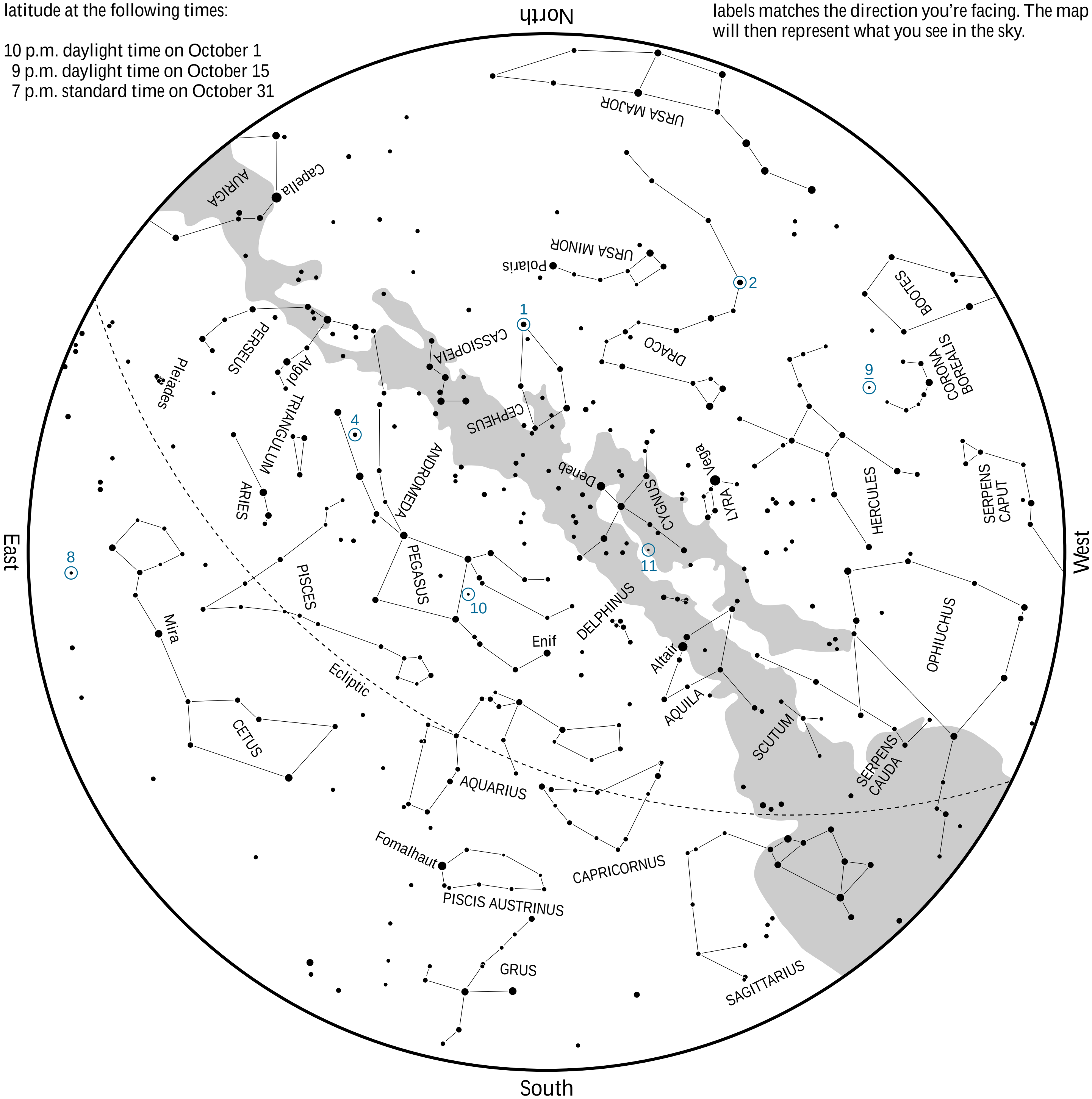
Where are the Distant Worlds?

October

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

10 p.m. daylight time on October 1
9 p.m. daylight time on October 15
7 p.m. standard time on October 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.



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Where are the Distant Worlds?

November

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

9 p.m. standard time on November 1
8 p.m. standard time on November 15
7 p.m. standard time on November 30

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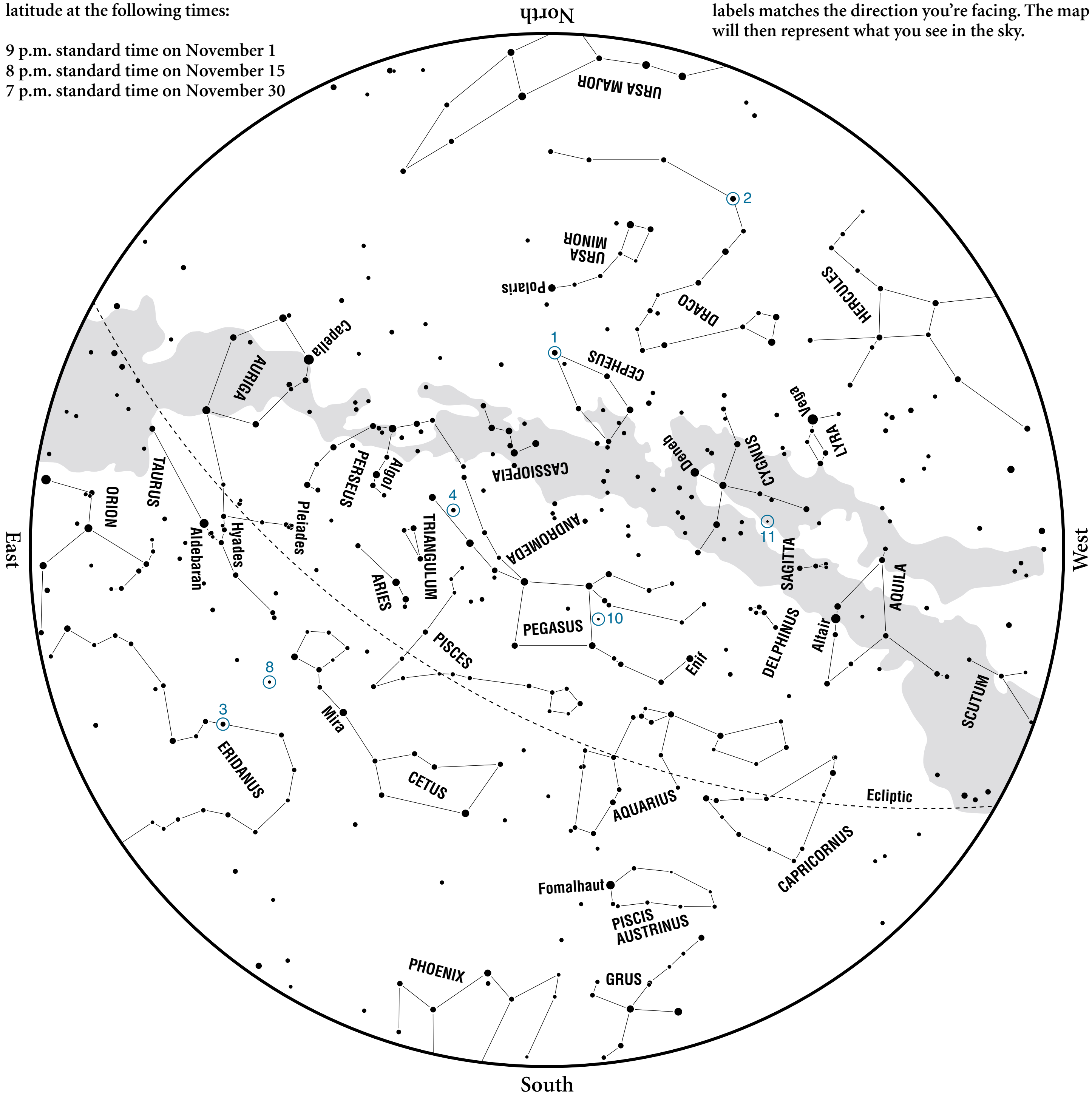

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14 – 55 Cancri

Where are the Distant Worlds?

December

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

9 p.m. standard time on December 1
8 p.m. standard time on December 15
7 p.m. standard time on December 31

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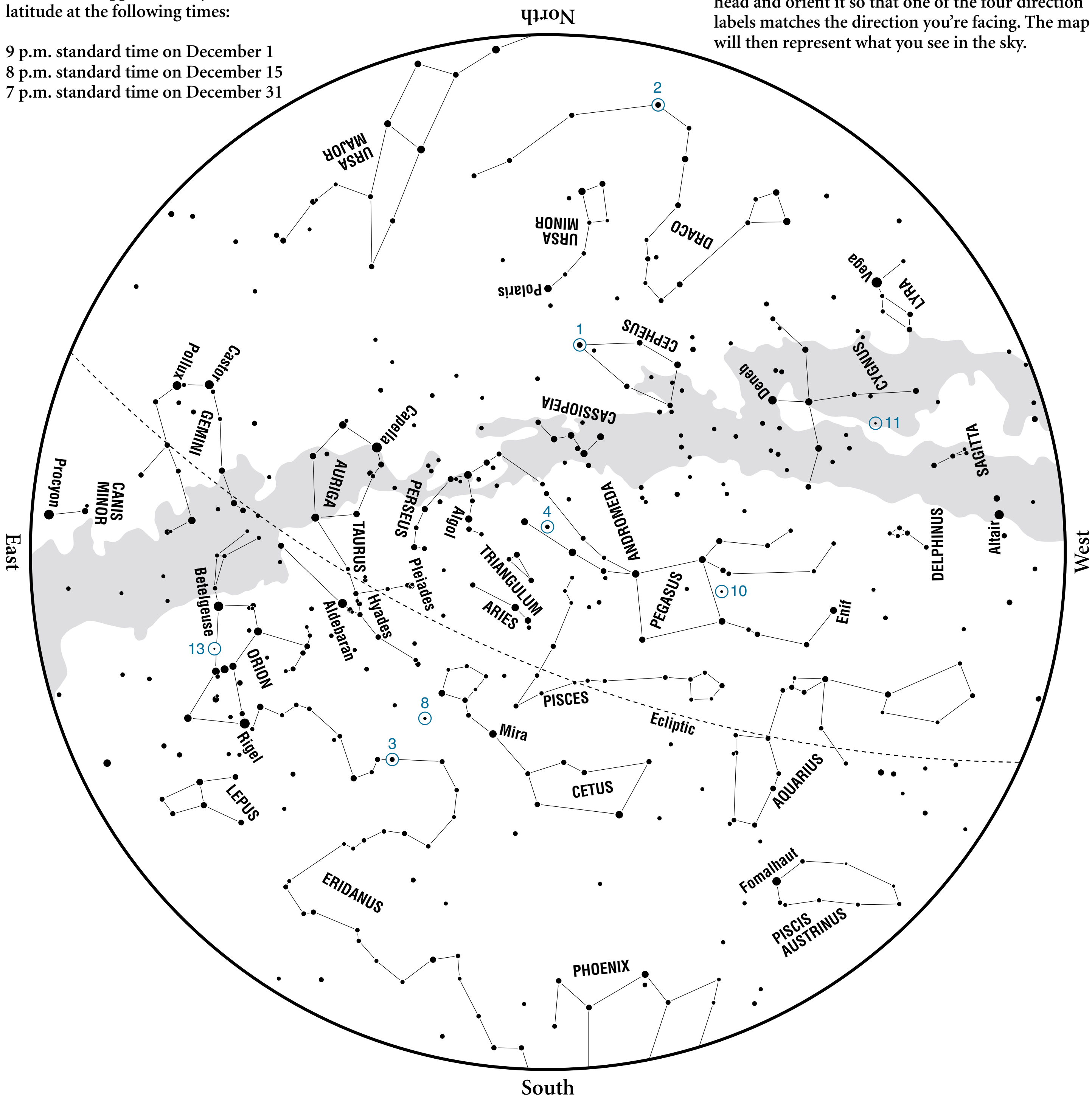

