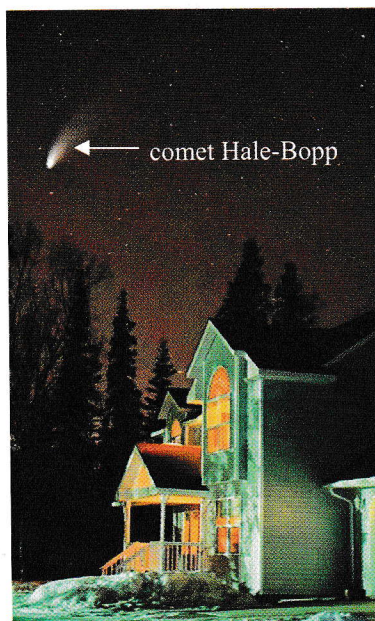


Millions of space rocks orbit our sun, but most of them are concentrated in an area between Mars and Jupiter. It makes sense, then, to have a lesson that discusses these space rocks before we study Jupiter, the next planet. The illustration on the front cover of this lesson is a NASA image of a comet that they call **Wild (Vilt) 2**. It was taken by a spacecraft called "Stardust," the first NASA spacecraft designed specifically to study a comet.

## Comets



This is a photo of comet Hale-Bopp in 1997.

Have you ever tried to build a snowman when there was only a little bit of snow on the ground? Well, if you have, you know how dirty that snowman looks because a lot of grass, dirt, and ground get rolled up into it. It becomes a big dirty snowball. Amazingly, that is exactly what astronomers call comets...dirty snowballs! Of course, comets are much bigger than your little snowman. In fact, many of them are so big that millions of snowmen could fit inside them.

The name "dirty snowball" gives you a clue about what a comet is made of, doesn't it? Comets are mostly big balls of ice. The ice is frozen water as well as dry ice, which you learned about in Lesson 7. This ice is mixed up with a bunch of rock, to make the center of the comet, which is called the **nucleus** (new' klee us). If you could make a comet, you would begin with a bunch of snow, ice, dirt, and rocks. Then, you would roll them all together into one big dirty snowball. After that, you would toss it into space to orbit the sun! It would be pretty neat to make a comet, but we know that only God can do that.

Comets have been seen for thousands of years. The ancient Chinese and other ancient civilizations kept written records of when comets appeared in the sky because they were frightened when comets appeared. Being unsure of what they were, many believed they meant something terrible was about to happen. Some of them appeared so bright that they could be seen during the day. Others had beautiful tails that would stretch halfway across the sky. You can imagine how strange that would have been to people who could see everything in the night sky so clearly because there were no city lights to drown out the stars.

The name **comet** comes from the Greek word **kometes**, which means "head of hair". A comet actually looks like a star with a head of hair, or a big smudge in the



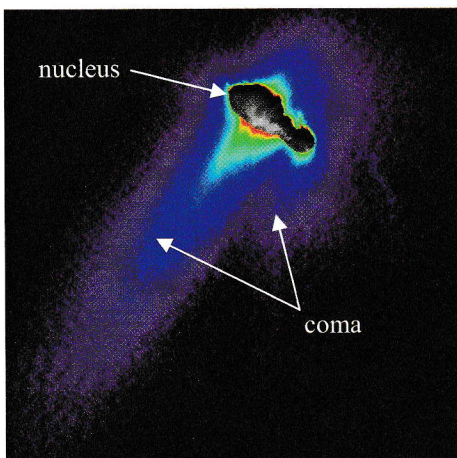
This is a photo of comet Schwassmann-Wachmann 3 in 1995. Do you see how it looks like a big smudge in the sky?



sky. If you ever got paint on your finger and tried to rub it off on a piece of paper, it would make a smudge. That is what a comet looks like to us. It's a bright, white smudge of light. It's really very large, though it looks kind of small.

## The Coma

The reason a comet looks like a smudge in the sky is because it has a **coma** (koh' muh) around it. The coma is a big ball of steam surrounding the ice. If you have ever seen dry ice, you have seen steam coming off of ice. That is like a comet's coma.



