**Intro and Group Assignments  (10 minutes)**

Hi! My name is Nicholas, and I study Astronomy at UC Berkeley. I use a big telescope to look at things in outer space. Have any of you wanted to take a vacation somewhere far away, or somewhere with an extreme climate? Well, today we’re going to go beyond planet Earth and explore the whole Solar System – keeping our eyes open for the most EXTREME interplanetary vacation spots.

Start off the activity by making a list of Solar System objects. In most classrooms, students will have already learned the planet names; some students might know about asteroids and comets. Have them name different objects, until the list includes at least:

- Sun
- 8 planets (*Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune*)
- Pluto
- asteroids
- comets

Students might also come up with some of the following:

- moons (*Earth’s, Io, Ganymede, Europa, Callisto, Titan, Triton, Charon, …*)
- dwarf planets and dwarf planet candidates (*Ceres, Eris, Makemake, Haumea, Orcus, Quaoar, Sedna*)

*I usually ask how many stars are in the Solar System, and most students respond that there are lots and lots. So it’s good to clarify the difference between the Solar System and the Galaxy.*

Next, make 10 groups of 2-3 students. It’s easiest to group students that are sitting next to one another. Give each group 2 cards: one with an image of the Solar System body, and one listing the diameter relative to Earth.

Explain that each group will be responsible for teaching their classmates about their object.

- Group 1: Mercury (diameter = 1/3 x Earth)
- Group 2: Venus (diameter = Earth)
- Group 3: Mars (diameter = 1/2 x Earth)
- Group 4: asteroids (diameter = 1/10,000 x Earth)
- Group 5: Jupiter (diameter = 11 x Earth)
- Group 6: Saturn (diameter = 9 x Earth)
- Group 7: Uranus (diameter = 4 x Earth)
- Group 8: Neptune (diameter = 4 x Earth)
- Group 9: Pluto (diameter = 1/5 x Earth)
- Group 10: comets (diameter = 1/10,000 x Earth)
**Planet Stations**  *(10 minutes)*

Before introducing the planet stations, explain the concept of a scale model.

- Today we’re going to use everyday objects to represent different bodies in the Solar System.
- We’re going to need to shrink the Solar System down, so we can see it all at once. We will make a scale model, where everything is shrunk down by the same amount. Our model’s shrinking factor, or scale factor, will be almost 1 billion (1 with 9 zeros).
- On this scale, we can use a grape to represent the size of planet Earth.
- You can pass around a bag of grapes so that each student can hold one.
- Be prepared for 20 different students to ask if they can eat the grape.
- Do an example with one of the planets, or with Earth’s Moon (1/4 x Earth’s diameter). Ask if anyone knows what “diameter” means, and draw a picture to explain.

Now tell students that they will represent their group’s object by choosing appropriate items from different “planet stations.” One station has a variety of round objects – they can look for something to represent their planet’s size, on the same scale where a grape represents Earth. The second station has notecards with facts about different bodies in the Solar System. The third station has different kinds of materials – they can look for materials to represent what their planet or body is made of, or what its climate is like. It might help if they visit the fact station before looking for materials.

Some teachers will want to regulate how many students get up and move around at the same time, or might want to systematically rotate groups through the three stations.

Planet Stations should be set at different locations in the classroom, to avoid crowding. See end of document for full inventory of Planet Box example items.

- **Planet Sizes:** e.g., fruit, balls, balloons
- **Planet Materials:** e.g., soil, rocks, ice
- **Planet Info:** labeled photographs of planets, notecards with facts for specific objects

Give the students about 5 minutes to look through the stations and choose items. Give them a 1-minute warning. Then have them return to their seats, next to their groupmates.

Five minutes might seem short, but 5th graders will forget or ignore your instructions pretty fast.
**Share-Out (15 minutes)**

Now instruct the students that each group will have 1 minute to share what they chose with the rest of the class. That’s about enough time to read one fact and show one object (either from the Sizes station or the Materials station). Lay down some ground rules:

- Every person in a group should share one fact or object
- The entire class needs to be respectful and pay attention to each group

Give students 1-2 minutes to decide who in their group will share what.

