

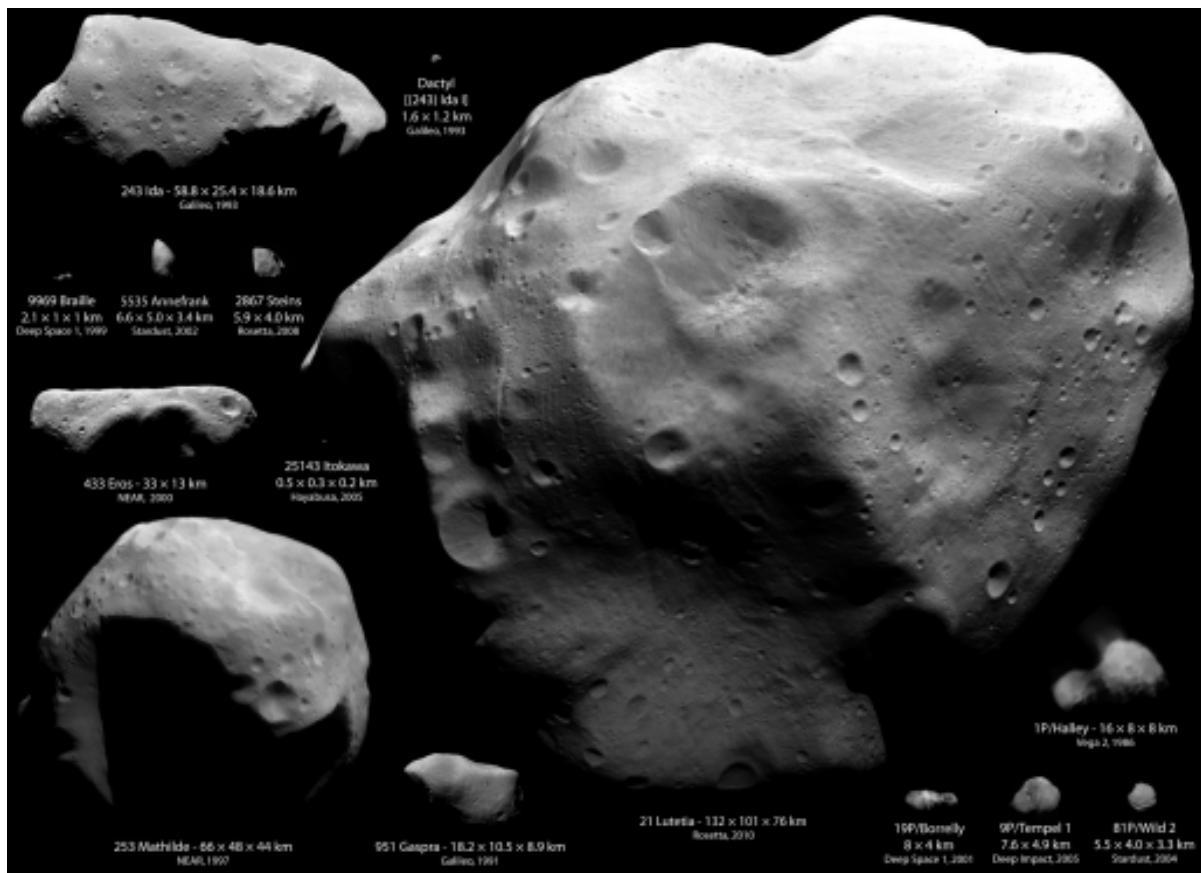
# Space Rocks Suggested Script

## PRESENTATION NOTES

This presentation can take from 20 minutes up to 45 minutes, depending on how many *Optional Presentation Activities* are included. Recommended for 7<sup>th</sup> grade to adult. (Use more activities with younger audiences)

1. What our smallest neighbors may be lacking in size, they make up for in their dynamic nature. Shown here are all of the asteroids and comets imaged up-close as of June 2010.

*The picture below shows their names.*



See a larger version here:

<http://www.planetary.org/blog/article/00002585/>

2.

