Strange New Planet

NASA JSC ARES Education adaptation 2009
ASU Mars K-12 Education Program 6/99
Adapted from NASA Education Brief "EB-112: How to Explore a Planet" 5/93

Key Topics * planetary exploration science observation * NASA science exploration mission sequence
* at higher level – instrumentation and technology used in exploration missions

Introduction

Strange New Planet allows participants to engage in a simulation of the process and sequence used in planetary exploration to progressively gain new information about unknown objects. As the students ask questions and seek new information, this activity demonstrates how scientists discover and investigate planetary features. Students will simulate remote sensing techniques – from telescopes to robotic missions. This activity uses inexpensive materials that an educator can easily assemble.

Lesson Length 45 – 60 minutes – more if students conduct Internet research

Suggested Grade Level 5-8 (with adaptations K-12- simple observations vs. more data collection related to current remote sensing data and techniques – older students could use cell phone cameras to record data)

Group Size 6 – 60 Group students in teams of 3-4. This is a group investigation activity.

Space Needed The room should be large enough to place the planets 5-10 meters (~ 15 - 30 ft) from the students conducting the observations. Planets could be in the hallway or another room. Space around the planets must be clear of tripping hazards so the observers can safely approach and orbit the planets.

Objectives

Students will:

- Make observations, collect data, and make simulated mission decisions as they depict robotic exploration.
- Identify planetary bodies in our solar system that are mission targets.
- Research solar system missions - optional.

About this Lesson

In the ***Strange New Planet*** activity, students enact missions that show the sequence NASA uses to robotically explore solar system bodies. Participants engage in a simulation of the process and sequence used in planetary exploration to progressively gain new information about unknown objects. Using ordinary cardboard tubes that simulate telescope, students take turns viewing unusual planets that the teacher has placed in the classroom. Groups of three to four students work as a research team as they plan missions to examine the strange new planets and answer questions formulated by their team. The designated observer will gather new information as they simulate fly-by, orbit, lander, and sample return missions. This activity demonstrates how scientists discover planetary features, question the formation of the features, and research the features more carefully using remote sensing techniques from telescopes to robotic missions. Students will focus on observation and reporting skills as well as developing questions and seeking answers.

Activity Leader will help students process each step of the investigation through careful questioning strategies – not by step by step instructions – so that the students can be the questioning investigators.

Students may use Internet resources to research the NASA missions that are exploring our solar system.

National Science Standards Addressed

Unifying concepts and processes in science:
- Evidence, models, and explanation

Science as Inquiry:
- Abilities necessary to do scientific inquiry

History and Nature of Science:
- Science as a human endeavor, Nature of science

Background

Right now, the most advanced scientific space fleet ever assembled is out there in our solar system hammering away at some of life's biggest – and toughest – questions: Where do we come from? Where are we going? Are we alone?

Clues to these mysteries are scattered among the objects that make up our solar system: our Sun, the planets, moons, comets and asteroids. Evidence of the earliest days of the solar system may exist in rocks on the cratered surfaces of Mercury, Mars and Earth's moon. Chemical clues to our origins may linger in the icy hearts of comets and distant Kuiper Belt objects or in the hazy atmosphere of Saturn's giant moon, Titan. A few of Jupiter's moons may even harbor oceans under their icy crusts.

Just as the robotic spacecraft of the 1960s pioneered a safe path for astronauts to walk on the Moon, today's advanced robotic explorers are charting a course that will take humanity back to the Moon and beyond. It won't be easy. These exploring machines must endure extreme heat and cold and intense radiation during long journeys across mind-boggling distances. Even at speeds up to 80,400 kph (50,000 mph), a one-way ride to Pluto takes about nine and a half years. If all goes well – and there are no guarantees in space travel – we will be among the first humans to see Pluto up close. We will have to wait until NASA's New Horizons spacecraft arrives at Pluto in 2015 for that particular view.

Fortunately, there's plenty to do – and to see – in the meantime.

Vocabulary

Launch, fly-by, orbit, probe, encounter, lander, and sample return, remote sensing, data, terrain, instruments, and spectrometer.

Materials

Teacher Materials for planets -- make 2 or 3 very different planets per classroom

Make planets from several different materials with other interesting materials on the surface – examples below.