Ask the groups to share in the numbered order above – this corresponds to increasing distance from the Sun. Between Venus and Mars, briefly note that we are skipping Earth, as we have already chosen a grape to represent it, and we get to constantly experience what it’s made of.

*I think the best way to provide positive reinforcement during this part is to repeat any exciting facts that the students read. They will be all over the place as far as sizes go. One or two groups might have a good estimate for the scaled size of their object, and a few might correctly choose an object larger than or smaller than a grape. But many groups will completely miss the concept of using a grape to represent Earth, or forget/ignore those instructions. It is also common for a group to choose size objects based on the features of the picture on their notecard (the pictures are not to scale).*
Scale Model  **(10 minutes)**

After each group has shared their items, remind the students that we want to make a scale model of the Solar System, where the Earth is a grape. Tell them that you saw some really good ideas while they were sharing what they did, and now it’s your turn to share.

First, show them how big the Sun is in the model. Use a 40-inch string tied around a whiteboard marker to draw (part of) an 80-inch diameter circle. Spread your arms out and show that if the Earth is a grape, the Sun is bigger than even you can reach.

Next, arrange the following model at the front of the classroom:
- Mercury = soybean or popcorn kernel
- Venus = macadamia nut or acorn
- Earth = grape (Sun and balloon dimensions assume ¾ inch diameter)
- Mars = red bean
- asteroids = cocoa powder (each grain ~ one asteroid)
- Jupiter = balloon, inflated to 8 inches diameter
- Saturn = balloon, inflated to 7 inches diameter
- Uranus = balloon, inflated to 3 inches diameter
- Neptune = balloon, inflated to 3 inches diameter
- Pluto = grain of rice or couscous
- comets = flour (each grain ~ one comet)

*Before the activity, ask the teacher if any students have food allergies. Have a substitute item prepared for Venus in case someone is allergic to nuts.*

Some things you might want to point out:
- Although the size of each object is to scale, the distances between the objects are not. The Solar System contains an overwhelming amount of empty space. If our model placed both size and distance on the “Earth = grape” scale, some of the objects would be miles apart.
- Balloons have been chosen to represent Jupiter, Saturn, Uranus, and Neptune because these planets are made mostly of gas.
- In the real Solar System, asteroids and comets are typically less than a mile across: very tiny compared to the Earth. So they are represented by individual grains of soil and flour. Different materials are used because asteroids tend to be rocky, and comets tend to be icy.

Once you are done assembling the model, invite students to come stand closer so they can see everything next to each other.
Discussion and Wrap-Up (15 minutes)

Now that we have seen several representations of different objects in the Solar System, we can think about how to describe or organize the important features of a planet.

Brainstorm #1 (devote ~ 5 minutes and ~ 1/2 of the chalkboard):
What are some qualities or categories we can use to classify Solar System objects?

Invite suggestions from students. If necessary, mention the following ideas:
- solid vs. gas
- rock vs. metal vs. ice vs. gas (density)
- round vs. lumpy (one criterion for defining what is big enough to be a planet)
- frozen vs. liquid vs. boiled water (temperature)

Using these classifications, summarize the fundamental things we have learned about the Solar System today:

- In addition to the Sun and 8 planets, the Solar System has many smaller objects like comets, asteroids, dwarf planets, and moons.
- The planets in our Solar System have 2 broad classes: large gas planets which orbit far from the Sun, and small rocky planets which orbit closer to the Sun.
- The closest objects to the Sun are very hot, and the furthest are very cold.
- Earth is very small compared to the Sun and some of the gas planets.

Next, tell students that astronomers have discovered thousands of planets orbiting other stars. But they are so far away that we don’t know very much about them – we’re just left with a bunch of our own questions.

Brainstorm #2 (devote ~ 3 minutes and ~ 1/2 of the chalkboard):
If you discovered a new planet, what things would you want to know about it?

Invite suggestions from students. Some common scientific questions include:
- How big is it?
- How heavy/massive is it?
- What is it made of?
- Does it have an atmosphere?
- How close is it to the star?
- What is its temperature?
- Could it have liquid water?
- What color is it?
- How old is it?
- Can it trap energy that it receives from the star?
- Does it generate its own energy/heat?
- Could it support life?
Whatever time is left over (hopefully ~ 5 minutes) can be used for a quick clean up (throw away smashed fruit, sweep up soil or flour) and an opportunity for the students to ask general questions about astronomy.