Today we'll be talking about asteroids.

Most asteroids orbit the Sun in the Asteroid Belt, between the orbits of Mars and Jupiter. Images like these show the location of the Asteroid Belt but can be confusing because it appears that the Asteroid Belt is littered with asteroids. In fact, on this scale, all of the asteroids and even the planets would be too small to see.

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*Credit: Lunar and Planetary Institute*

3.

Let's start at the very beginning. 4.6 billion years ago the Solar Nebula swirled from its own gravity. As it collapsed, planets began to form around the new Sun.

In the region between Mars's and Jupiter's orbits, Jupiter's gravity pulled on the small objects. Instead of pieces slowly coming together and sticking due to their gravity, wild collisions sent primitive asteroids flying out of their orbits or smashing each other to bits. No large planets ever formed in this region.

Models indicate the Asteroid Belt may have originally contained as much mass as Earth, but spread out in many small "proto-planets."

The Solar System calmed down by 3.8 billion years ago, after what astronomers call the Late Heavy Bombardment phase.

Currently there is less than 1/1,000th Earth's mass in the Asteroid Belt

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**Presentation Tip:**

You can show the Dawn Mission Video here. This is found on the Media & Resources CD under Add'l Resources. It is named DawnJourney.mov

*Images are an artist's conceptions of the early Solar System and impact*

4.

But we still see evidence of this time throughout the Solar System.

These rogue asteroids from the early Asteroid Belt were thrown in all directions and impacted all the rocky inner planets: Mercury, Venus, Earth and Mars. On many of the planets we still see the effects of these early impacts.

They impacted the outer gas giant planets as well, but rocks don't make craters in gas.

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*Mercury as imaged by MESSENGER*

*Mars Credits: ESA/DLR/FU Berlin (G. Neukum)*

5.	<p>Moons also show evidence of past cratering. Both of these moons have huge craters, as well as many smaller craters.</p> <p>On Mimas (right), the Herschel Crater is about one third as wide as the moon itself. If there were a crater of an equivalent scale on Earth it would be over 4,000 km in diameter, wider than Canada.</p> <p>----</p> <p><i>Phobos by Mars Reconnaissance Orbiter: NASA/JPL-Caltech/University of Arizona</i>  <i>Mimas as imaged by Cassini: NASA/JPL/Space Science Institute</i></p>
6.	<p>We even see craters on our own Moon. Like the rest of the craters that we've seen, most of the lunar craters are from impacts during that early wild time in the Solar System's history. But the Tycho crater (bright, bottom left) happened during the time of the dinosaurs. That's very recent for a crater!</p> <p>----</p> <p><i>Image courtesy David Haworth</i></p>
7.	<p>The image most of us have of the modern day Asteroid Belt is that it's packed with asteroids. This can make for exciting movies.</p> <p>&lt;click&gt;</p> <p>But it isn't exactly right. While there are millions of asteroids, they are spread very far apart.</p>
8.	<p>If you were standing on an asteroid, like in the story of the Little Prince, first of all, you could jump off of it and not come back down. But you also wouldn't likely see another asteroid in any direction. They are very far apart.</p> <p>---</p> <p><b>Optional Presentation Activity:</b> You might want to do some of the scale models in the "Scaling the Asteroid Belt" activity. For example, show the distance between asteroids in the Asteroid Belt compared to the distance between the Earth and Moon.</p> <p>---</p> <p><i>NEAR image of 253 Mathilde</i></p>
9.	<p>Even though asteroids are far apart, every so often they will collide. Scientists estimate that there is a major collision about once a year on average. When they do, they can smash into many pieces.</p> <p>These smaller chunks can be thrown into wild orbits.</p> <p>---</p> <p><i>Artists' impression of a collision NASA/JPL-Caltech/T. Pyle (SSC)</i></p>