- Playdoh© (multi colored spheres)

  or plastic balls, modeling clay, Styrofoam© balls, or rounded fruit (grapefruit, oranges, etc.)
- Cloves, vinegar, or mild scents like peppermint
- Small stickers, sequins, pony beads, candy, marbles, anything small and interesting!
- Cotton balls
- Toothpicks
- Small ball of Playdoh© or ball to use as a moon
- Glue (if needed)

Display materials

- Towel (Black or dark blue to put under and drape over planets – helps the planets stand)
- Tall stool or stack of boxes to display planets for observations – arranged for fly-by and orbits.
- Optional – large poster of space to display on wall opposite where the planets are displayed used to focus non observers on something while their teammate is observing

Student Team materials – <u>one per team</u>

- Viewers (sheet of paper rolled and taped as a tube or paper towel roll)
- 12 cm x 12 cm (5" x 5") blue cellophane squares - brown or yellow cellophane will also work as "atmosphere" (Advanced -- other colors may be used as filters for additional information)
- Rubber bands
- Small toothpick, very small flag, or very small sticker for teams to place on planet to designate their landing site.
- Strange New Planet Student Data Sheets – or blank paper

Teacher could display image on screen for the Team in the Lab while the Observers are viewing the strange new planets at the opposite end of the room.

- Optional!! If you want the students to simulate technology, then have magnets, small metric rulers, colored pencils for color checking, and even digital cameras if that is acceptable in your classroom. Let the students decide what technology they need on their missions. You could even use UV beads and a UV light!
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For the latest information on solar system exploration missions and Solar System Education, visit: http://solarsystem.nasa.gov/missions and http://solarsystem.nasa.gov/educ/index.cfm

Make Planets (* Planets may be made days in advance -- store in plastic bags to keep from drying out.)

- (*Keep the planets covered until students are ready to observe)
- Make 2-3 multi-colored clay or Playdoh© balls or choose an object such as a plastic ball or fruit (orange, grapefruit, etc) that allows for multi-sensory observations.

To make the objects interesting to observe, add color and texture to the planets by embedding beads, aquarium rocks, twigs, whole cloves, scents, yarn, clear flat glass from flower vase (looks like water), or very small stickers (butterfly stickers simulate possible life on a strange planet.) Not too much – but make the planets different.

Place some of these materials discreetly so that they are not obvious upon brief or distant inspection.

Make landform features -- some suggestions for features are:

- Create clouds by using cotton
- Make polar ice caps with white clay or Playdoh©
- Carve channels or rivers
- Make impact craters
- Make a small moon -- a grape or ball of Playdoh©
- Apply scent sparingly to a small area or imbed cloves in a specific type of terrain

Assemble viewing tubes - one per team

- Make or gather tubes for observing – paper towel cardboard is best, rolled and taped paper works
- Place cellophane on one end of each tube and secure with a rubber band (Cellophane can be hard to find and is optional.)

Set-up

- Choose appropriate location for the planets – consider that the students will observe the planets from a distance, then pass by (fly-by), then orbit the planet area. Planets may be in different room – so observers are the only ones going on each mission to bring back data.
- Place the planets on a tall stool or stack of boxes (use table or desk if necessary – not preferred.) A tray on top of a tall waste basket works. Place moon near one planet. Make sure the observers will be able to see the planets.
- Cover the objects with a towel before students arrive.
- Seat students in working teams of 3-4 students. Seat the teams as far away from the planets as possible. The planets could be in a hall or other room.
- Give each team one observing tube.
- Distribute Data Sheets for each team.

Roles for Activity Leader **The Leader will be fully involved in guiding, questioning, and mentoring teams as the teams investigate.**

Brief students on their task: To explore a strange new planet(s) asking questions and taking and reporting data like a science team. They will work as a science mission team. Let teams know that they are seated in their own Mission Control area.

Team jobs are:

Mission Observer,

Data Recorder,

Data Reporter,

and Scientist.

For each mission, team members who are not the current Mission Observer will face away from the planet display -- they are in Mission Control waiting to receive data from the Observer. Only the Observer on each mission gathers the data and takes it back to the team. The team members will rotate responsibilities with each student taking a different role for each mission. Use the viewers when observing the planet from a distance and for the fly-by. Other techniques or technology may be used for the orbiter mission (camera or ruler, etc.) Encourage use of all senses -- except taste.

