ALIEN EARTHS

Component Descriptions

The *Alien Earths* traveling exhibition invites visitors to join the search for habitable worlds. This incredible journey of exploration raises many challenges for scientists. How do we search areas beyond our solar system that we cannot reach with spacecraft? When we're observing from a great distance, we can only see the brightest objects–stars–and not the planets orbiting them. So how do we find what we cannot see? Visitors to *Alien Earths* will learn the creative methods and technologies that scientists are using and might use in the future to conduct a search of our galactic neighborhood.

Scientists have now found more than one hundred extra-solar planets, but so far, we haven't found evidence of life beyond Earth. *Alien Earths* addresses several basic questions that scientists ponder. How does what we know about life on Earth inform the search? Are we more likely to find intelligent life or microbes? How does life alter its environment? What can we learn about a distant planet's habitability from just a few pixels of light? If you're searching for signs of intelligent life, what do you look or listen for? The answers will engage visitors with one of humanity's fundamental concerns:

Are we alone?

Our Place in Space

When visitors enter *Alien Earths,* they encounter large graphic murals and the exhibition's title sign. "Our Place in Space" introduces them to the scope of the exhibit-tion and the vast spatial scales involved—from the atomic to the galactic. Humans fall between the microscopic and telescopic views presented. Where are scientists looking to find alien worlds? Visitors find out by pushing a button on a light box portrait of our Milky Way galaxy that highlights the search area. Our ground- and space-based observatories can only search for extra-solar planets in a relatively small region of the galaxy near our solar system. Scientists searching this region may one day discover something astonishing: that a distant world harbors life.

Image courtesy of Shami Chatterjee.

Star and Planet Formation

A ground-based instrument was used to obtain this portrait of the Spiral Galaxy NGC 1232. Image courtesy of European Southern Observatory.

Stars are born in clouds of gas and dust that condense under the powerful force of gravity. Visitors learn about star birth and the life cycles of different types of stars. They can also explore the behavior of infrared radiation and how scientists use it to peer into stellar nurseries. At one component, visitors can create their own solar system, set it in motion, and observe whether the configuration they created results in a stable system.

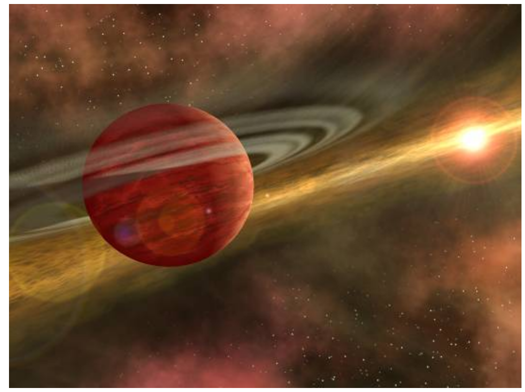
- Pressure Ball (Interactive). Up to three people can work together with hand pumps to increase the pressure in a star chamber that simulates a star forming region. As the pressure builds, the temperature increases until the "star" ignites with sound effects and a bright flash. This device demonstrates the important connection between temperature and pressure in star formation.

- Stellar Life Cycle (Interactive). On a wide screen monitor, visitors will interact with dramatic, animated video of the life cycle of three types of stars: a low-mass star, one that's Sun-like, and a high-mass star. Using a "SpinBrowser" interface dial, visitors can compare two stars at a time and view the footage in fast or slow motion, forward or reverse, or frame-by-frame.

NASA's Hubble Space Telescope captured this image of a star forming region within the Swan Nebula, which is located about 5,500 light-years away in the constellation Sagittarius. Image courtesy of NASA, ESA and J. Hester (ASU).

- Mission Invisible (Interactive). Stars and planets sometimes form out of the same clouds of gas and dust. How do scientists peer through the dust into the heart of these star forming regions in our galaxy? They look at the infrared spectrum. This component allows visitors to experiment with an infrared camera and a number of familiar objects, such as a piece of plexiglass and discover how they appear in the infrared as opposed to visible light. A light fog partially obscures the table and a beautiful image of a star forming region. The infrared camera reveals five heat sources imbedded in that image.