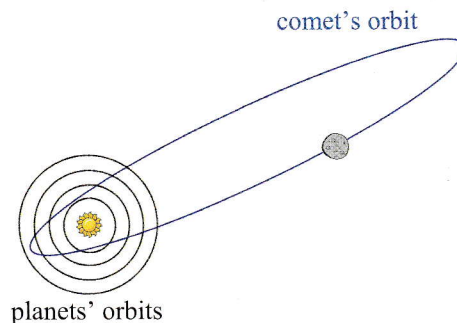
This is an image of comet Borrelly taken by the spacecraft Deep Space 1. False color has been used to emphasize the difference between the coma and nucleus.

When a comet first approaches the sun, it looks like a huge rock flying through space. Then as it gets close to the sun, it begins to heat up. The heat causes the ice to turn to steam, and that forms a steamy cloud around the comet, making the coma. The coma can be very large and bright, but it always looks a little blurry since it is really steam. As the comet flies through space, it leaves a tail of this steam behind it. Now remember, the comet is orbiting the sun. Do you remember what the solar wind is? It is a stream of particles shooting out from the sun. The solar wind pushes on the coma, and as a result, the coma always points away from the sun. Sometimes a comet has two tails; a yellow one and a blue one. The yellow tail is made out of dust particles, and the blue tail is the steam burning off the nucleus. The stuff in each tail reflects different light waves and produces different colors.

If you have ever watched Charlie Brown on TV, you might remember a character named Pigpen. A cloud of dust surrounds Pigpen, and when he walks, he leaves a trail of dust behind him. A comet is just like Pigpen! It always leaves a trail of dust particles behind it. These dust particles stay in the comet's orbit, so the comet has a very dusty, dirty orbit.

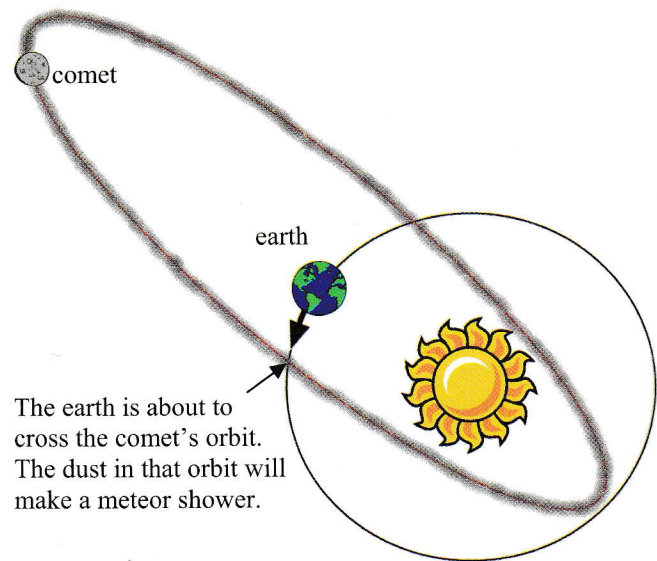
## A Comet's Orbit

Comets can have long, elliptical orbits that are far outside of the planets. Some orbit close to the planets, passing by the earth quite often, and some have orbits that take them far beyond Pluto for thousands of years. A comet always follows the same orbit, so it is easy to predict when a comet will pass by earth again. Once a comet has been studied, scientists can predict when we will be able to see it again.

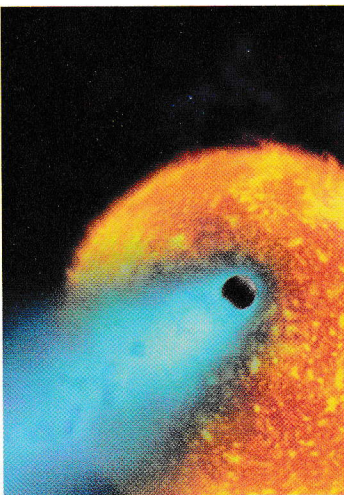


Remember that a comet is like Pigpen, leaving a trail of dirt behind it. When the earth passes through a comet's orbit, it runs into the dust and dirt that the comet leaves behind. An amazing and spectacular thing happens when these dust particles hit the earth's atmosphere. They catch on fire and create a little fireworks display for us! As they burn up, they look like beautiful shooting stars. It's a sight to see! These particles are actually very small, but, because they burn so brightly when they hit our atmosphere, we see them as if they are the same size as a star far out in space. Many people believe that a shooting star is an actual star up in space, but it's not. It's just a little piece of a dirty comet that left its mess behind when it passed by. When the earth moves into that dusty, dirty comet path, we see a bunch of shooting stars.

