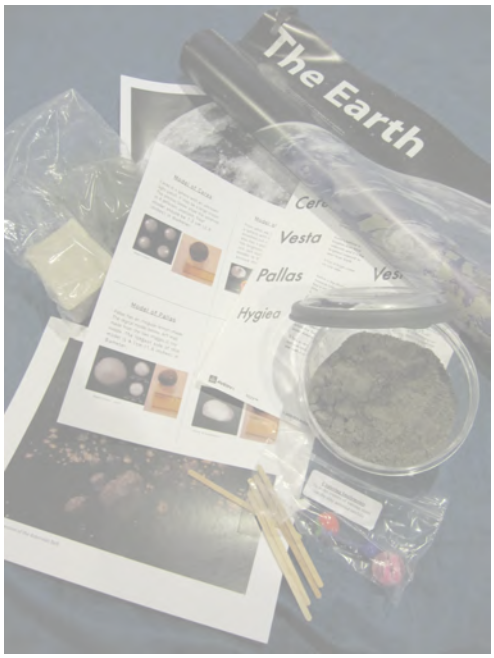
Scaling the Asteroid Belt



What's this model about?

Explore the Asteroid Belt and learn some surprising truths about just how difficult it would be to navigate.

Big Questions:

- Is it hard to navigate a ship through all of the debris in the Asteroid Belt?
- How dense is the Asteroid Belt?
- How did the Asteroid Belt form?

Big Activities:

Compare a scale model of the Earth and Moon with a model of the Asteroid Belt. See how empty the Asteroid Belt actually is.

Participants:

From the club: One presenter

Visitors: Appropriate for families, the general public, and school groups ages 10 and up. 5 to 15 visitors at a time may comfortably participate.

Duration:

The whole demonstration takes about 15-20 minutes. Pieces can be used in shorter explanations.

Topics Covered:

- Amount of material in the Asteroid Belt
- Average distances between asteroids in the Asteroid Belt
- Names of the first asteroids discovered
- Size and distance scale of the Earth and Moon
- Size of impactor that caused the Chicxulub crater and the downfall of the dinosaurs

Where could I use this activity?

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

What do I need to do before I use this activity?

What materials from the ToolKit are needed for this activity?	What do I need to supply to run this activity that is not included in the kit?	Preparation and Set Up

• 1-meter Earth Banner
• Scaled 29 cm Moon image
• Clay, a ruler, and cratering implements to make models, including the four largest asteroids:
  ○ Ceres, 7.3cm, black
  ○ Pallas, 4.1cm, black
  ○ Vesta, 4.1 cm, light gray
  ○ Hygiea, 3.4cm, black
• Artists' impressions of a busy Asteroid Belt
	(Optional) Space for a visitor to pace off 30 meters.	• Make models of the 4 largest asteroids (or more) asteroids at least 3 days prior to activity. See "Making Model Asteroids" at the end of this activity.
		• Hang the Earth Banner
		• Leave the Moon image face down until you need it.
		• Keep the asteroids out of view at first. You will use these during the presentation.

Background Information

Missions traversing the Asteroid Belt: When Pioneer 10 became the first spacecraft to cross the Asteroid belt in 1972, there was some concern that it would encounter an asteroid that could do damage. It did not and neither did the next 9 missions that passed through the Asteroid Belt. In fact, it is calculated that a spacecraft has less that a 1 in a billion chance of accidentally running into an asteroid. For your audience, **that means we could send a billion spaceships through the Asteroid Belt and likely never hit an asteroid!**

Dawn Mission Timeline

Launch	September 27, 2007
Mars gravity assist	February 2009
Vesta arrival	July 2011
Vesta departure	July 2012
Ceres arrival	February 2015
End of primary mission	July 2015