Stars visible to the unaided eye known to have planets — listed brightest to dimmest (stars visible this month are circled and numbered on the map)

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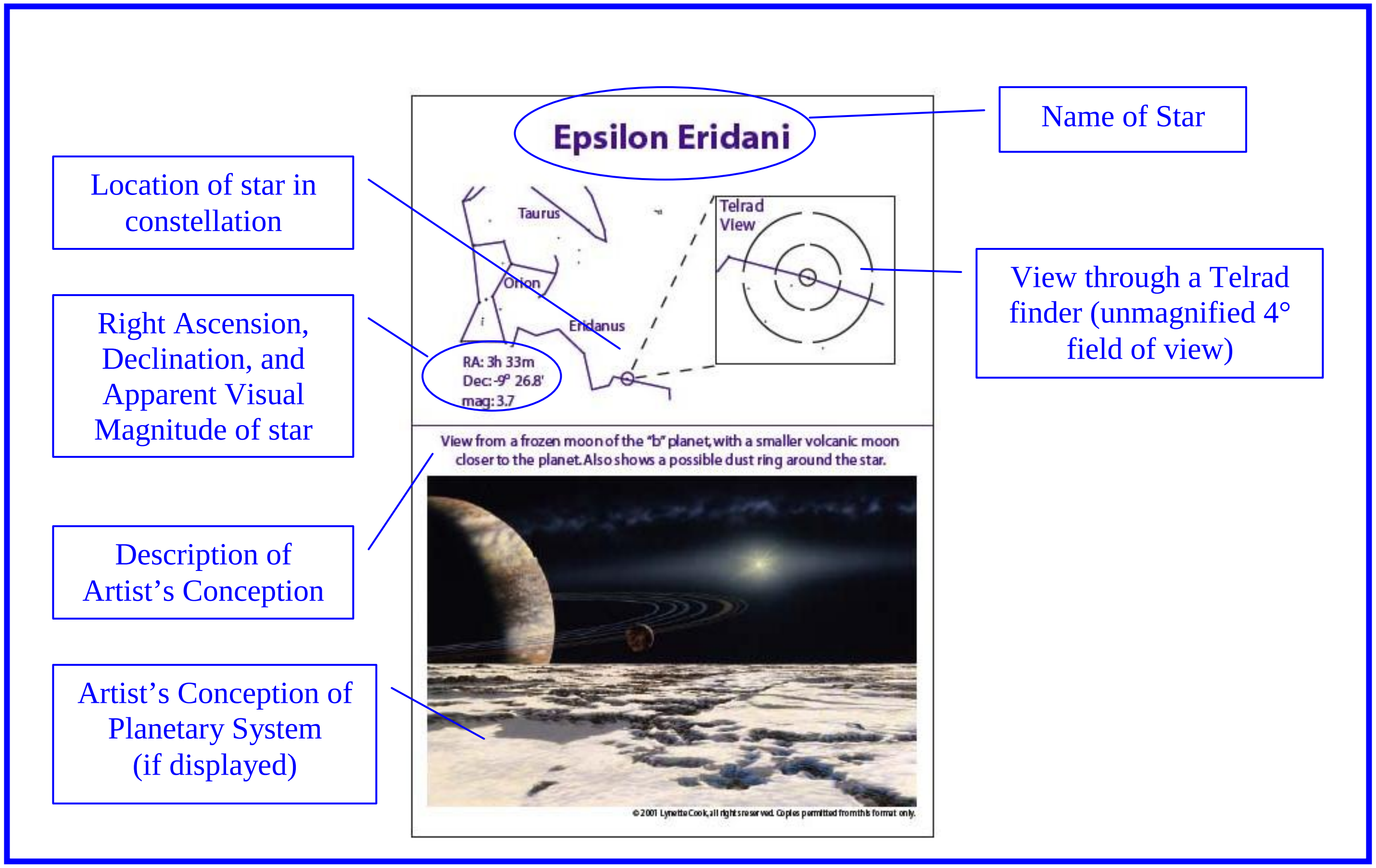
10 – 51 Pegasi
11 – Gliese 777a (Cygnus)
12 – HD 89744 (Ursa Major)
13 – HD 38529 (Orion)
14 – 55 Cancri

Planetary PostCards Key

FRONT



BACK

INFORMATION ABOUT THE STAR

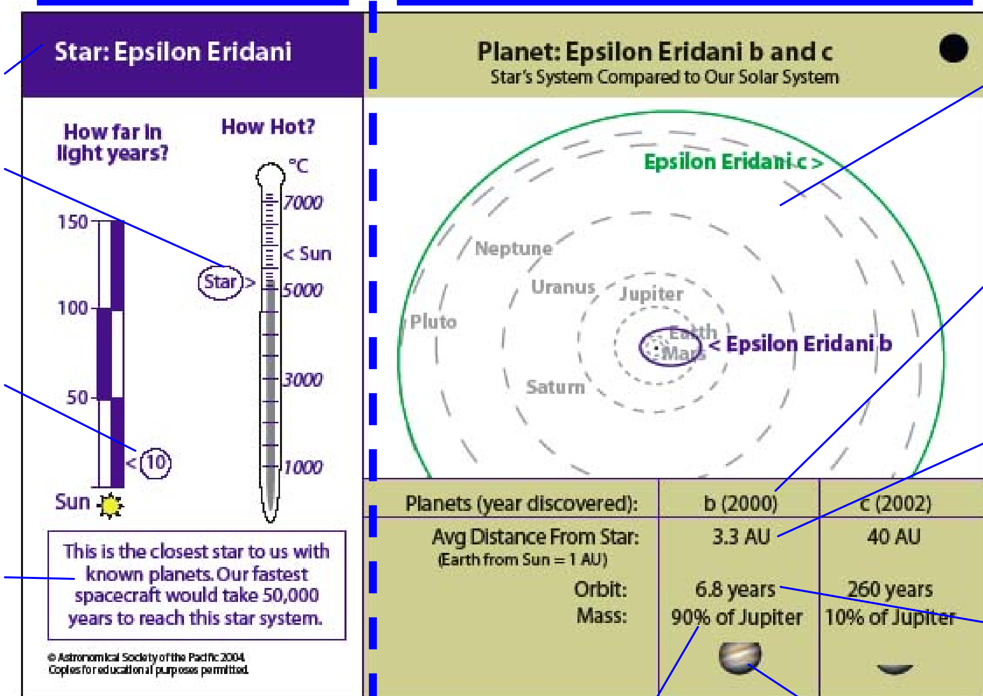
INFORMATION ABOUT THE STAR'S PLANETS

Name of the Star

Star's temperature compared to the Sun's temperature in Celsius

Star's Distance from the Sun in Light Years

Fun fact about the star and/or its planets



Orbits of the star's planets compared to the orbits of the Sun's planets

Planet's name (b, c, etc.) and the year it was discovered

Average distance of the planet from its star in Astronomical Units (AU = distance from Earth to Sun)

Period of the planet's orbit in Earth years or days

Mass of the planet compared to Jupiter's mass (Jupiter is 300 times the mass of Earth)

Icon(s) representing the planet's mass in Jupiters

Suggested Discussion Questions for Planetary PostCards

That star is hotter/colder than our Sun. How do you think that might affect its planets?

Here is where one of the planets orbits that star. What would it be like to live on this planet (or one of its moons)?

If Earth was orbiting that star, what might be different?

How big do you suppose this planet is compared to the planets in our Solar System?

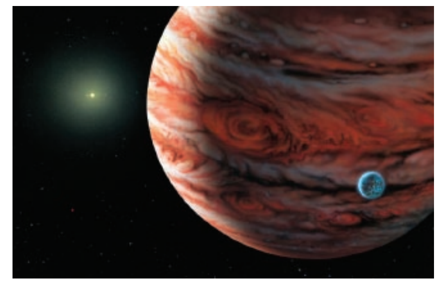
Do you think we have found all the planets in this system?

Our fastest spacecraft travels 42 miles per second. It would take 5,000 years for that spacecraft to go one light year. How long would it take to reach this star which is ____ light years away?

How different do you think Earth will be in that period of time?

PlanetQuest the search for another Earth

Planetary PostCards



Artist: Lynette Cook 55 Cancri System

Abbreviations and terms used on PostCards

RA = Right Ascension

Dec = Declination

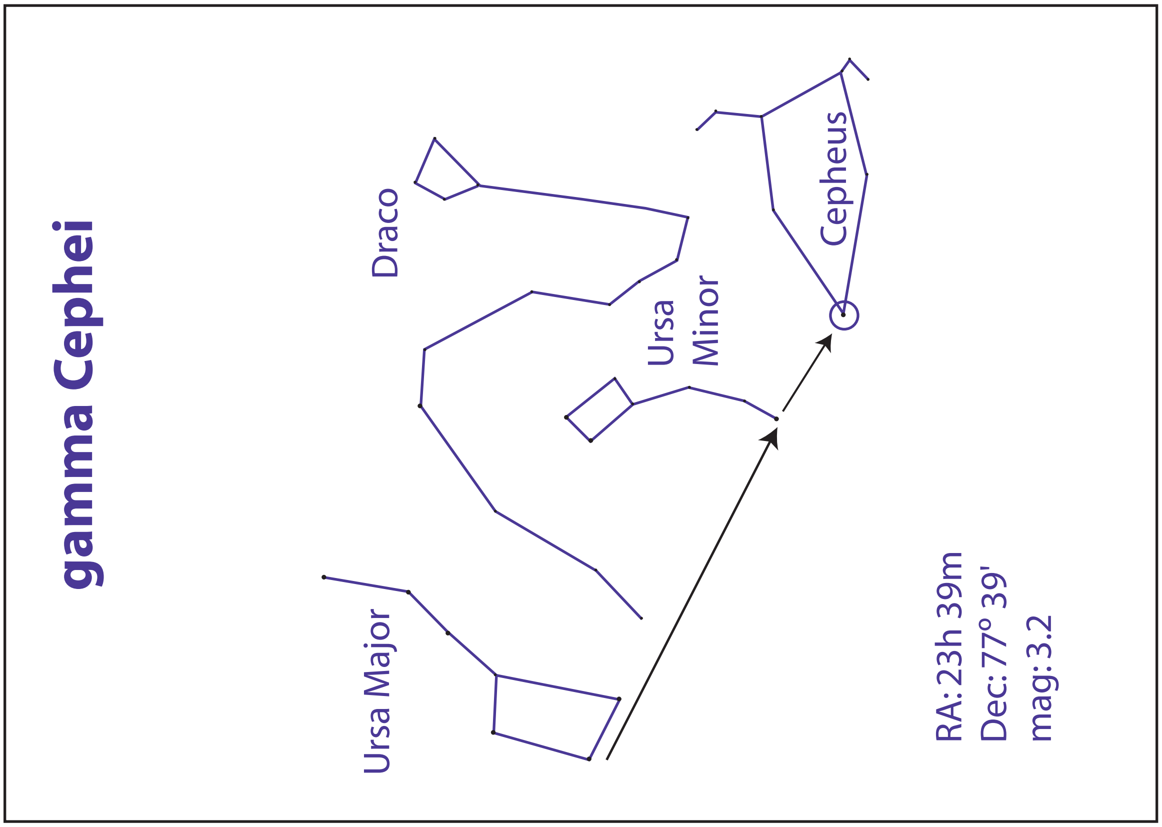
mag = apparent visual magnitude

AU = Astronomical Unit, the distance between the Earth and the Sun: 93 million miles or 150 million km

Light year = The distance light travels in a year. Light travels at 186,000 miles per second or 300,000 km per second. Light from the Sun takes 8 minutes to reach Earth.