They will have tons of general questions, so I try really hard to leave enough time for this. You can also e-mail the teacher ahead of time and say that you are willing to stay a little longer, if it fits in with the class schedule.

Thank the students for being great learners and participants!
Equipment Inventory

*Setting up the planet stations usually takes 5-10 minutes (depending on how organized you are when you pack the equipment).*

**Planet Sizes box:**
(*parentheses contain matching solar system objects, if Earth is a grape*)

- uninflated balloons *(students can inflate to adjust size)*
- coconut, grapefruit, small nerf ball, small squash *(Jupiter/ Saturn)*
- grapefruit, orange, tennis ball *(Uranus/Neptune)*
- kiwi, lime, clementine, racquetball, ping pong ball
- grape, blueberry, garbonzo bean, acorn *(Earth/Venus)*
- pea, small kidney bean *(Mars)*
- orzo pasta, soybean, popcorn kernel *(Mercury/Moon)*
- rice grain, sesame seed *(Moon/Pluto/Eris)*
- poppy seed, sand grain, salt *(Ceres, Sedna, other dwarf planets)*

You can include a ruler at this station too, but students rarely use it.

**Planet Materials box:**

- soil
- flour
- sand
- lava rocks
- solid rocks
- small icepacks
- metal
- magnets (magnetic fields)
- small electric fan (wind)
- inflated ziplock bag (gas)
- a mister that sprays water (gas/vapor)
- cocoa powder
- flour

**Planet Info box:**

- If you lived on Mercury, it would be extremely hot (800 degrees Fahrenheit) during the day, and extremely cold (-260 degrees Fahrenheit) at night
- Jupiter, Saturn, Uranus, and Neptune are made mostly of gas
- Jupiter, Uranus, and Neptune each have thin rings
- Venus is the hottest planet, with temperatures over 850 degrees Fahrenheit
- Neptune has an average temperature of -370 degrees Fahrenheit
- Saturn has more than 60 moons
- Saturn’s rings are extremely thin, and made of tiny ice particles
- Mars has frozen water underground
- Mars has polar “ice” caps made of carbon dioxide (dry ice)
- Pluto is smaller than Earth’s moon
- Mercury is the most metallic planet
- Mars has the tallest mountain and deepest canyons in the Solar System
- Mars’ red color comes from rusty rocks on its surface
- Mercury’s surface is covered with craters
- Venus is covered by thick clouds
- Venus’ thick atmosphere contains carbon dioxide and sulfuric acid
- Mars has a thin atmosphere made of carbon dioxide
- Jupiter, Saturn, Uranus, and Neptune have strong magnetic fields
- Mercury has a weak magnetic field
- Venus probably has active volcanoes on its surface
- Jupiter’s Great Red Spot is a giant hurricane, larger than the entire Earth. Giant hurricanes have appeared on Neptune as well.
- Strong winds moving in opposite directions create narrow bands of clouds on Jupiter and Saturn
- Neptune has the strongest winds in the Solar System
- Some parts of Uranus get sunlight for 42 years in a row, then have 42 years of nighttime
- Dust storms on Mars can cover most of the planet’s surface
- Neptune has the strongest recorded wind gusts in the Solar System – over 1200 miles per hour.
- Uranus’ blue-green color and Neptune’s blue color come from clouds of methane, a smelly gas
- Pluto’s surface shows light and dark regions
- Pluto’s surface is covered in nitrogen ice, colder than liquid nitrogen
- Some asteroids preserve very delicate minerals, while others melted and re-solidified a long time ago
- Comets are like dirty snowballs, with rock and ice mixed together
- Most asteroids are covered with craters
- When a comet comes close to the Sun, ice near its surface evaporates in explosive jets, creating a tail
- Most asteroids are lumpy and have very weak gravity. If you jumped off a small asteroid, you might not fall back down!
- Asteroids and comets contain some of the oldest known minerals, from the very beginning of the Solar System
Solar System Images

Mercury

Mars

Venus

Jupiter

Saturn