Pre-Launch Reconnaissance **This step takes 5 to 15 minutes**

Teacher notes: This step simulates Earth-bound observations. (See notes below**.)

- Ask one observer from each team to move to a designated observing place that is far away from the towel-covered planets. Observer takes the observing tube – telescope.

- Ask the remaining students at Mission Control to look at the Solar System Timeline or at a poster or picture that is away from the planets. Or the students may watch the observers. Just make sure the Mission Control team does not look at the planets.
- Ask observers to put the tube up to their eye – blue cellophane away from eye.
- Direct the observers' attention to the area where the planets are displayed.
- Remove the towel half way exposing only the half of each planet that faces the observers.
- Allow observers about 15 seconds to observe
- Replace the towel
- Discuss with the observers what they could see and what would make the seeing better.   Discuss that they are simulating observations from the surface of Earth.
- (** Guide students to associate the blue cellophane with the Earth's atmosphere. The molecules in the atmosphere inhibit really good observations.)
- Ask Observers to move one step closer to the planets – simulating telescopes in orbit around Earth – beyond the atmosphere.
- Ask Observers to remove the blue cellophane 'atmosphere' and observe again – remind Mission Control to look away!
- Remove towel – half way again.
- Allow 10-15 seconds for observations.
- Cover planets with towel.
- Ask students to return to their teams to report all the data.
- Teams record data and prepare to report the data.
- (** At this point, the observations will be visual and will include color, shape, texture, and position.)
- Ask Teams to discuss the questions they have about the planets that could be explored in future missions to the planet. Mission Scientist records the questions the team would like to explore.
- Ask each Data Reporter to tell what was observed.
- Honor all observations. Stress the variety of observations.
- (** Discuss the next step with the teams – How do you answer the questions you have about these planets? What would you need? What would you need to do? – Typical answers – get closer, go there – these are appropriate answers and can lead to the next step that NASA uses -- Fly- by Missions! The answer, "Taking a sample or landing," should be deflected to later when they have better information about appropriate landing sites – not yet. Some will say go to the internet – assure them that there is no information on the internet about these unique planets unless their Mission teams have already uploaded the information!)

Mission 1--The Fly-by   **This step takes ~10-15 minutes.**

- Ask each team to designate the next Mission Observer and to make sure that the observer knows the questions that the team wants answered with the Fly-by Mission. Observer will need the telescope tube – without the atmosphere.
- Ask each team Observer to line up where they can easily walk by the planet display.
- Ask each Observer to state the questions they will try to answer as they gather data for their team on the Fly-by Mission.
- Direct the students in Mission Control to look away from the planet display.
- Remove the towel – half-way again.
- Make sure there is a safe path for the Observer to walk with the tube up – safety!

- Using the telescope tube, each Observer will have a turn at walking past the uncovered side of the planet (the other side remains draped under cloth).
- Replace the towel over the planets.
- Observers should go back to their teams to share the data.
- Data Recorder writes the observations and the Data Reporter gets ready to report the data to the other teams.
- Teams discuss what the data means about the planets and what they want to look for on the next mission. Mission Scientist records the questions the team wants to answer.
- Ask each Data Reporter to tell what was observed.
- Honor all observations. (** Mention where there is agreement or disagreement of data – or different interpretations. All this is valid. Some descriptions may include familiar items – "We saw beads." Validate that scientists use descriptions that compare unknowns to things they know. Some teams may focus on one planet only and that is OK.)
- (** Discuss the next step with the teams – How do you answer the questions you have about these planets? What would you need? What would you need to do? Typical answer – fly-by again or land – both appropriate answers – but do they know the whole planet and the best place to land??)
- Guide the teams to think about NASA's next step -- Orbiter Missions!
- Ask teams to go back and check the questions they want the next Observer to consider as they orbit the planets.
- Ask teams to consider what technology they would simulate (see optional under team materials)

Mission 2--The Orbiter **This step takes ~10-15 minutes**

- Ask each team to designate the next Mission Observer and to make sure that the observer knows the questions that the team wants answered with the Orbiter Mission. Observer will need the telescope tube – without the atmosphere.
- Ask each team Observer to line up where they can easily walk around the planet display.
- Ask each Observer to state the questions they will try to answer as they gather data for their team on the Orbiter Mission.
- Direct Mission Control to look away from the planet display.
- Remove the towel completely.
- Using the telescope tube, each Observer will walk around the planet twice. Keep all observers going in the same direction.
- Replace the towel over the planets.