- View Space Theater (Video). Visitors may watch a film of beautiful and inspiring Hubble images on a large format monitor. The film was developed by the Space Telescope Science Institute.



NASA's Spitzer Space Telescope detected a clearing in the dusty, planet-forming disc around the star CoKu Tau 4. As suggested in this artist's conception, a planet may have swept away the disc material. Image courtesy of NASA/JPL-Caltech.

- Design a Solar System (Computer Station). This component allows several people to stand in front of a large, round touch screen and move planets of various masses into place around a star and then set them in motion. Visitors learn the basics of orbital mechanics and that all members of a planetary family affect each other. They may also realize how difficult, and perhaps rare, it is to achieve a stable solar system like our own.

- Our Solar System (Model). Visitors encounter a large, mechanical orrery of our solar system that accurately shows their relative motion as they orbit the Sun. Nearby graphics compare our solar system with several recently discovered solar systems.

- Planet Densities (Interactive). This component demonstrates that planets have different densities, and that a giant planet, such as Saturn, would actually float in water. Lucite containers holding "samples" of Earth, Jupiter, and Saturn are placed in water. Visitors may lift corresponding containers to compare the relative density.

- Planet Models. Nine models of the planets in our solar system, which are correctly scaled relative to one another, are arranged along the outside wall of the dome area. A mural compares Earth and its neighbors to what we know about extra-solar planets. The nine planets are also scaled to the geodesic dome over the adjacent Planet Quest area, which represents the Sun. Visitors learn that all of the extra-solar planets we've discovered so far are much larger than Earth, closer to the size of our solar system's giant planets, like Jupiter. They also learn that limits in our current technology prevent the discovery of small, rocky planets in distant solar systems. Even so, we may yet discover an alien Earth.

Planet Quest

Until very recently, the only planets we had discovered were all within our solar system. We can't send spacecraft across the galaxy at the speed of light or capture an image of a planet orbiting a distant star. So how did we discover the extra-solar planets that we've identified so far? Visitors to this area will learn about the ingenious methods that scientists have developed for searching for planets that we cannot see.

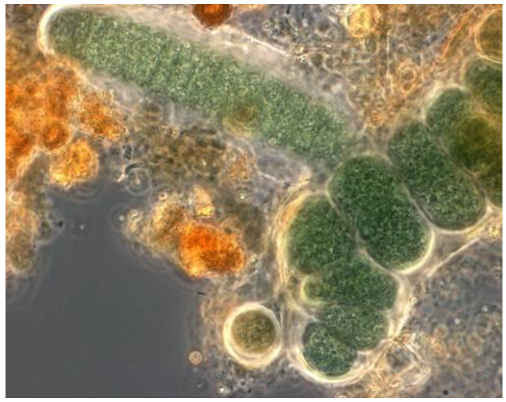
- Alien Earths News (Graphics and Computer Station). A geodesic dome rises over the Planet Quest area. A mural of the night sky fills the inside of the dome. Along the bottom edge is a timeline showing the chronology of planetary discovery and the explosive increase in recent years. We've now discovered over one hundred extra-solar planets. Visitors can find out about selected ground- and space-based missions, as well as about some amazing discoveries that are being made by scientists around the world.
- Other Worlds (Computer Station). Visitors can access a 3d atlas of the tiny portion of our galaxy where we've found extra-solar planets orbiting distant stars. Although these worlds are far away, they're nearby relative to the entire Milky Way galaxy. Some stars in this atlas can be seen by the naked eye in the night sky. Visitors can use the computer to turn on selected stars in the dome—representing a portion of the night sky—so that they can find those stars some evening after they leave the exhibition.
- Planet Transit (Interactive). This component demonstrates one of the methods scientists use to find planets. Visitors can place wooden balls representing planets of various sizes in orbit around a model star. When the planet orbits between the star and a light sensor, changes appear in a graph measuring the light from that star. When scientists see a similar change in the light of a distant star, they can infer the presence of a planet orbiting that star.
- Coronagraph (Interactive). Visitors manipulate an occulting disc to block the glare from a bright light representing a star. When the light is blocked, several other objects representing planets become visible.
- Planet Wobble (Interactive). This simple hands-on component demonstrates another method of detecting planets around distant stars. In the prototyping phase, this component attracted small groups of visitors who interacted with one another in playful exchanges. A large, circular, felt-lined tray holds pairs of wooden balls representing stars and planets that can be connected with dowels. Visitors experiment by spinning the large balls representing stars with or without planets, represented by smaller balls. The different masses of the objects affect the amount of wobble created as the planet orbits its star. Most extra-solar planets have been detected by observing a star's "wobble".