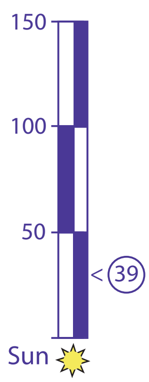
Jupiter mass = 1.9×10^{27} kg. Jupiter is about 300 times more massive than Earth (approximate difference between a large bowling ball and a small marble)

Temperature of the stars is in degrees Celsius

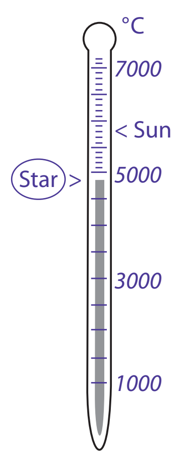


Star: Gamma Cephei

How far in light years?



How Hot?

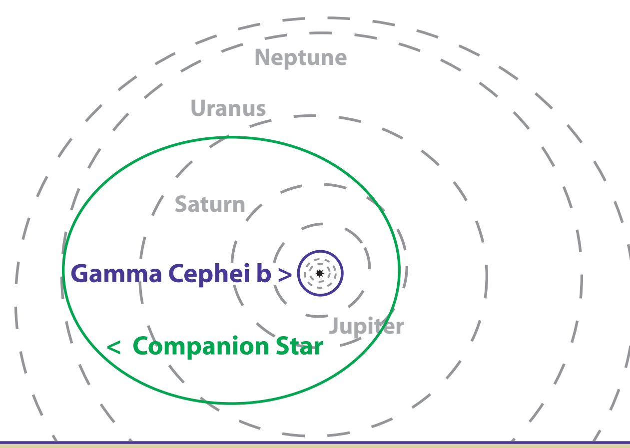


The brightest star with a planet is a Binary star AND it's a Red Giant!

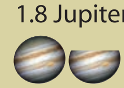
Its small "companion star" gets as close as 12 AU in a 40-year orbit.

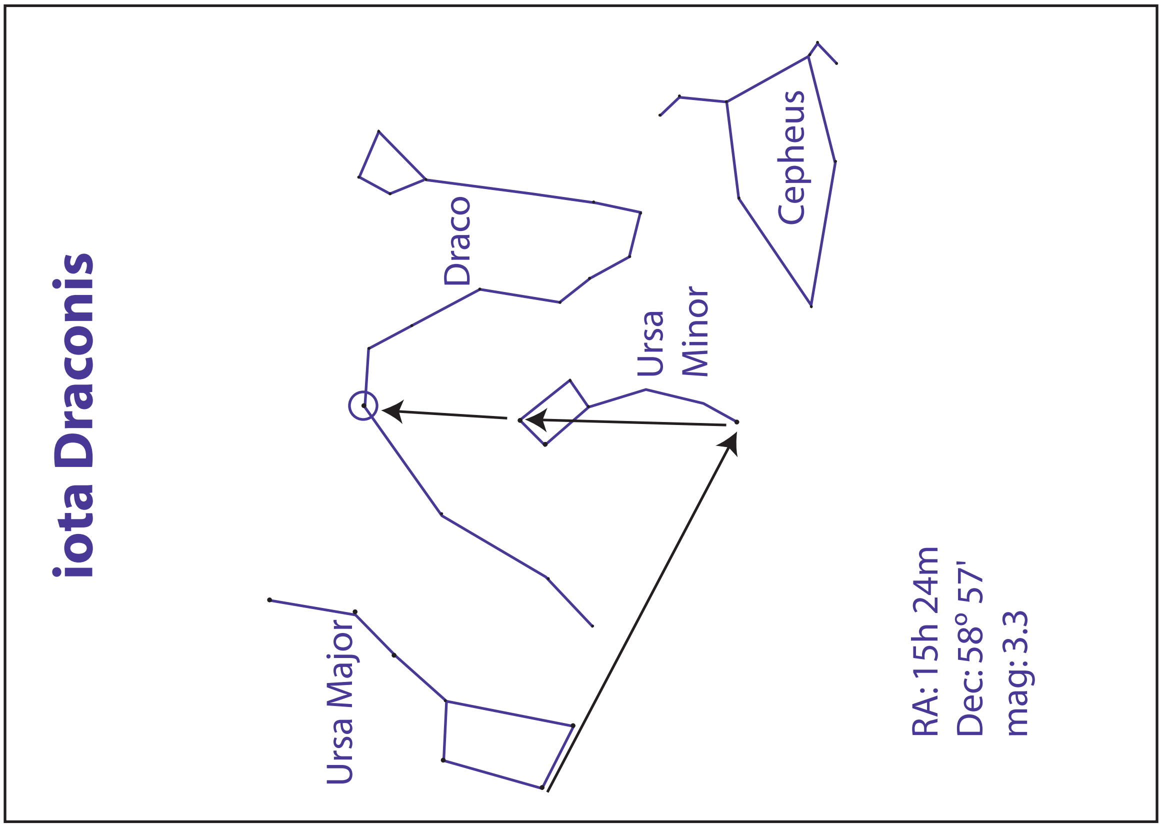
Planet: Gamma Cephei b

Star's System Compared to Our Solar System



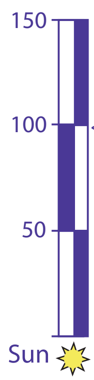
Planet (year discovered):	b (2002)
Avg Distance From Star: (Earth from Sun = 1 AU)	2 AU
Orbit:	2.5 years
Mass:	1.8 Jupiters



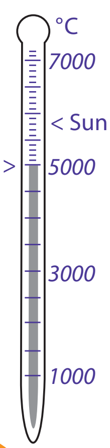


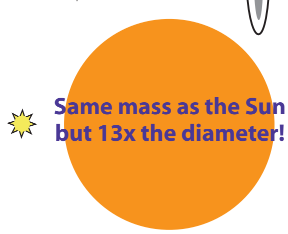
Star: Iota Draconis

How far in light years?



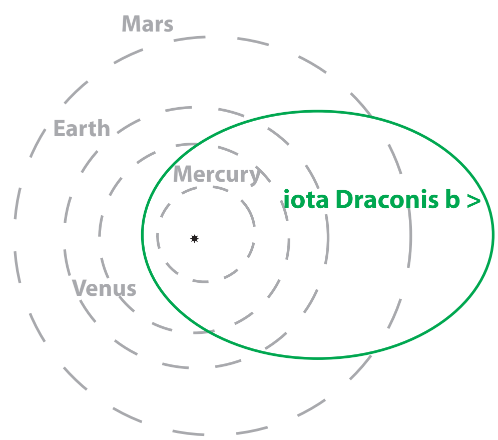
How Hot?





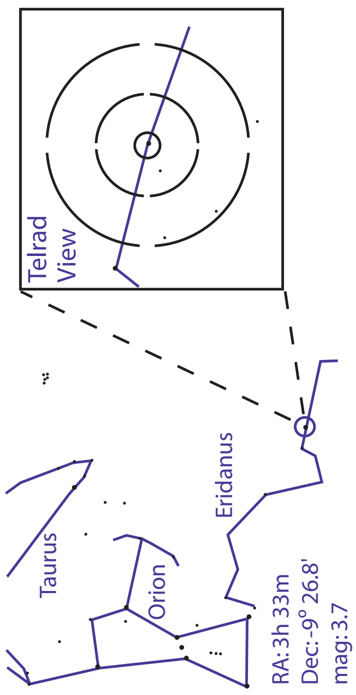
Planet: Iota Draconis b

Star's System Compared to Our Solar System



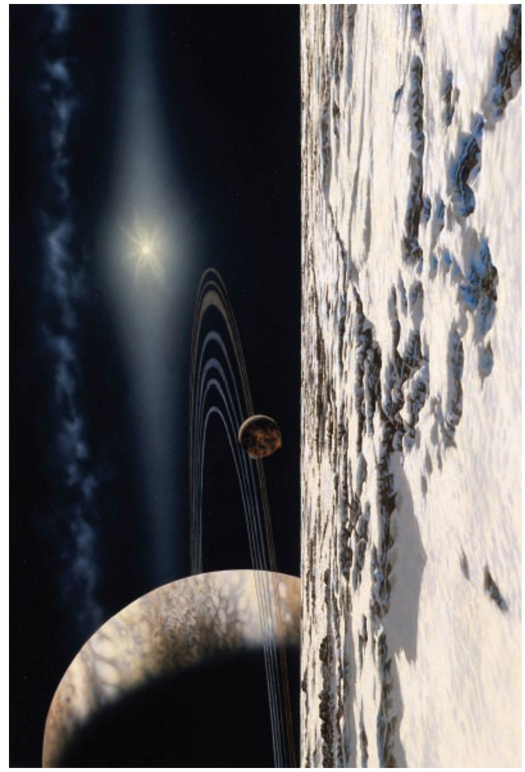
Planet (year discovered):	b (2002)
Avg Distance From Star: (Earth from Sun = 1 AU)	1.3 AU
Orbit:	1.5 years
Mass:	8.7 Jupiters(!)

Epsilon Eridani



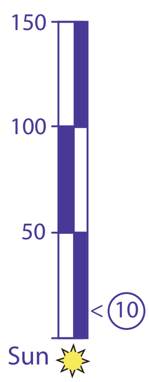
RA: 3h 33m
Dec: -9° 26.8'
mag: 3.7

View from a frozen moon of the "b" planet, with a smaller volcanic moon closer to the planet. Also shows a possible dust ring around the star.

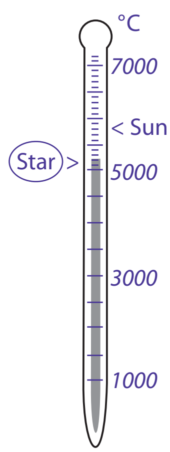


Star: Epsilon Eridani

How far in light years?



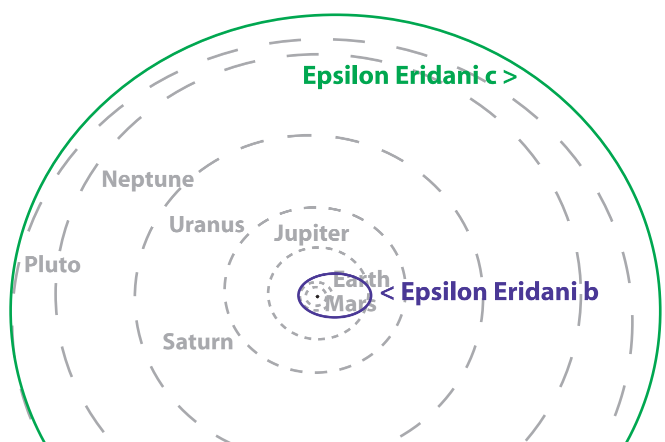
How Hot?

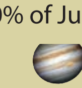


This is the closest star to us with known planets. Our fastest spacecraft would take 50,000 years to reach this star system.