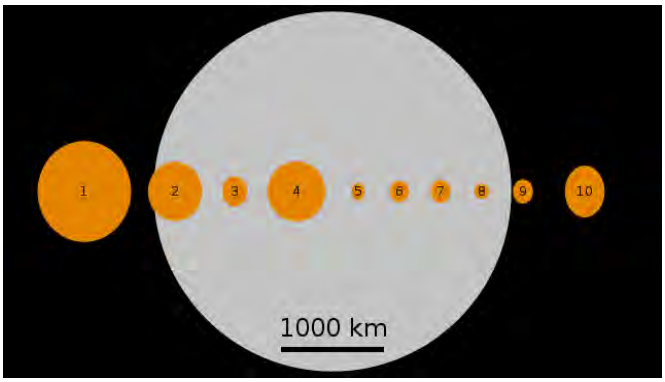
Additional Asteroid Belt materials:
On the Dawn website, you can find image galleries, activities, and much background information:
http://dawn.jpl.nasa.gov/mission/

Dawn Mission Solar System Ambassadors Speaker Kit
(non-public site for Solar System Ambassadors):
http://dawn.jpl.nasa.gov/DawnCommunity/speak_kit/index.asp

Interactive featuring the Visual Infrared and Imaging Spectrometer instrument aboard the Dawn spacecraft: http://dawn.jpl.nasa.gov/technology/VIR_inter.asp

A podcast giving a thorough discussion about the Asteroid Belt:
http://www.astronomycast.com/astronomy/episode-55-the-asteroid-belt/

The First 10 Asteroids to be Discovered:
All of these models will not be used in the activity as written. It is only necessary to make models of the 4 largest asteroids. With larger groups, you may want to have more on hand to pass around. Note that these are some of the very largest (hence some of the first to be discovered) asteroids in the Asteroid Belt. It is not a representative size distribution. Most would be the size of a grain of sand or smaller on the 1-meter Earth scale.



Size of the first 10 asteroids discovered compared to Earth's Moon

Learn about the history of asteroid discovery:
http://dawn.jpl.nasa.gov/DawnCommunity/flashbacks/fb_06.asp

Far Side of the Moon Information:
You'll notice that the far side of the Moon looks very different from the near side that we are used to seeing. There are few maria and lots of craters. The reasons for this are not well understood, but we do know a few things.

Here's the quick answer and you can find more details in the resources that follow. The Moon's crust is thinner and the core closer to the surface on the near side. Impacts during the Late Heavy Bombardment Phase (4 billion years ago) cratered the entire Moon, but the near side saw more lava flows due to the thinner crust and a core that was molten at the time. Lava flowed in to fill some of the basins with a dark basalt rock. Those are the maria we see today.

There's some basic information about the Moon's evolution here:
http://www.lpi.usra.edu/education/moonPosters/Poster1/backb.pdf

And a PowerPoint here:
http://www.lpi.usra.edu/education/powerpoints/moon_formation_processes.ppt

Science Friday Podcast about the far side of the Moon:
http://www.sciencefriday.com/program/archives/200902131

Detailed Activity Description

Scaling the Asteroid Belt

Leader's Role	**Participants' Role (Anticipated)**
To do: Point to the Earth Banner	
To say: Hey, take a look at this. What does this picture show?	Earth
Great! Let's make a model. If I could shrink the Earth down to this size, 1-meter, how big do you think the Moon would be? Show me with your hands. Those are good guesses. You're the closest. Here, I happen to have a model of the Moon here with me too.	Guess sizes
To do: Bring out the model of the Moon. Put it in front of the Earth to show size comparison.	
To say: See, you could fit almost 4 Moons across the Earth if you lined them up like this. Of course, they're not flat, they're spheres, but this is just a size comparison model. Now, here's the big question. At this scale, how far away would they be from each other? Show me what your guess is.	
To do: Hand the Moon to an audience member; encourage other visitors to offer suggestions.	Usually guess close

