

## The Planet Hunters Educator Guide

A resource for using QUEST video and audio in the classroom

Watch it online at <http://www.kqed.org/quest/television/view/502> | TV story length 8.52 minutes

Listen online at <http://www.kqed.org/quest/radio/exoplanets> | Radio story length 5.45 minutes

### QUEST SUBJECTS

<p><b>Life Science</b></p>	<p>Biology Health Environment</p>
<p><b>Earth Science</b></p>	<p>Geology Weather <b>Astronomy</b></p>
<p><b>Physical Science</b></p>	<p><b>Physics</b> Chemistry Engineering</p>

### CA SCIENCE STANDARDS

#### Grades 9-12

##### *Earth's Place in the Universe*

1. Astronomy and planetary exploration reveal the solar system's structure, scale and change over time. (a,g)
2. Earth-based and space-based astronomy reveal the structure, scale and changes in stars, galaxies and the universe over time. (a, b, d)

### PROGRAM NOTES

#### Watch **The Planet Hunters**

Do other planets like Earth exist? To find out, a team of astronomers from the University of California is building a new telescope in the hills east of San Jose. QUEST finds out what the chances are that there are others like ours somewhere in the cosmos.

#### Listen to **Exoplanets**

Since 1995, astronomers have identified more than 200 new planets, but these planets aren't in our solar system. Known as exoplanets, they're the planets orbiting other suns and Bay Area scientists are leading the search. QUEST reports on some of the latest efforts to find new planets - and maybe life - in outer space.



In this segment you'll find...

- how scientists use the Doppler technique to discover extra-solar planets.
- why astronomers find it difficult to discover Earth-sized extra-solar planets.
- the role played by astronomers in the Bay Area in extra-solar planet research.

### TOPIC BACKGROUND

Are we alone in the universe? Do planets like our own exist outside of our solar system? Astronomers are currently finding the answers to these and a host of other questions as they discover planets circling distant stars. These planets, called extra-solar planets or "exoplanets," are creating a buzz in astronomy circles around the world as the search for planets similar to Earth begins in earnest.

The first exoplanets were discovered in 1995 by Swiss astronomers. Since that time, scientists around the world have discovered approximately 250 exoplanets circling stars in other planetary systems.

Scientists observe the light emitted by stars for clues on a planet's existence. Simply put, stars are balls of gas (primarily hydrogen and helium) that give off heat and light. The light emitted from stars can be broken down into its composite colors by an instrument called a spectrograph. Scientists, using the spectrograph and a method known as the Doppler technique, look for "wobbles," or changes in the color (wavelength) of the star's light that are caused by the gravitational pull of a planet on the star. A change in the light's color (wavelength) indicates the presence of a planet orbiting that star.



The first exoplanets discovered were big -- the size of Jupiter or Saturn. Now, scientists are most interested in finding planets the size of Earth. Such a planet is far more difficult to find because it is so much smaller. To help astronomers find these planets, NASA Ames is developing the Kepler, a new satellite telescope designed to look for Earth-like exoplanets. The Kepler satellite's large telescope will be able to look at 10,000 stars at a time, speeding the process of discovery.

## Media Enhance Education

Video and audio can be powerful tools for meaningful learning. It all depends on you, the educator. The key to using media effectively is preparation. Make the most of learning opportunities by encouraging students to become active viewers and listeners. Pick and choose from the suggested questions and activities to offer an engaging media experience.

## Questioning

Oftentimes, teachers and students become frustrated during a media segment when students can't find the answers to a long list of questions. Provide a limited number of questions or topics for students. This focuses their attention during a media segment, helps to keep them engaged and generally results in higher quality answers. QUEST Ed. has provided a number of options for focus questions ranging from fact based to opinions, as well as "big picture" ideas.

## PRE-VIEWING

- Do planets exist outside our solar system?
- What evidence is there to support the fact that planets may exist outside our solar system?
- What tools do astronomers use to find planets outside our solar system?

## VIEWING FOCUS

NOTE: You may choose to watch the television and radio segments twice with your students: once to elicit emotional responses and get an overview of the topic and again to focus on facts and draw out opinions.

- How many known planets outside our solar system have been discovered?
- When was the first exoplanet discovered?
- Why is hunting for other planets so difficult?
- What happens to a star when there's a planet circling it?
- What technique do scientists use to detect planets?
- What is a spectrograph? What does it do?
- What roles do Chabot Space and Science Center and Lick Observatory play in planet hunting?