<p>10.</p>	<p>Comet Shoemaker-Levy 9 collided with Jupiter in 1994. This caught scientists' attention and showed that large impacts still occur in our Solar System. Astronomers began projects to search for asteroids and comets that may be headed for Earth. <i>(The rings on the left are larger than Earth. These are disturbances in the upper atmosphere.)</i></p> <p>Just fifteen years later, an amateur astronomer discovered a scar on Jupiter. It turns out another impact had just occurred.</p> <p>---</p> <p><i>SL-9 Image courtesy of H. Hammel, MIT and NASA/ESA 2009 impact image courtesy NASA, ESA, H. Hammel, and the Jupiter Impact Team</i></p>
<p>11.</p>	<p>In fact, we see evidence for over 170 impact craters on Earth. In this image, the red icons are exposed craters, visible from above. The green icons are craters that aren't so obvious. These invisible craters were mostly discovered by measuring gravity changes in the Earth's surface.</p> <p>You'll notice there aren't many in very geologically active regions like the west coast of North America. The ground is shifting and changing rapidly. And any craters that were formed there were quickly erased.</p> <p>---</p> <p><i>Image from Google Maps Meteor Crater Viewer</i></p>
<p>12.</p>	<p>The craters we do see are fairly new, in geological time. Earth recycles its surface frequently. Movements of Earth's crust, water, and atmosphere eventually cover the visible traces of impacts. These three craters all happened within the last 4 million years. That may seem like a long time on a human scale, but it is recent compared to the age of the Earth.</p> <p><b>Optional Presentation Activity:</b> "Craters on the Earth and Moon"</p> <p><b>Background Information on the craters:</b>  <b>Barringer (Meteor Crater):</b> 1.2 km (3/4 mile) across, 175m (570 ft) deep  50,000 yrs ago, before humans arrived in N. America  <b>Wolf Creek:</b> .875 km (1/2 mile) across  300,000 years ago, when modern humans were just starting to evolve  <b>Roter Kamm:</b> 2.5 km across (1.5 miles)  Almost 4 million years old, still only 1/1,000th the age of the Earth</p>
<p>13.</p>	<p>One that lots of people have heard about...</p> <p>The Chicxulub crater (pronounced <i>chicks-a-lube</i>) on the Yucatan peninsula in Mexico is not visible from above, but studies have shown that a large impact here coincided with the extinction of most land dinosaurs. There is much evidence that supports the idea that a large asteroid (~10 km or 6 miles across) impacted the Earth and caused worldwide destruction.</p>

	<p><b>Optional Presentation Activity:</b> If you have the Earth Banner displayed with the crater sites in North America, ask the audience to estimate on the scale of that Earth how big the asteroid would be that causes worldwide effects. They might be surprised to know that on this scale it would only have to be about the size of a grain of sand (&lt;1mm) to cause global destruction.</p>
14.	<p>But there are even more recent impacts. Some cause destruction. The Tunguska impactor exploded in the Earth's atmosphere over a remote forest, leveling trees over more than 800 square miles. It is estimated that an impact of this size occurs every 1,000 years on average. If this type of impact were to hit a city, it could cause serious damage. Luckily, most of the Earth is either covered in water or sparsely populated.</p> <p>Others are not dangerous to humans. A 10-meter piece of asteroid was seen approaching Earth in 2008. At this size, space rocks explode in the atmosphere in a bright display, but are not dangerous. A search committee combed the desert of Sudan and found about 11 pounds of meteorite pieces total, mostly in small fragments.</p> <p>For more information on 2008TC3:  <a href="http://www.nasa.gov/topics/solarsystem/features/asteroid_treasure_hunt.html">http://www.nasa.gov/topics/solarsystem/features/asteroid_treasure_hunt.html</a></p> <p>----</p> <p><i>Tunguska Image: NASA</i>  <i>Meteorite Image Credit: NASA / SETI / P. Jenniskens</i></p>
15.	<p>When pieces of an asteroid fall to the ground, we call these “meteorites.” In fact, 40,000 tons of extraterrestrial matter hit the Earth <i>every year</i>. That's more mass than the Titanic with everyone on it! Luckily, most of the space rock comes in tiny dust particles or pebble-sized chunks that vaporize in the atmosphere and never make it to the ground.</p> <p>A few pieces do get through the atmosphere and can be found on the ground as meteorites. Meteorites are older than any rock found on Earth. These pieces of asteroids tell us about what the Solar System was like when it first formed. (Don't worry; there are only two confirmed claims of people ever being hit by meteorites. You have a much better chance of winning the lottery.)</p> <p>-----</p> <p><b>Optional Presentation Activity:</b> The “Meteorite or MeteorWrong” activity can be used here to show visitors the properties of meteorites.</p>