Leader's Role	**Participants' Role (Anticipated)**
<u>*To say:*</u> Good guess, but it's actually a lot farther. You could line up 30 Earths in between the Earth and the Moon.	
<u>*If you have the room:*</u> *(To the visitor holding the Moon)* Could you start here at the Earth and take 30 steps *("big steps" if Moon holder is a young child)* that way and hold up the Moon when you get there? Great. Come back when I wave at you.	Walks 30 meters away
(When Moon reaches 30 meters) Wow, the neighborhood around Earth is fairly empty, huh? We're sitting here in California, planet Earth, with just the Moon going round and round, month after month. I guess there's a reason they call it "space".	
What would you guess is the busiest place in our Solar System?	Sun? Saturn's rings?
Have you ever seen pictures of the Asteroid Belt? What does it look like?	Yes! Lots of rocks!
<u>*To do:*</u> Hold up artists' impressions of the Asteroid Belt.	
<u>*To say:*</u> Yeah, the artists' impressions I've seen look really crowded there. Take a look at these. You know, NASA's Dawn Mission is traveling to the Asteroid Belt to visit two of the biggest asteroids, Ceres and Vesta. Do you think it might have to dodge a lot of asteroids on the way to visit these two?	Yes!
<u>*To do:*</u> Bring out the four largest asteroids and any others you have made- Ceres, Pallas, Vesta, and Hygiea.	
<u>*To say:*</u> Let's find out.	

Leader's Role	**Participants' Role (Anticipated)**
To say: I happen to have models here of the four largest asteroids in the Asteroid Belt, on the same scale as the Earth and Moon here. The biggest is Ceres. Is it bigger or smaller than our Moon?	Smaller
Yes, it's about the size of Texas if you hold it up to the Earth.	
To do: Hand out 4 asteroids *(or more if you have a larger crowd).*	
To say: Of course these are nowhere near the Earth and Moon. Does anyone know where the Asteroid Belt is?	Between Mars and Jupiter
Right, after Earth's orbit, there's Mars, then the Asteroid Belt and then Jupiter.	
To do: If you have the "Exploring the Solar System" banner, show the Asteroid Belt area.	
To say: Imagine we could scoop up all those asteroids, including the ones you're holding. On the scale you're got there, how big of a ball do you think they would make? Show me with your hands.	Make predictions, usually large
It turns out, there's not that much material in the Asteroid Belt. Those four biggest asteroids make up half of all the mass in the Asteroid Belt!	
At this scale, we could fit all of the asteroids in the Solar System -- including the biggest ones that you're holding -- in my hands. That's a lot smaller than the planet Earth, even than our Moon.	
To do: Compare your open hands to the size of the Moon.	

Leader's Role	Participants' Role (Anticipated)
To say: I'm sorry to say; those pictures and the asteroid belts you see in the movies aren't even close to what it's really like. In fact, the average distance between asteroids is over three times the distance from the Earth to the Moon! At this scale, that's a whole football field between asteroids. If you were at one asteroid, chances are you wouldn't even see another asteroid in any direction! What do you think about these drawings then? Yes, contrary to what those artists' impressions show, the Asteroid Belt is actually very sparse. None of the space missions that have gone through the Asteroid Belt have ever accidentally hit anything. (See "Background Information" for further details.) **So why is it so sparse?** Well, there used to be a lot more material in that region when the Solar System first formed. But instead of slowly coming together like the other rocky planets, this region of space had a huge neighbor that couldn't keep its gravity to itself. Does anyone remember what big planet is close to the Asteroid Belt? Right, Jupiter's gravity tugged on the small bits, sending them colliding with each other instead of slowly coming together. These fast collisions sprayed so many pieces of asteroids out of the belt that eventually it became fairly empty. This all happened billions of years ago, not long after the Solar System formed. But we can still see evidence of all of the asteroids being scattered out of the Asteroid Belt. Take a look at these craters on the Moon. Almost all of these were created during that period!	They're wrong? Jupiter

Presentation Tips:
On this scale, it would only take an asteroid about the size one of a grain of sand to make a crater the size of the Chicxulub crater. It was caused by a 15 km asteroid -- less than 1mm on this scale and spelled disaster for the dinosaurs that were roaming the planet then.