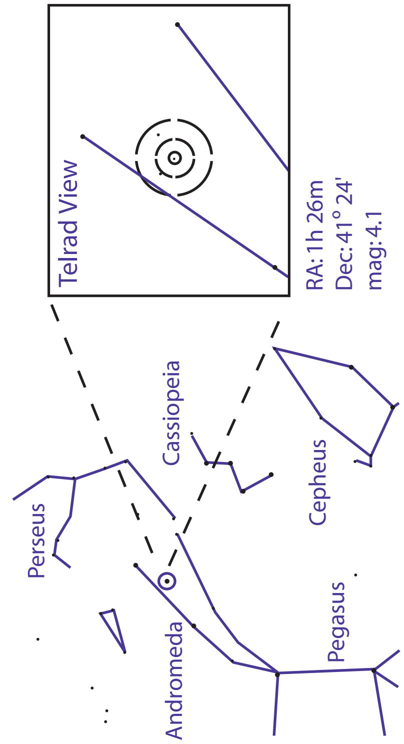
Planet: Epsilon Eridani b and c

Star's System Compared to Our Solar System



Planets (year discovered):	b (2000)	c (2002)
Avg Distance From Star: (Earth from Sun = 1 AU)	3.3 AU	40 AU
Orbit:	6.8 years	260 years
Mass:	90% of Jupiter	10% of Jupiter
		

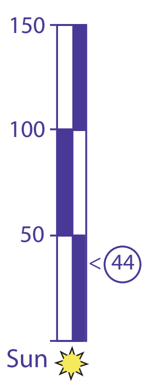
Upsilon Andromedae



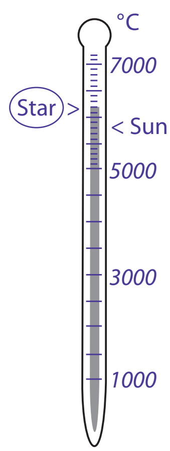
Shows all three known planets – the outer and most massive planet is shown with a ring like Saturn's.

Star: Upsilon Andromedae

How far in light years?



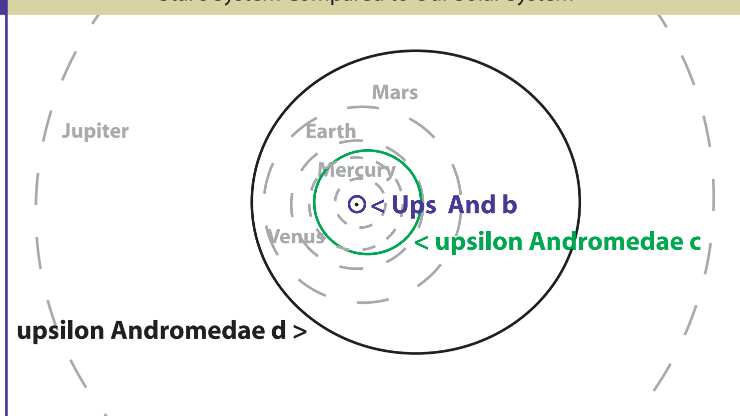
How Hot?



This is the first star discovered with a confirmed multi-planet system. Planet b was discovered in 1996 and c & d in 1999.

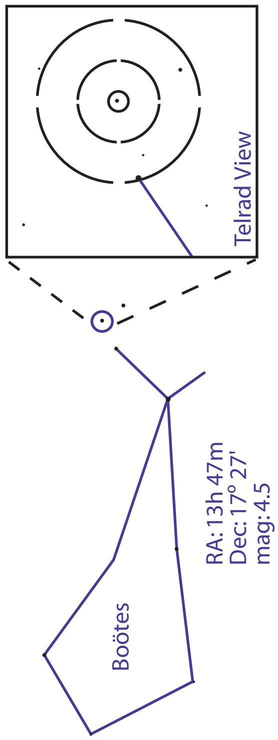
Planet: Upsilon Andromedae b, c, and d

Star's System Compared to Our Solar System



Planets (year discovered):	b (1996)	c (1999)	d (1999)
Avg Distance From Star: (Earth from Sun = 1 AU)	0.06 AU	0.83 AU	2.5 AU
Orbit:	4.6 Days	8 Months	3.5 Years
Mass:	71% Jupiter	2.1 Jupiters	4.6 Jupiters

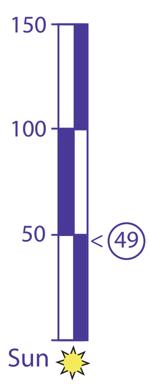
Tau Bootis



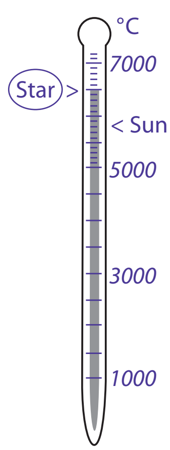
View of the Jupiter-like planet with its star in the background.

Star: Tau Bootis

How far in light years?



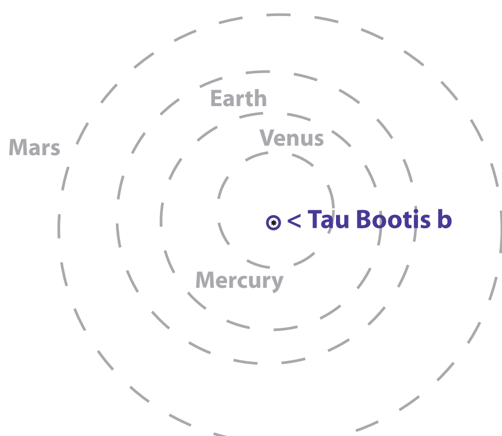
How Hot?



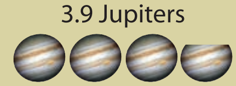
This huge planet is orbiting so close to its star and its star is so hot, this may be the hottest planet yet discovered!

Planet: Tau Bootis b

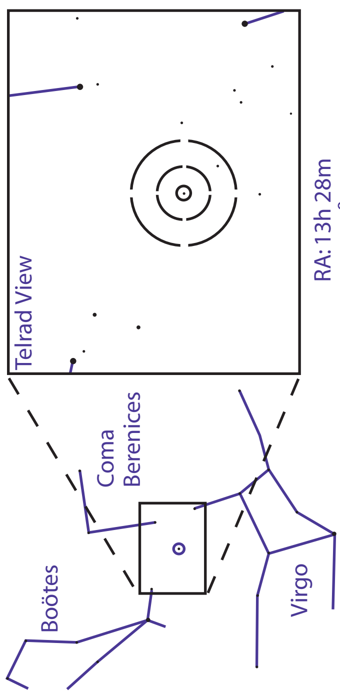
Star's System Compared to Our Solar System



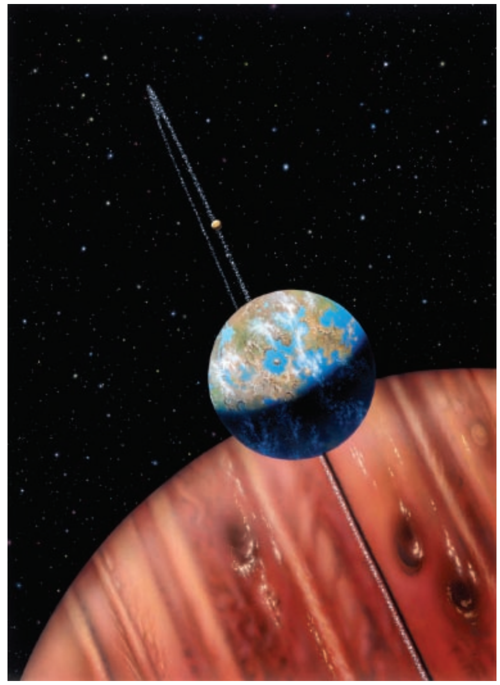
Planet (year discovered):	b (1996)
Avg Distance From Star: (Earth from Sun = 1 AU)	0.05 AU
Orbit:	3.3 days
Mass:	3.9 Jupiters



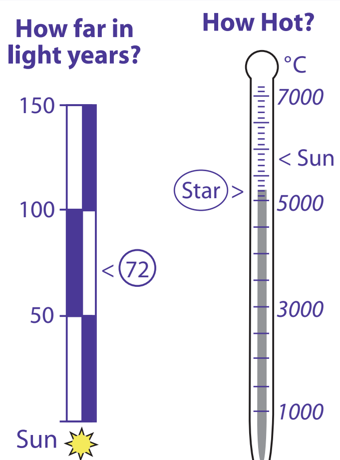
70 Virginis



The planet is shown with a ring and two moons. A small, gold moon and the other moon resembling Earth.



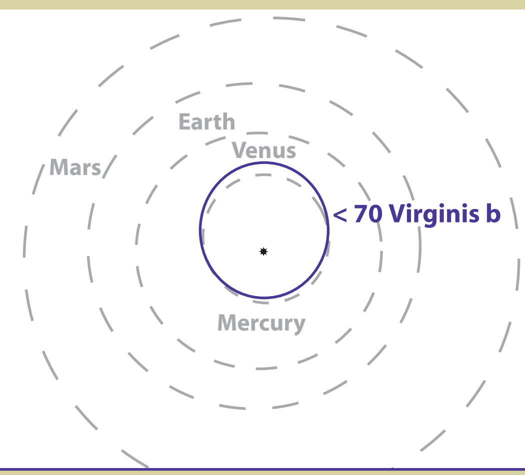
Star: 70 Virginis



This massive planet is orbiting a star cooler than the Sun. It may have moons with liquid water. The planet is shown on the front with a ring and two moons. One moon is shown resembling Earth, having oceans and land.

Planet: 70 Virginis b

Star's System Compared to Our Solar System



Planet (year discovered): b (1996)

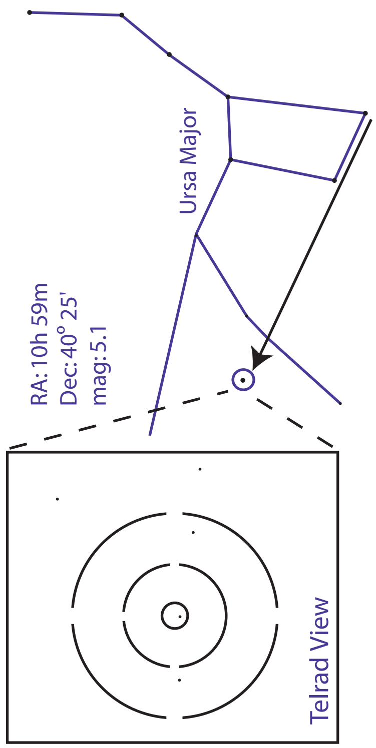
Avg Distance From Star: 0.4 AU
(Earth from Sun = 1 AU)

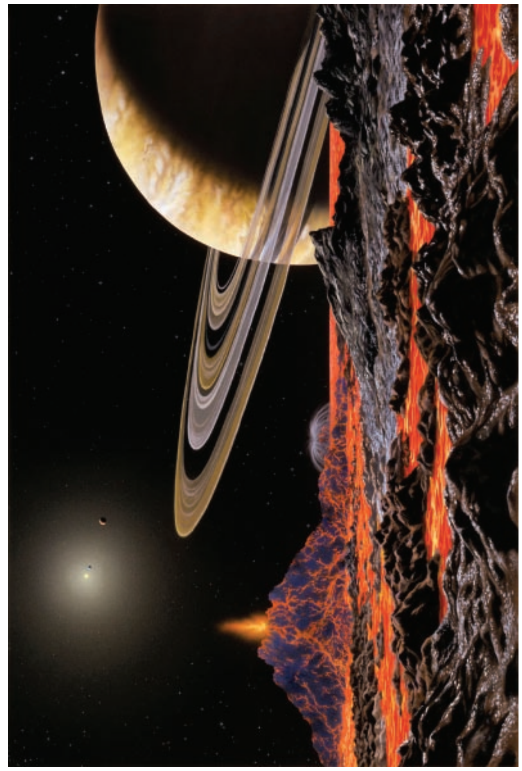
Orbit: 117 days

Mass: 6.6 Jupiters

47 Ursae Majoris

RA: 10h 59m
Dec: 40° 25'
mag: 5.1



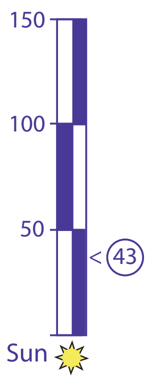


View from a possible moon of the outermost planet. Also shown: the confirmed inner planet and a possible "water world" close to the star.