When we have shooting star shows like that, we call them **meteor showers**.



Because we know where the comets' orbits are, we know when we will pass through them. As a result, we can predict (which means to make a good guess) when we will have a meteor shower. There is a good one between August 9<sup>th</sup> and August 13<sup>th</sup> every single year. It is called the **Perseid** (per' see id) meteor shower. Mark your calendar now so you will remember! There are many more meteor showers each year. The activity at the end of this lesson involves watching the next meteor shower.



This is an artist's idea of what it looks like when a comet passes close to the sun.

If a comet's orbit around the sun takes less than 200 years, it is called a **short-period comet**. That means its orbit period is short. Now 200 years doesn't seem like a very short period to you and me, but for a comet, it is a short period. After all, compare that to **long-period comets** that can take thousands of years to make one orbit around the sun!

Most short-period comets get heated up by the sun so often that the ice around the comet gets burned off. It just goes by that hot sun too often to stay a big ball of ice for very long. To understand this, suppose you kept bringing a dirty snowball inside by the fireplace every few minutes. What would happen? It would eventually lose the snow and become just a pile of dirt. Since there is rock in all of that ice, when a comet's ice burns off, it looks like a big rock floating in space, called an **asteroid** (as' tuh royd).



## Creation Confirmation

The fact that comets burn off their ice as they approach the sun is a problem for those who want to believe that the solar system is billions of years old. You see, if the solar system were billions of years old, the short-period comets that come by the sun so often would have no ice left on them by now! Since some comets come close to the sun every 70-80 years but still have ice on them, they can't be very old at all! In fact, comets must only be a few thousand years old since they still have ice on them. If they were millions or billions of years old, the ice would have all burnt off by now.



This is a picture of Halley's comet, which is a short-period comet, taking only 76 years to orbit the sun.

Of course, if you want to believe that the solar system is billions of years old, you can find some way to get around this problem. Those who believe that the solar system is very old think that there are sources in the solar system that continually produce new comets. They even have names for these sources: the Kuiper (ky' pur) Belt and the Oort (ort) cloud. They believe that the Kuiper Belt produces short-period comets and that the Oort cloud produces long-period comets. Although the Kuiper Belt does exist (you will study it later on in the course), it does not have nearly enough dirty snowballs in it to continually make new comets, so it doesn't seem like a good source for short-period comets. We have never even seen the Oort cloud, so we don't even know whether or not it exists. Even if it does exist, it probably doesn't have enough dirty snowballs, either. In the end, it seems more reasonable to believe that the solar system is only a few thousand years old.

*Explain all that you remember about comets so far. Tell about how comets indicate that the solar system is only a few thousand years old.*

## Famous Comets

One famous short-period comet is known as comet Halley, or Halley's comet. This comet appears every 76 years. Chinese stargazers saw it 240 years before Christ was born! The Chinese kept great records of all they saw in the sky. They were very interested in the universe. In the 1600s, Edmund Halley studied ancient records and determined that the comet recorded by ancient Chinese astronomers returns every 76 years. Isn't it amazing that we can study ancient documents, written thousands of years ago, and learn more about astronomy? Sadly, Edmund Halley never got to see the comet's next arrival and learn that he was right after all. Seventy-six years is a long time. However, it did come by earth again, just when Mr. Halley predicted it would. Because of this, we named the

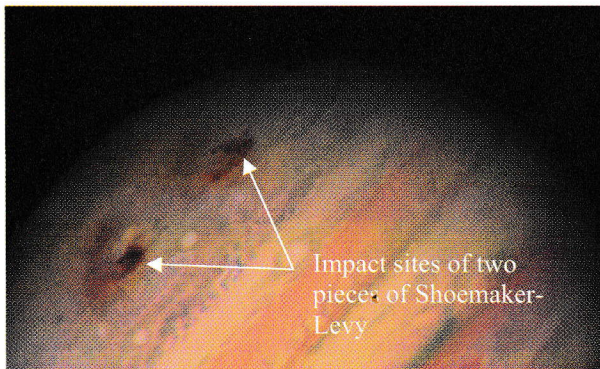


comet after him. That was nice, wasn't it? Do you think you will ever have a comet named after you? What would we call the comet you discovered?