Included in the ToolKit are fact sheets on NASA's Dawn Mission to the Asteroid Belt. These will give you more information and allow you to answer visitors' questions. Also, see their website for background, current mission status, and activities you can do in a classroom:
http://dawn.jpl.nasa.gov/mission/

If you have the Solar System banner, be sure to check on dawn's progress. You can place the Mission sticker in its correct location:
http://dawn.jpl.nasa.gov/mission/live_shots.asp

Materials

Where do I get additional materials?

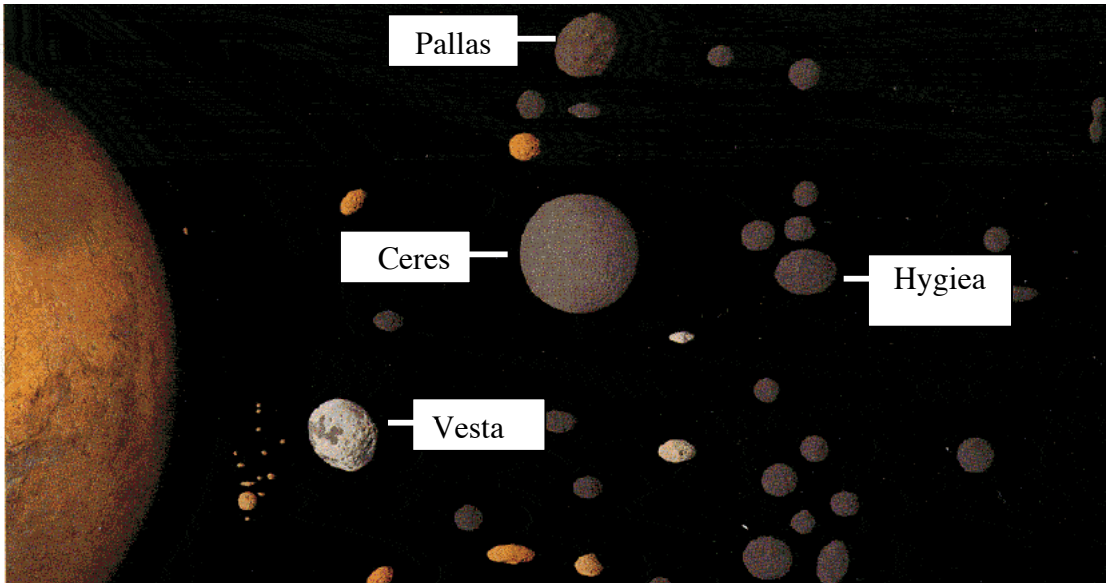
1. Find air-dry clay in art stores or toy-stores. Das Modeling Clay does well without cracking. Dried models can be painted with non-toxic paints or markers
2. Ruler: hardware store or many grocery stores
3. Artists' impressions of the Asteroid Belt can be found online by searching images of "Asteroid Belt"
4. Earth Banner: Print your own from the files found here:
    - http://nightsky.jpl.nasa.gov/download-view.cfm?Doc_ID=460

Making Model Asteroids

Important note:
Until Dawn arrives, none of the four biggest asteroids have ever been seen up-close. For now we have to make models using what we do know.

Make a clay model of each asteroid using the dark and light clay supplied in the ToolKit. The light clay will be used to make Vesta only. **Images on the following page** give you tips to make each asteroid the correct size and approximate shape.
Use tools such as erasers, pens, and other small, round implements to make the craters that likely cover all of the asteroids.

Allow it to dry for 2-5 days or until hard. **It may require a few coats of paint or black marker to get a true black color.**



This image shows the scale size and variations in color of the largest asteroids, with Mars on the left for comparison. © Andrew Chaiken