- Observers should go back to their teams to share the data.
- Data Recorder writes the observations and the Data Reporter gets ready to report the data to the other teams.
- Teams discuss what the data means about the planets and what they want to look for on the next mission. Mission Scientist records the questions the team wants to answer.
- Ask each Data Reporter to tell what was observed.

- Honor all observations. (**Encourage cross conversation about the data – where teams agree or where there is very different but sometimes corroborating data.)
- (** Discuss the next step with the teams – How do you answer the questions you have about these planets? What would you need? What would you need to do? Typical answers –' Land on it' or 'get samples' or 'Go there!' – all appropriate answers.)
- NASA's next step is to conduct Lander Missions!
- Ask teams to go back and check the questions they want the next Observer to consider as they land on a planet – just <u>one landing site per team</u>. So they must focus on only one planet and they must narrow the area to the size of a quarter - maximum. Teams should discuss the pros and cons of picking an area that would allow for data from different types of terrains.

Mission 3--The Lander **This step takes ~ 10 minutes**

- Ask each team to designate the next Mission Observer and to make sure that the observer knows the specific planet to observe and the questions that the team wants answered with the Lander Mission. Observer will need a toothpick or small paper flag to designate the Team Landing Site.
- Ask each team Observer to line up where they can easily walk around the planet display.
- Ask each Observer to state the questions they will try to answer as they gather data for a landing site on one planet.
- Direct Mission Control may look since all have seen the planets.
- Remove the towel completely.
- Each Observer will walk around the planet twice. Keep all observers going the same direction. (** Remind Observers that they are looking at one planet and designating the very best landing site where the next mission will take a sample. Remember to focus on an area no bigger than a quarter.)
- Observers should go back to their teams to share the data about why they picked a specific Landing Site. They should share the data that designates the characteristics of the team landing site – good enough for the Sample Return Observer to get back to the same site. Drawing a map of the landing site would be appropriate.
- Data Recorder writes the observations that will guide the next Sample Mission and the Data Reporter gets ready to report the data to the other teams.
- Ask each Data Reporter to tell what was observed and why the Landing site was picked.
- Honor all observations/reports -- discuss landing sites. (**Encourage conversation about the importance of the specific landing sites and possible multiple data sets.)
- Inform the teams that they may take one tiny sample from the designated landing site – <u>one tiny pinch!</u>
- Ask each team to discuss what materials/features they will Sample with the tiny pinch.

Mission 4--Sample Return **This step takes ~ 10 minutes**

- Ask each team to designate the next Mission Observer and to make sure that the observer knows the specific spot on the planet where the Team Sample will be taken. Discuss sampling methods – a small pinch of material or a small drill core of material would be appropriate – other ideas may work too – just be sure they do not take a really large fist full of planet.
- Assemble a Mission Observer from each team and allow them to sample according to their Team's directions.

- Mission Observers take the sample to the Team
- Team members analyze the sample – using all senses except taste. (** Some may have noted scents or living material – noses help simulate lab spectrometers. All returned samples would be analyzed in labs with spectrometers and other instruments that tell the chemistry, mineralogy and signs of life.)
- Data Recorder writes description of the Sample.
- Data Reporter gets ready to report to the news media – team should decide on a major headline they want the world to know about! Be ready for the Press Release Conference.
- Ask each Data Reporter to share their Team headline.
- (** Honor all reports – encourage other teams to clap!)

Adaptations

To shorten the time for the activity

- First observation may be done in the group with students looking at something to determine that the cellophane obscures a good view and that it represents the atmosphere.
- The Third Mission – Landing could be removed. The teams would go to the sample return after the orbiter

To add more information for the students.