## POST-VIEWING – Links to activities mentioned here can be found on the following page.

- **Review** students' answers to the Viewing Focus Questions.
- **Design** a habitable world outside our own by visiting the AstroVenture Web site.
- **Model** a planet crossing in front of a star on the Kepler Web site.
- **Investigate** "wobble"
- **Explore** how Kepler discovers planets  
<http://kepler.nasa.gov/Mission/QuickGuide/howKeplerFindsPlanets/>

*I think it's in our genes that we look up at the night skies ...and in so exploring, perhaps we will learn a little bit more about where we came from, why we humans live our lives, and where our roots are here on the Earth.*

- Dr. Geoff Marcy

## LESSON PLANS / ACTIVITIES



### Kepler Education and Public Outreach Programs NASA

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

- Here you'll find a multitude of resources for grades 1-12, as well as informal education related to the Kepler Mission: A Search for Habitable Planets. Many of the resources were developed by the Lawrence Hall of Science.

### Extreme Planet Makeover NASA

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

- An interactive where students try their hand at making their own planet.

### A Whole New World New York Times Learning Network

<http://www.nytimes.com/learning/teachers/lessons/19991116tuesday.html>

- Students explore the existence of extra-solar planets through the investigation of direct scientific evidence.

## WEB SITES

### The Extrasolar Planets Encyclopedia

<http://exoplanet.eu/>

- A Web site that provides a catalog of information about extra-solar planets, including a tutorial, "Search for Planets"

### California & Carnegie Planet Search

<http://www.exoplanets.org>

- This site contains information and current research on extra-solar planets.

Look for the



indicating resources from QUEST partner organizations

# QUEST QUAD

## FIELD NOTES



### Go outside and ...

#### ☉ Identify the constellation Cygnus

- This constellation is where astronomers have found evidence of an extra-solar planetary system.

## FIELD TRIP



### Visit ...

#### ☉ Chabot Space and Science Center

10000 Skyline Blvd., Oakland 94619

[www.chabotspace.org](http://www.chabotspace.org)

- Ask an astronomer questions you may have about exoplanets or what it's like to be a planet hunter.
- View planets during Chabot's free telescope viewing times on Friday and Saturday evenings (check website for details)

#### ☉ American Museum of Natural History

- Take a virtual field trip to the Exoplanets and the Search for Life exhibits.

<http://www.amnh.org/exhibitions/exoplanets/>

## FIELD RESEARCH



### Find out more about...

- ☉ Lick Observatory and the work scientists are doing there with exoplanets
- ☉ The Doppler effect
  - Why do forecasters use it in their weather reports?

## FIELD TEST



### Experiment with...

- ☉ Looking at the planets of our solar system through a telescope or pair of binoculars
- ☉ Building your own spectroscope to see what colors make up white light  
[www.cs.cmu.edu/~zhuxj/astro/html/spectrometer.html](http://www.cs.cmu.edu/~zhuxj/astro/html/spectrometer.html)

## VISIT OUR PARTNERS

The Bay Institute  
[www.bay.org](http://www.bay.org)

California Academy of Sciences  
[www.calacademy.org](http://www.calacademy.org)

Chabot Space and Science Center  
[www.chabotspace.org](http://www.chabotspace.org)

East Bay Regional Park District  
[www.ebparks.org](http://www.ebparks.org)

Exploratorium  
[www.exploratorium.edu](http://www.exploratorium.edu)

Girl Scouts of Northern California  
[www.girlscoutsbayarea.org](http://www.girlscoutsbayarea.org)

Golden Gate National Parks Conservancy  
[www.parksconservancy.org](http://www.parksconservancy.org)

The J. David Gladstone Institutes  
[www.gladstone.ucsf.edu](http://www.gladstone.ucsf.edu)

Lawrence Berkeley National Laboratory  
[www.lbl.gov](http://www.lbl.gov)

Lawrence Hall of Science  
[www.lawrencehallofscience.org](http://www.lawrencehallofscience.org)

Monterey Bay Aquarium  
[www.mbayaq.org](http://www.mbayaq.org)

Monterey Bay Aquarium Research Institute  
[www.mbari.org](http://www.mbari.org)

Oakland Zoo  
[www.oaklandzoo.org](http://www.oaklandzoo.org)

The Tech Museum of Innovation  
[www.thetech.org](http://www.thetech.org)

UC Berkeley Natural History Museums  
<http://bnhm.berkeley.edu/>

U.S. Geological Survey  
[www.usgs.gov](http://www.usgs.gov)

## OTHER WAYS TO PARTICIPATE IN QUEST



### LOG ON

[www.kqed.org/quest](http://www.kqed.org/quest)



### LISTEN

**KQED 88.5 FM San Francisco &  
89.3 FM Sacramento  
Mondays at 6:30am and 8:30am**



### WATCH

**KQED Channel 9  
Tuesdays at 7:30pm**

## IMAGE CREDITS

**Chabot Space and Science Center;** Chris Bauer

**Planet orbiting a star;** NASA



From KQED Public Radio, I'm Amy Standen with our Monday look at science and environmental issues from Quest.