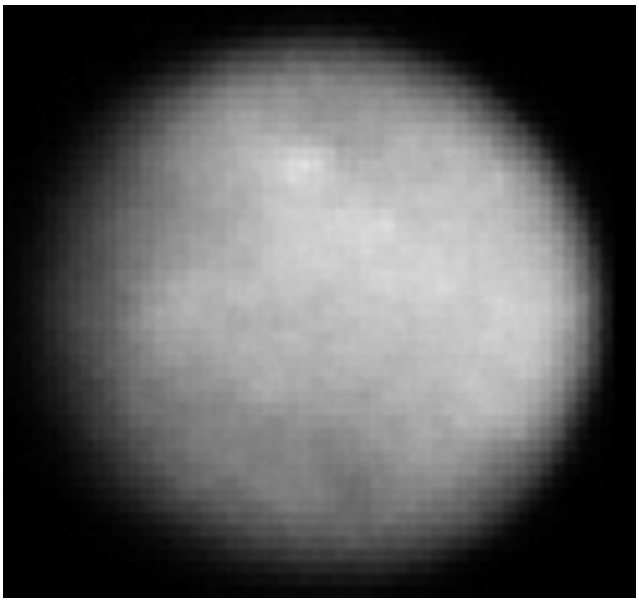
Use the images on the bottom left corner of the Earth Banner as a guide, but remember to use the ruler to measure the longest sides.

Making Models of Asteroids 1–10

To scale with a 1-meter Earth

1 Ceres (Dwarf Planet)

- 7.3 cm (3 in)
- Spherical with a bright spot, possibly a crater?
- Black



Model from Hubble data/NASA

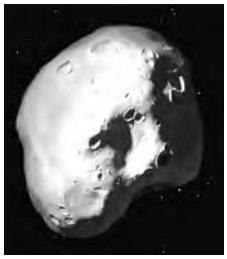
2 Pallas

- 4.1 cm (1½ in) on the longest side
- Egg-shaped
- Dark Gray

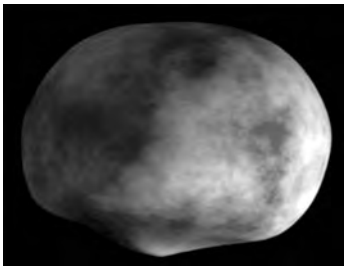
Model from photometric data: Torppa, 2003

3 Juno

- 2.5 cm (1 in)
- Large crater in one side, as seen with Hubble
- Dark Gray



Artist's conception of the large craters on Juno (David A. Aguilar, Harvard-Smithsonian Center for Astrophysics)



Model from Hubble data/NASA

4 Vesta

- 4.1 cm (1½ in) on the long side
- Large crater with central bump seen on one side
- Light gray