- Ask students to look up fly-by, orbiter, lander, and sample return missions on NASA web sites.
- Have students research different NASA missions and report on the type of instruments, etc.

Age adaptations

- Older students could use a variety of materials from a typical classroom to make measurements or calibrations – colored paper, etc to determine exact color, cell phone pictures, or metric rulers. An advanced group could use UV lights to examine the planets – the teacher might embed UV beads or other items that look different in UV.

Strange New Planet Student Data Sheet Team Members:

Beginning Observation

What did the observer see?

What did other teams observe?

What more could you find out about the planet(s) with a new Mission?

What questions will your team try to answer with the next Mission?

First Mission

What did the observer see?

What did other teams observe?

What more could you find out about the planet(s) with a new Mission?

What questions will your team try to answer with the next Mission?

Strange New Planet Student Data Sheet Team Members:

Second Mission

What did the observer see?

What did other teams observe?

What more could you find out about the planet(s) with a new Mission?

What questions will your team try to answer with the next Mission?

Third Mission

What did the observer see?

What did other teams observe?

What more could you find out about the planet(s) with a new Mission?

What questions will your team try to answer with the next Mission?

Strange New Planet Student Data Sheet Team Members:

Fourth Mission

What did the observer see?

What did other teams observe?

What more could you find out about the planet(s) with new Mission?

What was your Team's Press Release science Headline?

Resource Materials

NASA's Discovery and New Frontiers Missions

Unlocking the Mysteries http://discovery.nasa.gov/multimedia/mysteries.cfml Mission Design Activity

http://discovery.nasa.gov
http://discoverynewfrontiers.nasa.gov/

The small-class Discovery missions and the medium-class New Frontiers missions complement NASA's flagship missions to meet the many scientific and technical challenges of deep space exploration. The Discovery and New Frontiers missions provide the diversity of vantage points – flybys, orbiters, landers, and sample returns – for optimum scientific value. The discoveries produced by these missions not only dramatically advance our understanding of the solar system; they also allow NASA to further refine its exploration strategy.

Past, Recent, and Upcoming Mission Events in the NASA Discovery Program

Mars Pathfinder -- Lander and rover
Launch 02/1997
Rover Landing 07/04/1997

Deep Impact -- Impacted and observed Comet Tempel 1
Launch 12/2004
Probe Encounter Comet 07/04/2005

Genesis -- Solar Wind Sample Return
Launch 08/2001
Landing Sample Return 09/2004
On-going scientific research

Stardust -- Sample Return Comet Wild 2
Launch 02/1999
Encounter Comet –collect dust 01/02/2004
Comet sample return to Earth 01/2006
On-going scientific research and citizen science – Stardust at Home

MESSENGER -- Mercury Orbiter
Launch 08/2004
Venus Fly-by 10/2006
Mercury Fly-by 1/2008
Mercury Fly-by 10/2008
Mercury Fly-by 09/29/2009
MESSENGER Mercury Orbit Insertion 3/18/2011

Dawn -- Asteroid Orbiter
Launch 09/2007
Gravity assist fly-by of Mars 02/04/2009
Orbit Vesta 08/2011-2012
Orbit Ceres 02/2015

Kepler -- Planet Finder
Launch Orbiter 03/2009
Active Science Research 07/2009

EPOXI (Deep Impact spacecraft continuation)
Fly-by of comet Hartley 2 11/2010

GRAIL -- Moon Orbiter
Launch 09/2011
Moon Gravity Orbiter 2011

Stardust-NexT (Stardust spacecraft continuation)
Fly-by of comet Tempel 1 2/2011

InSight -- Mars Lander
Study the interior 9/2016

New Frontiers Mission Events

New Horizons -- Pluto/Charon Encounter
Launch 01/2006
Fly-by Pluto 07/2015

Juno -- Investigation of Jupiter
Launch 2011
Orbit Jupiter 2016

OSIRIS-REx – Asteroid Sample Return
Launch 9/2016
Two-year orbit 2019-2020
Sample return to Earth 9/2023

Discovery Technology


JHU/APL

Solar system exploration presents unique challenges. It requires highly capable robotic vehicles that can travel vast distances with an array of instruments to make detailed scientific measurements. It requires power to fly the missions and place the space probes into orbit around or on the surface of another world, where they must be able to survive and function in hostile environments. The spacecraft acquire and transmit data and sometimes return planetary samples back to Earth. The scientific requirements of solar system exploration have driven some of the most remarkable engineering achievements of the past four decades.