16.	<p>So, who thinks we should we be concerned about future impacts?  It shouldn't keep you up at night, because the chance is small that a devastating impact will happen during our lifetime. But there are an estimated 1,000 objects large enough to do regional damage (&gt;1km) that are classified as "potentially hazardous objects." The vast majority of these are asteroids, but some are comets too.</p> <p>---</p> <p><b>Background Information:</b>  As of August 5, 2009, 6,244 near-Earth asteroids are known, ranging in size up to ~32 kilometers  Colliding with anything smaller than a house (about 40 m) is not a large concern because it explodes in the atmosphere  Anything up to about 1km would do extensive local damage  Anything over 2km would have worldwide impact</p> <p><i>Top image is a NEO (2010 AL30) that passed between the Earth and Moon's orbit. It was less than 15 meters across, so not considered dangerous. An asteroid this size hits Earth every few years, on average. They explode in the sky as giant fireballs but pose little threat.</i>  <i>Bottom image is an artist's conception of a large impact</i></p>
17.	<p>There have been some close passes, but we haven't found anything yet that will impact the Earth. But our best chance at avoiding an asteroid or comet is to know about any future impact far in advance. The more notice we have, the more options there are to avoid it.</p> <p>Amateur and professional astronomers are working together and actively searching for asteroids now.</p> <p>---</p> <p>Top image is Near Earth Object 1999 JM8. It could impact earth in a few centuries and is large enough to have global consequences (3.5 km). Image Courtesy Of Lance Benner, NASA JPL</p> <p>The bottom image shows Apophis, an asteroid that worried a lot of astronomers for a few weeks. It turns out, as they learned more about its orbit, it has almost no chance of hitting Earth. But it served as a reminder that these Near Earth Asteroids are all around us. Orbit of Apophis courtesy JPL Small-Body Database Browser</p>
18.	<p>NASA is also using infrared technology to search for asteroids, both in the Asteroid Belt and near Earth. In infrared cameras, asteroids are much brighter and easier to see.</p> <p>---</p> <p><b>Optional Presentation activity:</b> Use Asteroid Hunters to show why infrared</p>

	<p>technology is so good at detecting asteroids.  <i>See WISE PowerPoint in the Manual and Resources CD for much more information.</i></p>
<p>19.</p>	<p>If we have enough advance warning about a future impact, it is possible that even a small nudge could change the orbit enough to avoid an impact. The Earth orbits the Sun at about 30 km/sec. That means it moves a whole diameter in about 7 minutes. So if an asteroid were headed our way, we'd only have to delay it by about 7 minutes and the Earth would have moved on. If we find it early enough, a small tug for a long time might be enough to change an asteroid's orbit.</p> <p>Strategies include (from top left, clockwise) 1) a heavy gravity tractor that parks close by and pulls it slowly due to the gravitational attraction, 2) lasers focusing light to "push" the asteroid, 3) nuclear rockets to impact and "bump" the asteroid, and 4) an impactor to push it off track. This last option is the first detection method ever designed. The European Space Agency is working on this mission called "Don Quijote."</p> <p>The next generation may be tasked with saving the human race from a devastating impact so it's not too early to start thinking about it.</p> <p>Options illustrated here, left to right:  Top: Gravity Tractor, lasers focusing light  Bottom: Don Quijote impact scenario, rockets to hit it or blow it up</p>