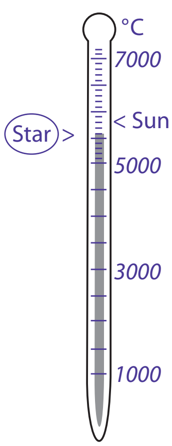
Star: 47 Ursae Majoris

Same Size as Our Sun

How far in light years?



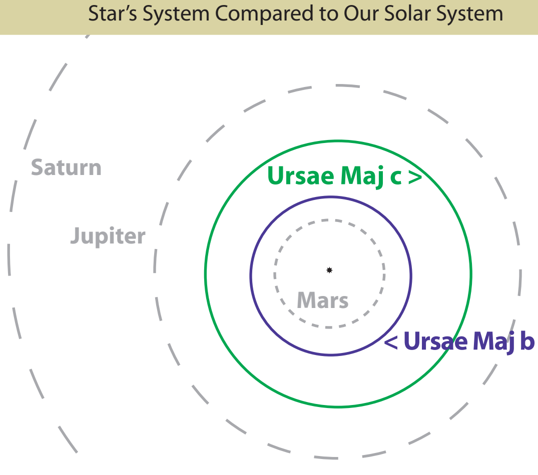
How Hot?



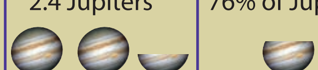
Two giant planets are orbiting in nearly circular orbits far from their star. This system is somewhat like our Solar System. Might rocky planets like Earth exist closer to the star?

Planets: 47 Ursae Majoris b and c

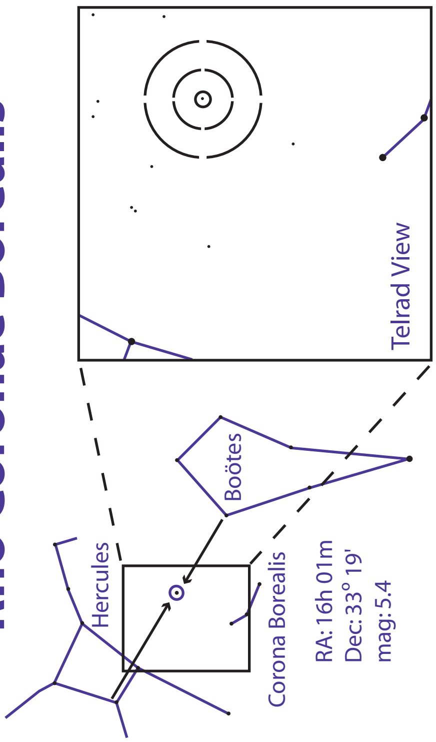
Star's System Compared to Our Solar System



Planets (year discovered):	b (1996)	c (2001)
Avg Distance From Star: (Earth from Sun = 1 AU)	2.1 AU	3.7 AU
Orbit:	3 years	7.1 years
Mass:	2.4 Jupiters	76% of Jupiter



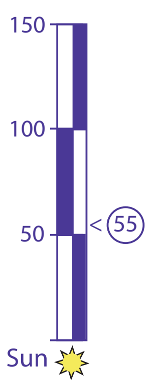
Rho Coronae Borealis



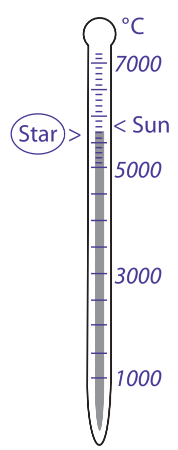
Jupiter-like planet orbits its star at about the same distance as Mercury orbits the Sun.

Star: Rho Coronae Borealis

How far in light years?



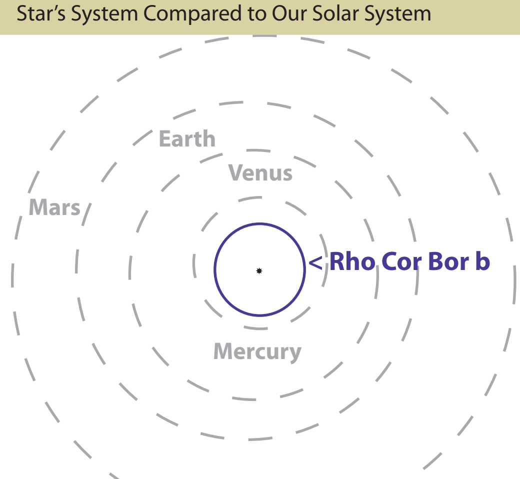
How Hot?



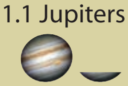
A belt of rocky/icy objects appears to orbit this star at about the same distance as the Kuiper Belt from our Sun. The occasional comet may appear in skies of this star's planet(s).

Planet: Rho Coronae Borealis b

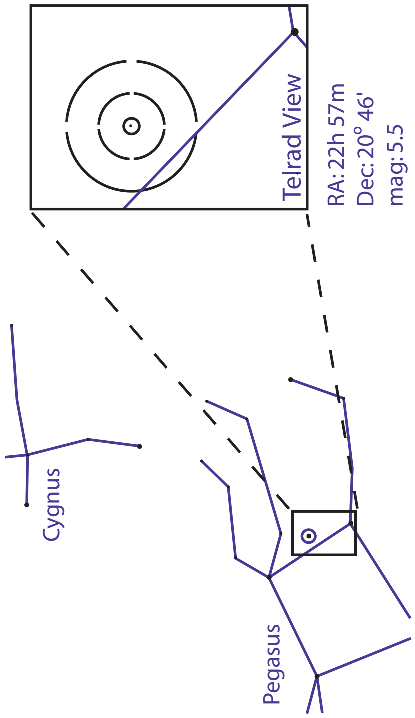
Star's System Compared to Our Solar System



Planet (year discovered):	b (1997)
Avg Distance From Star: (Earth from Sun = 1 AU)	0.23 AU
Orbit:	39.6 days
Mass:	1.1 Jupiters



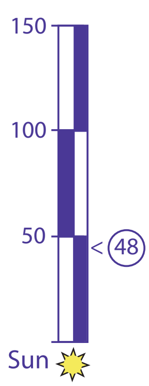
51 Pegasi



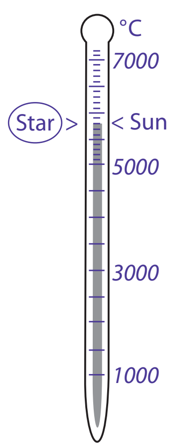
The "hot Jupiter" orbiting very close to its star.

Star: 51 Pegasi

How far in light years?



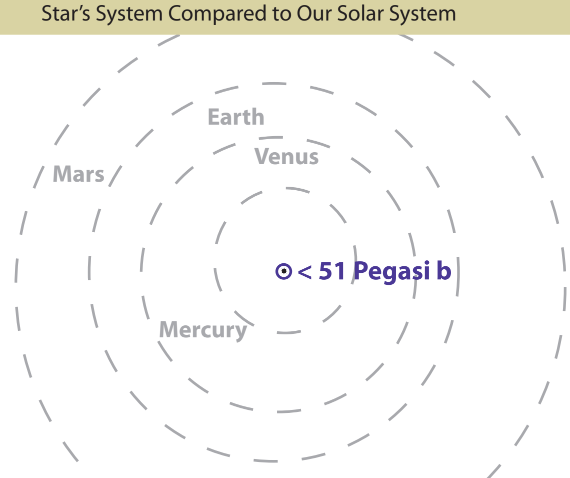
How Hot?



This star was the FIRST sun-like star discovered to have a planet – in 1995, the first evidence that other stars like our Sun have planetary systems.

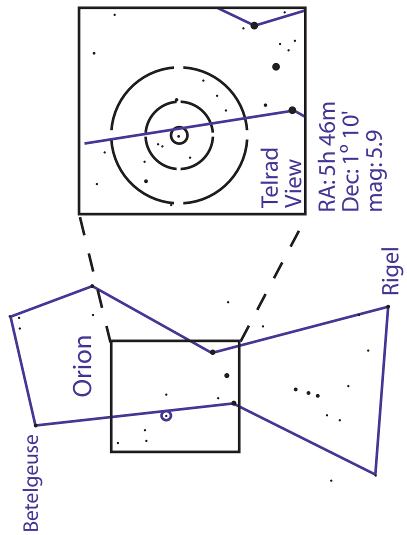
Planet: 51 Pegasi b

Star's System Compared to Our Solar System



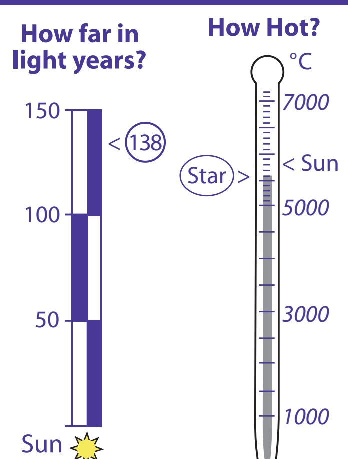
Planets (year discovered):	b (1995)
Avg Distance From Star: (Earth from Sun = 1 AU)	0.05 AU
Orbit:	4.2 days
Mass:	50% of Jupiter

HD 38529 (Orion)



View from the surface of a hypothetical icy moon of the outermost planet, which is shown with rings and two other moons.

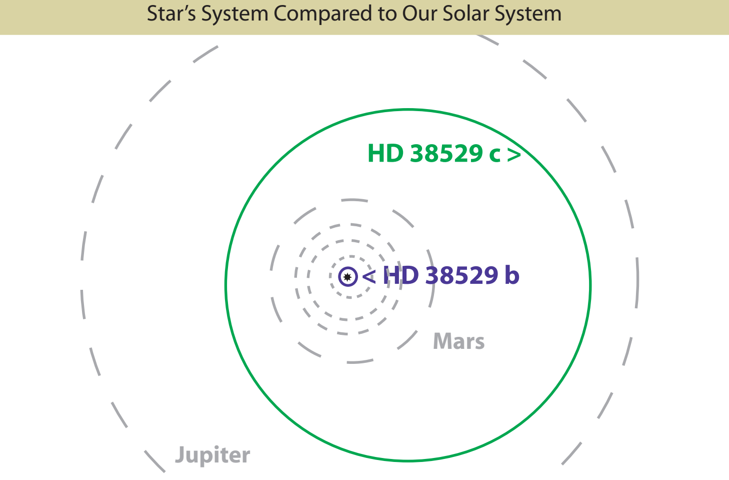
Star: HD 38529 (Orion)



This star is very dim – it is about how bright our Sun would look from the distance of this star. Compare this "small" star to Orion's Betelgeuse – a red giant over 400 light years away or Rigel – a blue hot supergiant at over 750 light years.

Planets: HD 38529 b and c

Star's System Compared to Our Solar System



Planets (year discovered):	b (2000)	c (2002)
Avg Distance From Star: (Earth from Sun = 1 AU)	0.12 AU	3.5 AU
Orbit:	14.4 days	6 years
Mass:	77% of Jupiter	11.3 Jupiters

WHY DO WE PUT TELESCOPES IN SPACE?

Quick Links

About the Activity

- What's this activity about?
- Helpful Hints
- Background Information:
- Detailed Activity Description

Materials:

- What materials from the ToolKit do I need?
- What do I need to prepare?
- What must I supply?
- Where do I get additional materials?
- Images: (Print these out on paper or as transparencies)
  - Ground-based vs space-based comparison
  - Image of Eagle Nebula to use as "mystery" object

What's the Activity About?