We learned in school there were nine planets in our solar system. Pluto got demoted and now there are eight. But take a look outside our solar system and even bigger discoveries are taking place. Since 1995 astronomers have identified more than 200 new planets orbiting other suns. As Andrea Kissack reports, much of this exploration is happening right in the Bay Area.

High atop Mount Hamilton just east of San Jose is a series of white domes dotting the 42-hundred foot crest line. Inside each one is a powerful telescope opening a window on our universe. The search for extra solar planets, or planets outside our solar system, began right here at the University of California's Lick Observatory.

FISHER: "There are five stars that I will be looking at tonight. And I have just finished modeling the planets around them."

Debra Fisher is a professor of Astronomy at San Francisco State University and a planet hunter.

In preparation for this night's observation, the shutter of Lick's biggest dome opens, revealing a huge telescope with a mirror three meters in diameter. Fisher trains it on a small point in the Milky Way. Astronomers prefer to search in this hazy swath of light because it's jam packed with stars.

FISHER: "So our first star will probably be B - 8."

Each time Fisher calls out a star, or sun, a technician presses a few buttons directing the giant telescope to move.

Although Fisher is looking at stars that are some of our closest neighbors, they are still trillions of miles away. So it's no easy task to find planets that may be orbiting one of them. The planets are so dim they can get lost in the glare of their sun. To find them Fisher relies on the basic laws of gravity. As the planet orbits the star it tugs on it, just slightly, creating a tiny wobble. And to spot this almost undetectable wobble, astronomers watch the wavelengths of light change.

FISHER: "If you are sitting on a boat in the ocean and there are waves going by and you hear those waves hitting the boat with a certain frequency. And now you turn on the motor and you drive into the waves then you begin to hit the waves at a higher frequency. And now you turn the boat around so that you are driving in the same direction as the waves and now the frequency you perceive is lower. And it's the same whether you are the boat moving through the ocean or whether your boat is stationary and it's the ocean moving towards you."



The discovery of the first few hundred extrasolar planets by teams from Lick and Switzerland proved our solar system is not unique. Most of these planets have been hot gas giants like our own Jupiter.

KOCH: "The giant planets are easy to find, you can do that from the ground."

David Koch is the Deputy Principle Investigator for NASA's extra solar mission at the Ames Research Center in Mountain View.

KOCH: "The problem is if you want to look for earth sized planets you have to go to space, you can't find them looking through the atmosphere of earth. "

And so early next year NASA will be launching a bus sized telescope into outer space that will look for planets like earth. The Kepler telescope is named after Johannes Kepler, who first discovered the laws of planetary motion in 1602. The telescope, which will orbit our sun, can observe a hundred thousand stars at a time.

Inside his tiny photometry lab at NASA Ames, Koch opens the door to what looks like a foil covered phone booth.

KOCH: "This foil covered phone booth is actually the exterior of our experiment. "

The Kepler telescope is being built at Ball Aerospace in Boulder. It will be launched from Cape Canaveral and the information sent back from Kepler will be analyzed in Mountain View. Inside the darkened phone booth, Koch runs tests of equipment identical to what will be flying on Kepler. He is testing the 'transit method' which is what the Kepler will use to detect planets.

KOCH: "When a planet passes in front of the star it blocks a tiny bit of light from that star during the transit. And what you do then is you have to monitor lots of stars looking for this tiny little dip in the change in brightness. Finding just one dip doesn't tell you if you have a planet. Finding even two dips doesn't tell you it's a planet but if you find a sequence of three dips in the brightness of the star that are perfectly spaced and periodic and they repeat over and over again, then you know it must be a planet that is passing in front of the star as we are viewing if from here on earth. "

Koch and Fisher are using Kepler's laws of planetary motion in a vast extra solar search for new life.

FISHER: "It's a giant jigsaw puzzle, trying to fit everything together so we will have amazing view of our place in the universe. Whether there are other beings like us, whether there is more primitive life, plant life, for example, on other planets. And I think we'll have a handle on that in the next 10 to 20 years and I think that will be very exciting. "

Fisher's work will soon be aided by a new, bigger telescope being built at Lick Observatory just for extra solar planet hunting. NASA will launch the Kepler



telescope in February. It will remain in space staring constantly at one star field in the Milky Way for at least three and a half years.

For Quest, I'm Andrea Kissack. KQED Radio News.