The biggest and brightest comet that has come by earth in the last century is comet Hale-Bopp. Its name is a little strange because two men discovered it, so it is named after both of them. This is a long-period comet, which means it will not return to earth for quite some time. It is so gigantic that its coma (the steam burning off of it) is as big as the sun. It didn't come close enough to the sun to cross our orbital path, so we do not get the pleasure of seeing a meteor shower display from its dust trail. Of course, it's probably a good thing that it did not pass too close to the earth. It is such a big comet, that a "close encounter" with it would be scary! After all, imagine what a huge comet would look like if it got too close to the earth!



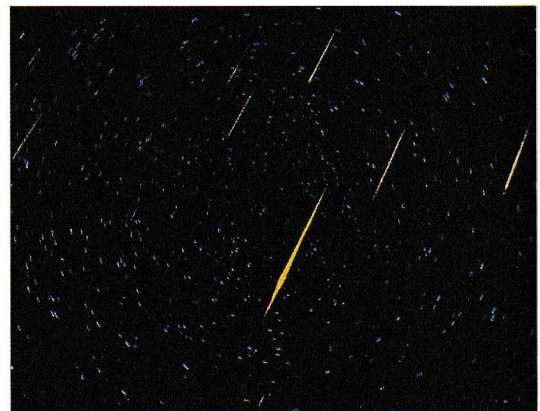
Comet Hale-Bopp



This Hubble Space Telescope image of Jupiter shows two spots where pieces of Shoemaker-Levy hit.

A comet that made recent history is the Shoemaker-Levy comet. This comet actually broke up into several comets. They were gigantic, and people watched them every night as they were orbiting the sun. One night, an amazing thing happened. As these big comet pieces were approaching Jupiter, they were pulled right into Jupiter's by its gravity. They crashed into Jupiter for six days, causing giant explosions on the gassy surface of Jupiter. It was an amazing sight to see.

If a comet comes by, be sure to take a good look at it, because it probably will not come back again in your lifetime. Even though you will not see the comet again, you may be able to see its trail every year when the earth passes through the dirty particles it left behind. Comets are beautiful lights traveling through the sky, and the trail of dust they leave behind gives us an amazing shower of lights. What a special gift of beauty God gave us! All of this reminds us of the glory of God and how He formed the world to show us how great He is. He gave us special gifts of lights in the sky that reflect His bright, shining glory.



This is a photograph of meteors during the Leonid meteor shower.



# Meteorites

Remember all the dirt that comets leave behind? Dirt and rocks left by comets, as well as dirt and rocks from planets, are floating about in space. We call them **meteoroids** (mee' tee uh royds'). Each time a meteoroid hits the earth's atmosphere and burns up, it is called a **meteor** (mee' tee or). As you already learned, meteors burn up inside our atmosphere and look like little streaks of light, which we often call shooting stars. If a very large meteor hits our atmosphere, it will burn very brightly. These bright meteors are often called "fireballs."

Most meteors are very small. But occasionally, an object falls through the atmosphere and does not completely burn up because it is just too large. These larger objects hit the earth and are



This is a photograph of a meteorite that was once a part of Mars. It was probably launched from Mars as a result of an asteroid impact, and it ended up on earth.

called **meteorites** (mee' tee uh rites'). No matter what it was while it was in space, if it hits the earth, it's called a meteorite. Usually the meteorites that hit fall into the ocean, since the earth is mostly covered by oceans. Once in a while, however, a meteorite will fall onto land. Some people are meteorite hunters, spending all their free time searching the earth for meteorites. The meteorites that have been found on earth have been many different sizes. There are some that are very small and some that are very large. The largest one found weighed 60 tons. That's as heavy as a whale, or thirty cars piled on top of each other.