SUGGESTION:

- ***View the Training Video for suggested ways to demonstrate this.***

Big Question: Why do we put telescopes in Space?

Big Activity: Investigate simulated atmospheric conditions through mock telescope

Participants: Adults, teens, families with children 6 years and up
If a school/youth group, 3rd grade and higher
From one participant to 2 groups of 3 participants. Limitation is due to quantity of resources provided in the ToolKit. Up to 3 people can share a tube telescope. If you want more groups, you can supply more tube telescopes and atmosphere (bubble wrap) – See the sections "*Helpful Hints*" and "*Where do I get additional materials*".

Duration: 20 minutes

Topics Covered:

- How the atmosphere limits our ability to view the heavens from the surface of Earth
- Benefits of placing telescopes in space

Activities:

Experiment with mock telescopes and materials that simulate atmospheric conditions

Helpful Hints:

For more than about 10 people, you will need to acquire more telescopes (paper towel tubes are fine), clouds (cotton balls), small flashlights, and more atmosphere (bubble wrap) and rubber bands. For the "mystery object" you may want to use a larger object than the small ball, such as a colorful, decorated balloon or ball (as shown in the photo at the right) and cover it with a towel until everyone is ready to view it.

If you are doing this inside and have access to a computer projector, you can use the TelescopesInSpace.ppt (PowerPoint presentation) found in the *Multimedia Gallery* folder on the PLANETQUEST OUTREACH TOOLKIT MANUAL AND RESOURCES CD in the *PowerPoints* sub-folder.

Using an overhead projector, you can project an image of a celestial object (for instance, the image of M16, the Eagle Nebula provided ***here***) on a screen to use as the "mystery object", as shown in the photo above. Print the image on a transparency (if you do not have the equipment at home to do this, your local copy shop can do it for you).

If you are outside and have a laptop computer, you can display a photo of a celestial object on your computer screen for the "mystery object".

Another option is to make separate stations with full sets of materials at each station. A presenter will need to be at each station.

This activity can be done in these locations:

- Outside in the early evening or at night (not as effective outside during the day – you need a very shaded location)
- Inside at night
- Inside during the day where you can darken the room at least to the level of twilight.

Background Information:

There are two primary factors why we put telescopes in space:

1. Effects of the atmosphere: distortion, light pollution, weather, daylight
2. Only limited bands of the electromagnetic spectrum can penetrate our atmosphere: mainly radio and optical radiation (kinds of light). Infrared, ultraviolet, etc are almost completely absorbed as they pass through our atmosphere.

NOTE:

This activity only illustrates the first factor: the effects of atmospheric distortion, light pollution, and daylight that affect our ability to view the sky. This activity does not cover types of light other than optical due to limitations of materials needed to illustrate this. If you are interested in activities and discussing how the atmosphere limits our ability to detect infrared, UV, and so on from outer space, please refer to:
http://www.ipac.caltech.edu/Outreach/Multiwave/activities.html

For more information on the effects of the atmosphere:
http://spaceguard.ias.rm.cnr.it/tumblingstone/issues/num8/tele/tele-atmo.htm

More about Telescopes in Space:
http://earthsci.terc.edu/content/data_centers/es2806.cfm?chapter_no=datacenter

To subscribe to **satellite pass predictions** by email – to allow your visitors to watch for telescopes in space or other satellites:

http://science.nasa.gov/RealTime/JPass/PassGenerator/

Adaptive Optics:

Of course, adaptive optics assists with improving the view from ground-based telescopes, but the precision required to find small planets around other stars can be best achieved in space.
For more on the Keck Telescope and adaptive optics:
http://planetquest.jpl.nasa.gov/Keck/keck_technology.html

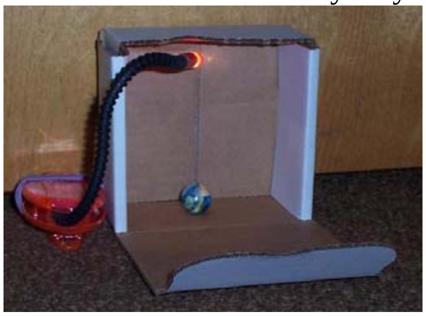
Earth's atmosphere:

In this activity, we use a piece of bubble wrap to represent Earth's atmosphere. All the weather in our atmosphere occurs within 10 miles of the surface of Earth – the lowest 10 miles of the atmosphere. Commercial airplanes fly about 7 miles high. 80% of the atmosphere is in that first 10 miles. On the scale used in this activity, that is only a bit thicker than a regular piece of paper. As you ascend out from the surface of Earth, the atmosphere gets thinner and thinner – above 300 miles (represented by the thickness of the bubble wrap) the atmosphere is so thin it no longer has much influence on degrading the orbit of satellites.
A common question you may get is "How high is Mount Everest?" – it is roughly 5 miles high. That's why it is so difficult to breathe up there.
This is one reason why we put telescopes on top of high mountains – like the Keck telescope in Hawaii - the air is thinner and so there is less interference from the turbulence of the atmosphere.

Detailed Activity Description

Leader's Role	**Participants' Roles (Anticipated)**
INTRODUCTION: *To Ask:* Who has heard of the Hubble Space Telescope? What is it? (a telescope in space) NASA is putting telescopes out in space for many purposes. In the next 15-20 years, some will be sent up to find Earth-size planets around other stars. Why do you suppose we put telescopes out in space? What is it about being down here on the surface of the Earth that interferes with our ability to see things clearly in outer space? How does our atmosphere interfere with our ability to see the things in outer space? *To Do:* Holding out the globe, ask your visitors to guess how thick the Earth's atmosphere is compared to the inflated globe.	Discuss ideas (e.g. rain, clouds, light pollution, sunshine, wind) Indicate with their hands how far away from the surface of Earth the atmosphere extends.
To Model: Take a piece of bubble wrap and lay it flat on the surface of a globe.  *To Say:* This bubble wrap represents our atmosphere. Satellites are put in orbit above 300 miles – this is about the height where the atmosphere no longer has much influence on degrading the orbit of satellites. Our atmosphere is very thin compared to the diameter of our planet, which is about 8000 miles in diameter. *To Do:* Ask your visitors to pick any two cities on the globe that are about 300 miles apart and show that the bubble wrap is about as thick as the distance between the cities. (e.g. San Jose and Los Angeles in California).	Listen and observe.

To Do: Wrap the piece of atmosphere bubble wrap around end of tube telescope with the bubbles facing out. Secure with a rubber band.  *To Say:* This represents looking at the sky with a telescope through the atmosphere from the surface of Earth.	
To Do: Place all other materials on the table. Place the small "star" (the snake light with its hood off) about 10 feet away. If you are inside, turn out (or down) the lights. *To Say:* We can simulate some of the effects of the atmosphere. Air is constantly in motion with all of its many layers moving around. *To Ask:* What do you notice?	Participants look at the mock star through the tube telescope and move the tube around slightly. Participants volunteer their observations.
To say: Experiment with other things that can interfere with our ability to see out into space. IF YOU ARE OUTSIDE IN THE DARK, pick a star near the horizon and ask what the participants notice about the star. (twinkling).	Participants place the cotton "clouds" in front of the telescope. Shine the "city lights" flashlight toward the end of the tube (keeping the light slightly to the side of the tube). Breathe on the bubble wrap at the end of the tube (fog). Discuss how the image of the mock star is affected.
If you are INSIDE, turn the lights on full bright. If you are OUTSIDE, turn the big flashlight on and aim it at the end of the tube. SAY: Now, what happens every morning? The sun just rose. Can you see stars in the daytime?	

DO: Place a "mystery object" (such as a marble or other object) in a box with a light shining on it. (See Helpful Hints section for additional ideas for the mystery object)  Turn off the lights (or the big flashlight). Have the participants look at the object through the tube with atmosphere. (No peeking without the tube telescope) ASK: Describe what you are looking at. What do you notice? What kind of detail can you see? SAY: Let's go up above the atmosphere and see how the view changes. DO: Take away the atmosphere from the front of the telescope, and leave the "star" on. Have the participants look at the star and at the object without the atmosphere on the tube (from above the atmosphere). ASK: Now what can you tell me about the object you saw? SAY: If we fly up above the atmosphere, is the sky dark or light? (Dark – this works better outside) The atmosphere scatters the sun's light and when you get above the atmosphere, even if you can see the sun, you can still see stars.	Give descriptions of what they see Describe object Discuss this idea
ASK: So why do we put telescopes in space? (Atmosphere scatters light, has weather. Out in space, we have nothing in the way. We can observe at any time. There is no day and night in outer space.) SAY: The Hubble Space Telescope is capable of producing photos Earth-based telescopes cannot produce. DO: Show comparison images of ground and space photo of Eagle Nebula SAY: All planets discovered to date have been large Jupiter-sized planets detected from Earth-based telescopes. The precision required of the NASA missions to find the much smaller Earth-size planets around other stars, SIM (Space Interferometry Mission) and TPF (Terrestrial Planet Finder), can only be achieved in space.	Discuss ideas

Materials:

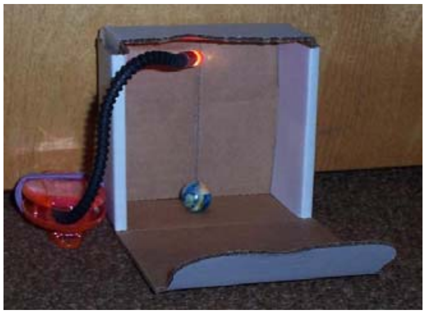
What Materials from the Outreach ToolKit do I need?

- Tube mock telescopes
- Bubble wrap (atmosphere)
- Snake Light (with hood removed) for a star
- Snake Light (with hood attached) to light up object in box
- Small multi-colored ball ("mystery object" placed in box to identify)
- Box 4" x 4" x 2" (same box as used in the Galaxy Model activity)
- Cotton ball (clouds)
- Small squeeze flashlight (city lights)
- Rubber band
- Image comparing ground-based vs Hubble photo
- 1 World globe – 12 - 14 inches in diameter
- Labels (See "Item Labels" below)

OPTIONAL: "Why do we Put Telescopes in Space?" PowerPoint (TelescopesInSpace.ppt). This is found in the *Multimedia Gallery* folder on the PLANETQUEST OUTREACH TOOLKIT MANUAL AND RESOURCES CD in the *PowerPoints* sub-folder.

What do I need to prepare?

- Place batteries into the snake lights
- Box – fold the 4"x4"x2" box
- Attach the marble (or other object) with a small bit of clay inside the box as shown below.



- To show the ground-based vs Hubble photo, you may want to either print it out, print it as a transparency for use with an overhead projector, or use the image from the TelescopesInSpace.ppt PowerPoint found in the *Multimedia Gallery* folder on the PLANETQUEST OUTREACH TOOLKIT MANUAL AND RESOURCES CD in the *PowerPoints* sub-folder.

See "Helpful Hints" for additional ideas.

What must I supply?

- 1 Large flashlight (the Sun) – not needed if this is done indoors

Where do I get additional materials?

- Tube mock telescopes: Paper Towel tubes – ask your club members to save them and bring them to the club meetings.
- Bubble wrap: save bubble wrap packing materials – be sure they are the small (1/2" or smaller) bubbles. You may have someone in your club with access to packing materials. Or from an office supply store.
- Snake light: Order from Oriental Trading Company 800-526-9300 or at http://www.orientaltrading.com. Order Item # 50/80 Transparent Snake Book Light
- Small flashlight: These may be available at hardware stores, but another source is Quantum Promotions. They will sell as few as 10 flashlights at once. They refer to these as "sample" shipments. You can order them by any of these methods:
  EMAIL: sales@quantumpromotions.com or contact the sales rep, Steve Tallman, at: stallman@quantumpromotions.com.
  FAX: 510-420-1930.
  CALL toll free at: 1-877-776-6674.
  For 10 squeeze flashlights, the quoted price as of June 2003 is $3.28/ea, plus shipping.