Search for Life

What we know about life on Earth informs our search for life beyond Earth. Visitors to this area will be surprised to learn that our planet's most abundant life form is the microbe. Since we can only observe from a great distance, what would a habitable world's chemical signature be if it were reduced to a pinpoint of light? And if we wanted to focus on a search for evidence of intelligent life forms, what would we look and listen for?

- Life Scanner (Computer Station). Visitors can place their hands on a plate associated with a computer that "scans" the hand and then produces charts revealing the countless life forms living on and within our bodies. All life forms are made from the same chemical building blocks. Without microbes, life on Earth as we know it would not exist.

- Microbial World (Interactive). A rogue's gallery of microbes is presented on a large format monitor. The video is controlled by a "SpinBrowser" interface dial that allows visitors to interact with the footage.



Cyanobacteria found in Lake Toolik (Alaska, USA). Image courtesy of Michele Bahr and David Patterson.

- Biomass (Interactive). This component consists of a set of containers representing the relative weights of the biomass of different life forms on Earth. Visitors can lift each container to feel the following relationships: animal life = 1, plant life = 9, and microbial life = 90. Most visitors will probably be surprised to learn that microbial life makes up 90% of the total biomass on Earth.

- Sensing Life (Live Speciman Interactives and Computer Station). If we can only observe an alien world from a great distance, how will we know if it harbors life? Because we know from our own planet that life changes its environment. So if life is present on a planet, we may be able to detect the chemicals that indicate a "bio-signature." The Sensing Life component includes a jar with a Winogradsky column of complex microbial communities whose metabolic processes consume some chemicals and produce others as waste. Tubes extend from three different layers to sniff bottles for sampling simulated smells from the layers. Visitors are amazed that the top layer of the column actually smells OK. That's not true for the other two layers. A living microbial mat with oxygen probes and readouts is accompanied by a computer-based tour through the mat. Mats are one of the most ancient life forms on Earth. Visitors can also use a computer station to learn more about the chemical processes that are occurring at different layers in the W-column.

- Waterworld (Interactives). Liquid water is necessary for life. Two components demonstrate the properties of water and how it behaves. The pressure of a gas depends on the energy of its molecules and the volume of its container. In the

Molecules in Motion device, visitors can vary both energy and volume to see and hear how pressure changes. Gas molecules are represented by ping pong balls. In the second device, visitors can decrease the pressure in a chamber and watch the water boil away even though the temperature does not change. Thus, visitors learn that temperature and pressure are important in allowing liquid water to form, an important criteria for a habitable world.

- Life's Chances: Understanding Numbers (Interactive and Computer Station). This component includes a computerized version of the Drake equation, a salt counting interactive, and a construction of salt canisters that surround a small, mirrored room that visitors may enter. If the room were filled with salt, there would be about 100 billion crystals, which is about how many stars there are in our galaxy. To understand these numbers, visitors may place some salt on a scale that measures the mass and calculates the number of salt crystals. This method is used by scientists to estimate the number of stars in the Milky Way galaxy.

- Looking for Life (Computer Station). If an alien world is so far away that we can't travel there, how will we know if it holds life? Visitors are shown a series of images (from viruses to distant planets) and asked whether the image shows signs of life. At each stage, an "analysis" tool helps the user understand how life can be remotely detected and defined.

- Listening for Life (Interactive). Visitors can listen to various audio samples, examine a graphic map of the sounds, and try to determine which ones are naturally produced, such as sound originating from a pulsar, and which may be created by an intelligent life form. Flip panels reveal the answers. Scientists from the SETI Institute helped develop this piece.

Digital mosaic of the Andromeda Galaxy created by Robert Gendler.