The challenges common to all planetary missions - immense distances, long flight times, stringent limitations on mass, power, and data rate - mean that technology advances in these areas benefit all missions. The short development times and cost constraints of Discovery and New Frontiers missions mean they are always seeking new technologies to accomplish their science objectives.

Important technological innovations used in Discovery and New Frontiers missions:

- Discovery's first mission, **Mars Pathfinder** (http://mars.jpl.nasa.gov/MPF/), successfully demonstrated the use of deployable airbags to safely land a payload on another planet and a robotic rover to transmit science data.
- Robotic sample return missions are a priority to scientists, and **Stardust** (http://stardust.jpl.nasa.gov/tech/) and Genesis have led the way. **Aerogel** (http://stardust.jpl.nasa.gov/tech/aerogel.html), developed in the 1930's and used previously in space as a thermal insulator, is employed by Stardust to capture particles of comet and interstellar dust in its collector grid. It is a silicon-based solid with a porous, sponge-like structure in which 99.8 percent of the volume is empty space. Genesis (http://genesismission.jpl.nasa.gov/mission/craft/index.html) used a series of wafers made of sapphire, silicon, gold and diamond to collect raw solar wind particles in outer space. The two missions had to meet the challenges of designing sample handling and packaging systems and safe, lightweight Earth entry vehicles.
- **MESSENGER** (http://messenger.jhuapl.edu/index.php) faces intense heat at Mercury, where the Sun is up to 11 times brighter than on Earth and surface temperatures can reach 840 degrees Fahrenheit. But MESSENGER will operate at room temperature behind a sunshade made of heat-resistant ceramic cloth. It also made deep space communications history with its electronically-steered phased array antennas that will allow scientists to send back twice as much data about the planet than originally envisioned.
- **Deep Impact**'s (http://solarsystem.nasa.gov/deepimpact/index.cfm) great challenge was to target and successfully impact the 3.7 mile diameter comet Tempel 1 while traveling at a relative velocity of 6 miles per second. The two-part spacecraft used newly developed avionics elements and innovative software to accomplish its goals. After separation, the "smart" impactor guided itself into the path of the comet nucleus, with some path corrections made by the navigation team at JPL, while the flyby spacecraft slowed down to observe the impact and return images.
- Prior to the **Dawn** (http://dawn.jpl.nasa.gov/technology/index.asp) mission, chemical propulsion had been used on all previous planetary missions. A major step forward in interplanetary transportation technology occurred in 2001 with the successful flight of Deep Space 1, powered by solar electric propulsion. This technology can reduce the propellant required to reach certain planetary destinations by a factor of 10 or more. Dawn is the first Discovery mission to use solar electric propulsion which will allow it to fly by two asteroids on one trip through space.
- The key technology at the heart of the **Kepler** (http://kepler.nasa.gov/) mission to search for Earth-size planets around other stars is a set of charged coupled devices (CCDs) in the photometer to measure the brightness of hundreds of thousands of stars at the same time. It's only been in recent years that the technologies to conduct such a search reached maturity.
- The **New Horizons** (http://pluto.jhuapl.edu/spacecraft/overview.html) mission to Pluto has stepped up to the many challenges it faces due to the huge distance it must travel (32 times farther than the Earth-Sun distance) and the length of time it will take to get there (9.5 years). The large distance from the Sun means that solar cells cannot be used to power the spacecraft. Electrical power would be provided by a single radioisotope thermoelectric generator, or RTG, provided by the Department of Energy. The onboard systems must be designed to operate in a cold environment, so the mission uses a "thermos bottle" design to maintain safe operating temperatures in deep space. The spacecraft is using a regenerative ranging capability that can yield up to 30 dB improvement over standard ranging at long distances. And it has an advanced digital receiver that consumes 60% less power than current deep

space receivers.

NASA "Spinoffs" show how technologies developed to explore space are being used by all of us every day. http://www.nasa.gov/vision/earth/technologies/spinoffs_index.html