- 12"-14"World globe: Bookstores and school supply stores carry globes; for inexpensive inflatable globes, try Oriental Trading Company 800-526-9300 or at http://www.orientaltrading.com . Order Item #IN-49/1290.
- Box: You can use almost any small box: a shoe box, a gift box

Item Labels

Telescope

Atmosphere

City Lights

Clouds/Fog

Star

WHY DO WE PUT TELESCOPES IN SPACE?

View from the Auckland Observatory in New Zealand
(on the surface of the Earth)

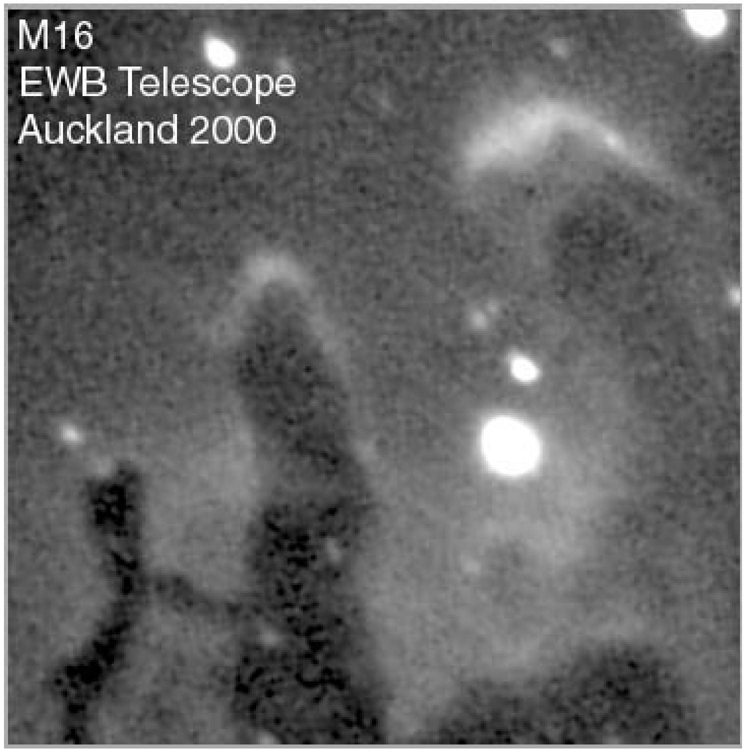


Image courtesy of Dr. Ian Griffin and the Auckland Observatory

View from the Hubble Space Telescope
(above the Earth's atmosphere)

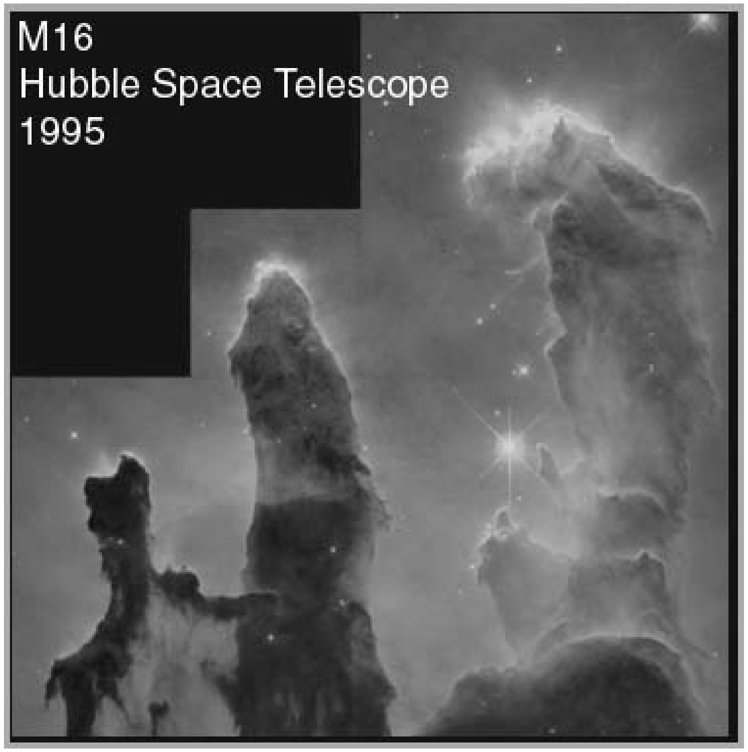
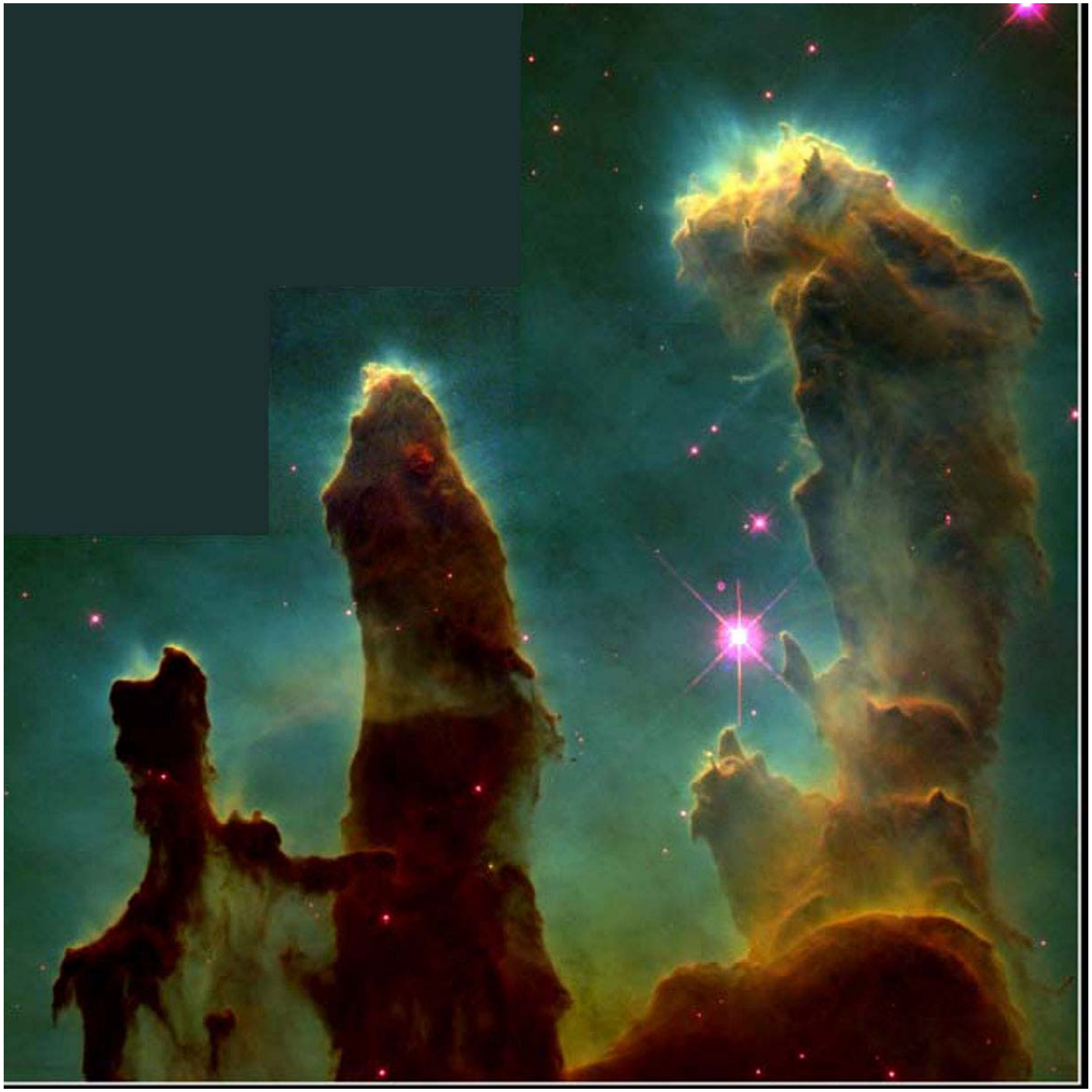


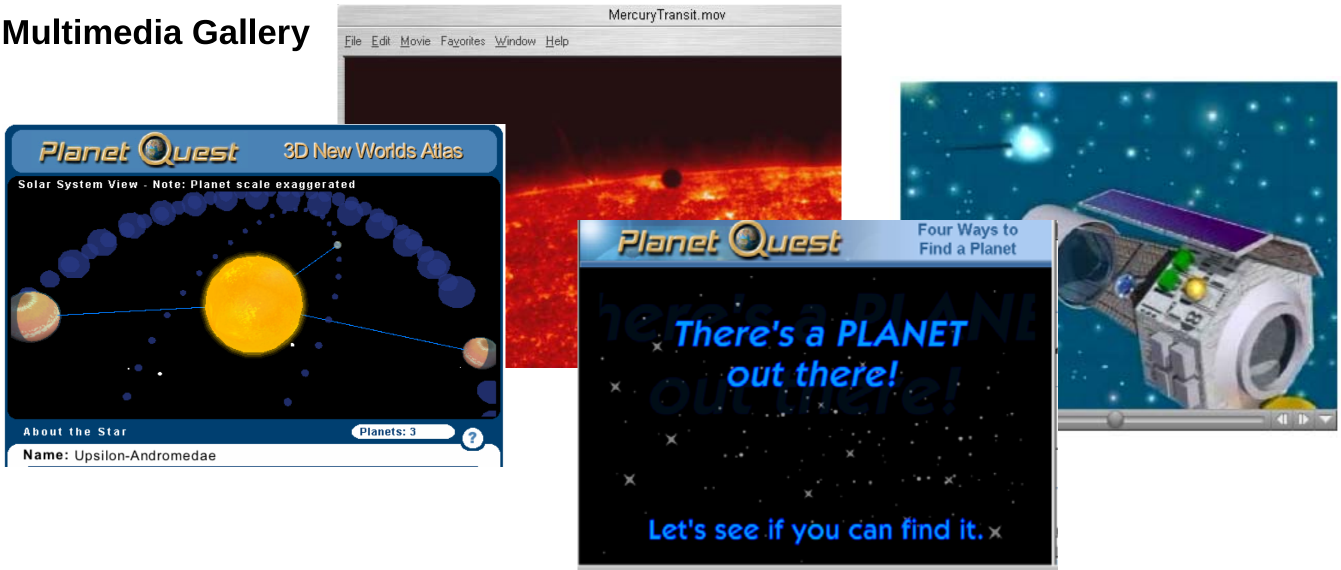
Image from NASA and Space Telescope Science Institute

<u>Comparison Image of the Eagle Nebula (M16)</u>

"Mystery" Object



Multimedia Gallery



Additional materials allow the presenters to include multimedia in the activities. These can also be used in stand-alone presentations.

These are found on the PLANETQUEST OUTREACH TOOLKIT MANUAL AND RESOURCES CD in the *Multimedia_Gallery* folder. Inside the *Multimedia_Gallery* folder, you will find three sub-folders:

- *Interactive_Gallery*
- *Movies*
- *PowerPoints*

Instructions for Viewing Multimedia

To view the 3D models in the *Interactive_Gallery* sub-folder:

WINDOWS USERS: You will need to install the Cult3D plug-in on your computer, which is included in the *Plug-ins* folder under the *Interactive_Gallery* folder. Select the appropriate choice for your platform and browser, double-click, then follow the on-screen instructions.

MAC USERS: If you are using an Apple (Mac) computer, please download the appropriate plug-in version from the following web site: http://www.cult3d.com/download/download.asp

In Mac OS X, the models must be viewed in Netscape 6.1 or higher for full functionality.