5 Astraea

- 1.3 cm (½ in)
- No images available
- Dark Gray

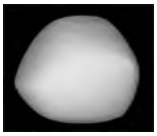
6 Hebe

- 1.6 cm (2/3 in)
- Dark Gray

Model from photometric data: Torppa, 2003

7 Iris

- 1.6 cm (2/3 in)
- Dark Gray



Model from photometric data: Kaasalainen, 2002

8 Flora

- 1.1 cm (½ in)
- Dark Gray

Model from photometric data: Torppa, 2003

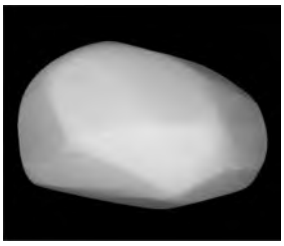
9 Metis

- 1.8 cm (¾ in)
- Dark Gray

Model from photometric data: Torppa, 2003

10 Hygiea

- 3.4 cm (1 1/3 in)
- Black



Model from photometric data: Kaasalainen, 2002

A Note About Asteroids

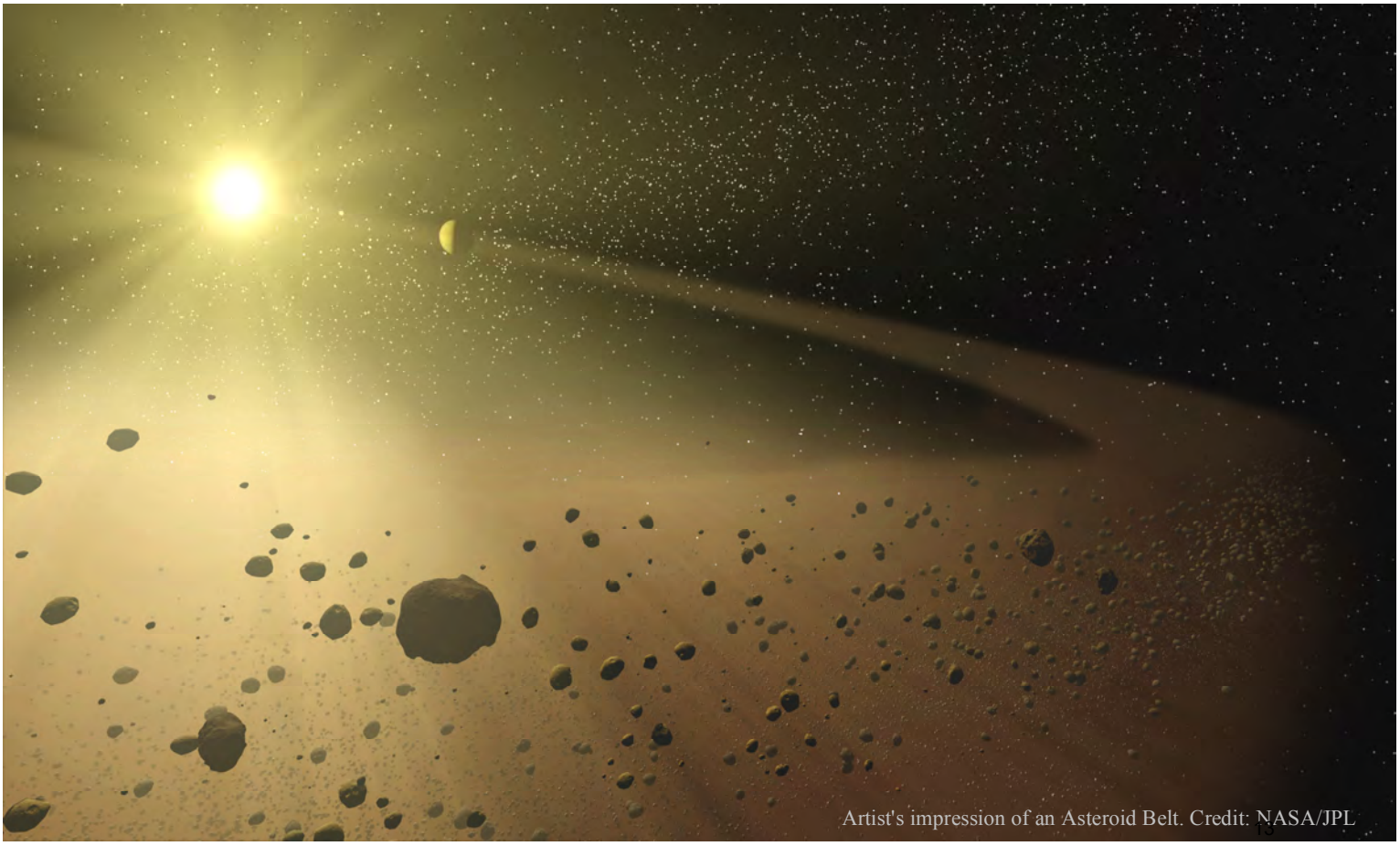
These models give the general shape of the first 10 asteroids ever discovered, to scale with a 1 meter Earth. These include the 4 largest asteroids in the Asteroid Belt. Most asteroids are much smaller.

We haven't visited these asteroids yet, so we don't know about their surfaces in detail. But all of the asteroids are likely covered in craters, like on this one that we have visited.

Be sure to add craters of different sizes to your asteroid models.

Photo of asteroid 21 Lutetia by the Rosetta Mission/ESA (Not to scale with a 1-meter earth)

Artist's impression of the Dawn spacecraft with targets Vesta (left) and Ceres (right) Credit: NASA/JPL



Artist's impression of an Asteroid Belt. Credit: NASA/JPL