Multimedia Presentations:

Here is a list of some of the presentations available in the *Multimedia Gallery* folder on the PLANETQUEST OUTREACH TOOLKIT MANUAL AND RESOURCES CD and in the "Media and Resources" slide-lock bag in the ToolKit box . The location and name of the file in the *Multimedia Gallery* folder is shown below each presentation.

- **POWERPOINT ON THE SEARCH FOR ANOTHER EARTH**
  PowerPoints > SearchForAnotherEarth.ppt

- **POWERPOINT TO INTRODUCE YOUR CLUB TO THE NIGHT SKY NETWORK**
  PowerPoints > NSNClubIntro.ppt

- **POWERPOINT FOR "WHY DO WE PUT TELESCOPES IN SPACE?"**
  PowerPoints > TelescopesInSpace.ppt

- **ANIMATIONS ON PLANETQUEST MISSIONS AND SCIENCE**
  Interactive_Gallery > index.html

- **ANIMATIONS ON KEPLER MISSION**
  Movies > Kepler_Mission.html

- **ANIMATIONS ON KEPLER MISSION SCIENCE**
  Movies > Kepler_Science.html

- **3D NEW WORLDS ATLAS**
  Interactive_Gallery > index.html > 3D New Worlds Atlas
  You can use this to view in 3D many of the extrasolar planetary systems that have been found.

- **Mercury Transit Video**
  Movies > MercuryTransit.mov
  Or
  Movies > MercuryTransit.mpeg
  You can use this when explaining about the Transit method in the activity: "How Do We Find Planets Around Other Stars"

- **DVDs on the Space Interferometry Mission (SIM) and other topics – DVDs included in the "Media and Resources" slide-lock bag in the ToolKit box.**

Helpful Hints

If you are planning a presentation to a large group and do not have access to a computer projector, you may print the PowerPoint presentations onto transparencies for use with an overhead projector. If you do not have the equipment to make transparencies, your local print shop will be able to make them for you.

National Science Standards Mapped to PlanetQuest Activities

The numbers in the cells refer to the ID number of the PlanetQuest Kit Activity (see table at the bottom of the page).

SCIENCE CONTENT	Sky	Apparent Motion	Stars			Ideas	Actual Motion	Matter
TEACHING METHOD	Atmos-pheric Processes (K-4, 5-8)	Sun is a star like nighttime points of light (5-8)	Sun is a star (K-4)/ an avg star(5-8)	Sun formed from cloud of gas & dust (9-12)	Heavier elements form in stars (9-12)	Gravity governs Motions in universe (5-8)	Gravity is force that keeps objects in orbit (5-8)	Compounds combine to form living & non-living things (5-8)
SI-Science As An Inquiry	4	1, 3	1, 3				3	
TC-Technology Connections	4	1, 3	1, 3				3	
PS-Personal/Social Connections		2		2	2	2		2
NH-Nature & History of Science		2		2	2	2		2
UC-Unifying Concepts & Processes	4							

ID	PlanetQuest Kit Activity	Teaching Method	Science Content
1	Where are the Distant Worlds? Star Maps	SI/TC	Apparent Motion; Stars
2	Telescope Treasure Hunt: Star & Planet Formation	PS/NH	Apparent Motion; Stars; Ideas;Matter
3	How do we Find Planets Around Other Stars?	SI/TC	Apparent Motion; Stars; Actl Motion
4	Why Do We Put Telescopes in Space?	SI/TC/UC	Sky

PLANETQUEST the search for another Earth

PlanetQuest Activity Bag Inserts

Media and Resources (Getting Started)

Where are the Distant Worlds?

Telescope Treasure Hunt

Why Do We Put Telescopes in Space?

How Do We Find Planets?

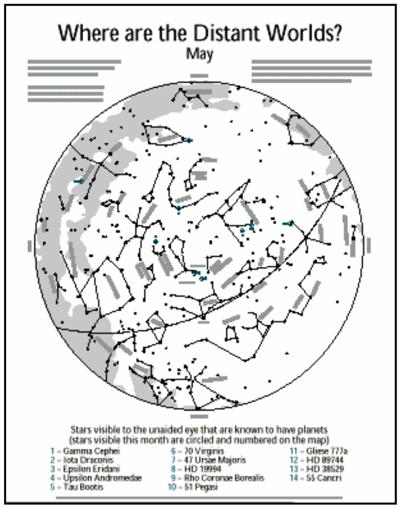
MEDIA & RESOURCES

GETTING STARTED WITH THE NIGHT SKY NETWORK AND THE OUTREACH TOOLKIT

1. **INSERT "OUTREACH TOOLKIT MANUAL AND RESOURCES" CD INTO YOUR COMPUTER. Click on PlanetQuestManual.pdf to navigate through the Outreach ToolKit Manual. Review the section on "Your Club's Membership in the Night Sky Network". You need the free Adobe Acrobat Reader to view the manual: http://www.adobe.com/products/acrobat/readstep2.html**
2. **VIEW THE TRAINING VIDEO.**
3. **INTRODUCE THE NIGHT SKY NETWORK and TOOLKIT TO YOUR CLUB and find members who want to participate.**
4. **REGISTER YOUR CLUB'S PARTICIPANTS in the Night Sky Network.**
5. **PLAN EVENTS. You might get started by bringing copies of the "Where are the Distant Worlds?" Star Maps or the "Telescope Treasure Hunt" Lists to your next public astronomy night.**
6. **AFTER EACH EVENT, log the event into the Night Sky Network. A Club Coordinator will need to approve logged events.**
7. **See Outreach ToolKit Manual for more details.**

WHERE COULD I USE THE ANIMATIONS AND OTHER RESOURCES INCLUDED HERE?

MEDIA / RESOURCE	Pre-Star Party - Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Meeting	Gen Public Presentation (Seated)
			K-4	5-8	9-12		
Animation: Overview: The Search Begins… (Summary of the NASA missions)	√	√		√	√	√	√
Animation: Four Ways to Find a Planet	√	√		√	√	√	√
Kepler Science Animation (Transit Method)	√	√		√	√	√	√
SIM DVD – NASA Scientists talk about the SIM mission	√	√		√	√	√	√
The Search for Another Earth (PPT)	√	√		√	√	√	√



Where are the Distant Worlds?

DESCRIPTION:
A new twist to the standard star map! Hand out custom star maps to help your visitors find constellations *and* to identify the stars discovered to have planets.
Use the Planetary PostCards to discuss what the planets around the star might look like.

Questions to stimulate discussion:

- That star is hotter/colder than our Sun. How do you think that might affect its planets?
- Here is where one of the planets orbits that star. What would it be like to live on this planet (or one of its moons)?
- If Earth was orbiting that star, what might be different?
- Do you think we have found all the planets in this system?

See Outreach ToolKit Manual and Training Video for more details and suggestions.

WHERE COULD I USE THIS ACTIVITY?

Star Party	Pre-Star Party - Outdoors	Pre-Star Party - Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Meeting	Gen Public Presentation (Seated)	Gen Public Presentation (Interactive)
				K-4	5-8	9-12			
√	√ (Introduce Activity)	√ (Introduce Activity)	√ (Introduce Activity)						

WHAT DO I NEED TO DO TO BEFORE I USE THIS ACTIVITY?

What do I need to do to complete the materials?	What do I need to supply to run this activity that is not included in the kit?	Do This Before Your Event
Optional: You may want to prepare a page to photocopy onto the reverse side of the star map that has your club information on it.	Red flashlights	**Print out and Photocopy:** Current month's star map for your visitors.

PLANETQUEST the search for another Earth

Telescope Treasure Hunt: How do Stars and Planets Form?

DESCRIPTION:
How are the different objects you view through the telescopes at a star party related to each other? Your visitors tour the telescopes to hunt for the objects that contribute to stellar and planetary formation, using a set of stickers and a "Treasure List". Visitors mark each object they view or place one of their stickers next to the object on the Treasure List. You have the opportunity to discuss how the object you are showing in your telescope contributes to building stars like our Sun and planets like the Earth you are standing on. See Outreach ToolKit Manual and Training Video for more details and suggestions.

WHERE COULD I USE THIS ACTIVITY?

Star Party	Pre-Star Party - Outdoors	Pre-Star Party - Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Meeting	Gen Public Presentation (Seated)	Gen Public Presentation (Interactive)
				K-4	5-8	9-12			
√	√ (Tell Story of Star & Planet Formation)	√ (Tell Story of Star & Planet Formation)	√ (Tell Story of Star & Planet Formation)						

WHAT DO I NEED TO DO TO BEFORE I USE THIS ACTIVITY

What do I need to do to complete the materials?	What do I need to supply to run this activity that is not included in the kit?	Do This Before Your Event
***Optional*:** If you have more amateur astronomers participating than the number of badges in the ToolKit, print out on a color printer "Ask Me About Other Worlds" badges and insert them into badge holders. ***Optional*:** Include your club's information on the reverse side of the Treasure List.	Telescopes	If out of stickers, purchase more. If using stickers, cut stickers into strips, if necessary. For use as a reference, you might want to hand out a Treasure List to each participating astronomer. **Print out and Photocopy:** Treasure Lists for your visitors to use.

Why Do We Put Telescopes in Space?

DESCRIPTION:
Want an easy way to explain why stars twinkle and views through the telescope are sometimes wavy? Let your visitors experiment with mock telescopes and materials that simulate atmospheric conditions. See Outreach ToolKit Manual and the Training Video for details.

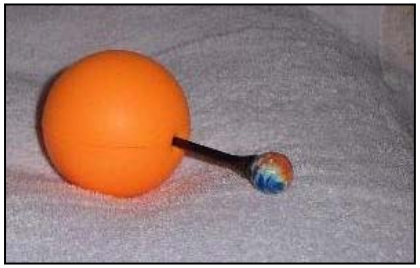
WHERE COULD I USE THIS ACTIVITY?

Star Party	Pre-Star Party - Outdoors	Pre-Star Party - Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Meeting	Gen Public Presentation (Seated)	Gen Public Presentation (Interactive)
				K-4	5-8	9-12			
√	√	√	√	√	√	√	√		√

WHAT DO I NEED TO DO TO BEFORE I USE THIS ACTIVITY?

What do I need to do to complete the materials?	What do I need to supply to run this activity that is not included in the kit?	Do This Before Your Event
Fold the 4"x4"x2" box. Place "mystery" object inside. Place batteries in snake lights.	*Optional:* Large Flashlight	If you anticipate presenting to more than 10 people at a time, you may want to acquire more tubes (paper towel tubes), rubber bands, and bubble wrap.

PLANETQUEST the search for another Earth



How Do We Find Planets Around Other Stars?

DESCRIPTION: Explain how we've found and will find planets around other stars! Manipulate foam balls (representing stars) to simulate the ways we find planets now and how future NASA missions may find planets: star wobble (astrometry and radial velocity), transits, direct imaging of planets. See Outreach ToolKit Manual and the Training Video for details.

WHERE COULD I USE THIS ACTIVITY?

Planet-Finding Method	Star Party	Pre-Star Party - Outdoors	Pre-Star Party - Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Meeting	Gen Public Presentation (Seated)	Gen Public Presentation (Interactive)
					K-4	5-8	9-12			
Wobble	√	√	√	√	√	√	√	√		√
Details on all methods		√	√	√		√	√	√		√

WHAT DO I NEED TO DO TO BEFORE I USE THIS ACTIVITY?

What do I need to do to complete the materials?	What do I need to supply to run this activity that is not included in the kit?	Do This Before Your Event
Insert golf tee with planet into the foam ball. Attach a very small (less than 1 mm) ball of clay to end of toothpick and insert in another foam ball.	Nothing	Nothing else

PlanetQuest the search for another Earth