There is a place in Antarctica where the ground is covered with meteorites. More than 10,000 (ten thousand) of them have been found lying on the snow. Antarctica is cold, and the ground there is always frozen with layers and layers of ice. Astronomers know that the rocks must be meteorites, because they were sitting above the thick snow covering the ground beneath. These rocks literally fell from the sky! Several of them were made of the same material found on Mars, so scientists think that they are Martian meteorites.

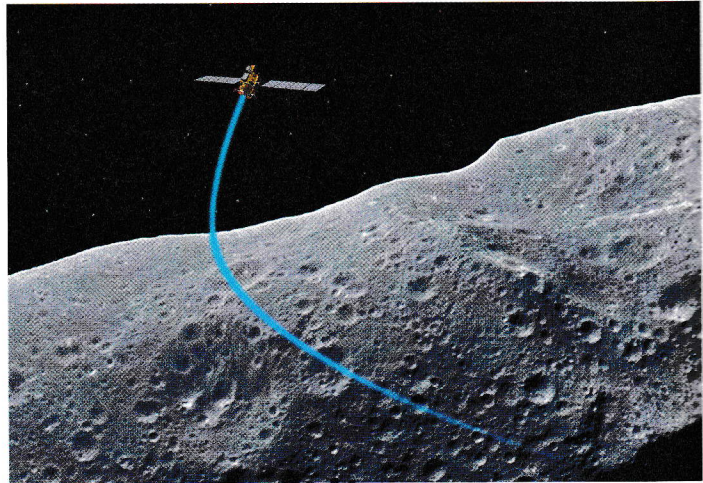
# Asteroids

An asteroid is a rock orbiting the sun in our solar system. Wait a minute. Isn't a rock orbiting the sun called a meteoroid? Well, yes, it is. The difference between an asteroid and a meteoroid is size. Asteroids are large rocks (typically larger than a football field), while meteoroids are small rocks. Asteroids are not covered with ice the way comets are. Once a comet burns off all its ice, it looks just



like an asteroid. This makes scientists think that at least some of the asteroids that are in our solar system are actually comets that have burned off all of their ice.

Asteroids are made of earth-like material like iron, rock, and carbon. When they enter our atmosphere, they begin to burn up, just as meteoroids and comets do. When an asteroid hits the earth, it is called a meteorite. However, it looks so much like the earth's rocks, that unless it falls in a place where there are not very many rocks, it is hard to tell it apart from other rocks. The ones that are found most often are the iron ones because they are shiny and stand out. There could be a meteorite in your backyard, but you probably can't tell the difference between it and an earth rock.



This is an artist's idea of what it looked like when the NASA spacecraft Deep Space 1 encountered an asteroid. This spacecraft tested new technologies that would be used in further deep space missions.

There are millions of asteroids out in space. Some are the size of a football field, and some are bigger than the state you live in. They come in all shapes as well. Many of them have been named, like Kleopatra, an asteroid that actually looks like a big dog bone! Asteroids are sometimes described as mountains in space or "planetoids," which means "little planets." Most of them can be found between Mars and Jupiter, in what is known as the **asteroid belt**. When a spacecraft goes to explore one of the planets past Mars, it must first pass through the asteroid belt. It can steer through the asteroids in the belt, however, because they are spaced far enough apart so that the spacecraft can wind its way in between them.



This is a photograph of the asteroid Kleopatra.

*Can you tell me the differences between comets, meteoroids, meteorites, and asteroids?*

## Asteroid Belt

Let's learn a little more about the asteroid belt I just mentioned, because it is an interesting part of our solar system. The asteroid belt is a ring of asteroids that orbit the sun between Mars and Jupiter. We actually use the asteroid belt to separate the planets into two groups. Planets that are "inside" the asteroid belt (which means they are closer to the sun) are called the **inner planets**. Planets that are "outside" the asteroid belt (which means they are farther from the sun) are called the **outer planets**. This means that Mercury, Venus, earth, and Mars are the inner planets, while Jupiter, Saturn, Uranus, Neptune, and Pluto are the outer planets.



If you look at the drawing on the right, you will see that the asteroid belt looks a lot like the orbit of a planet. Well, there may be a reason for this. There is evidence that there was once a planet that orbited the sun between Mars and Jupiter. What happened to that planet? It may have exploded, and the asteroids in the asteroid belt may be the remains of that planet. Yikes!

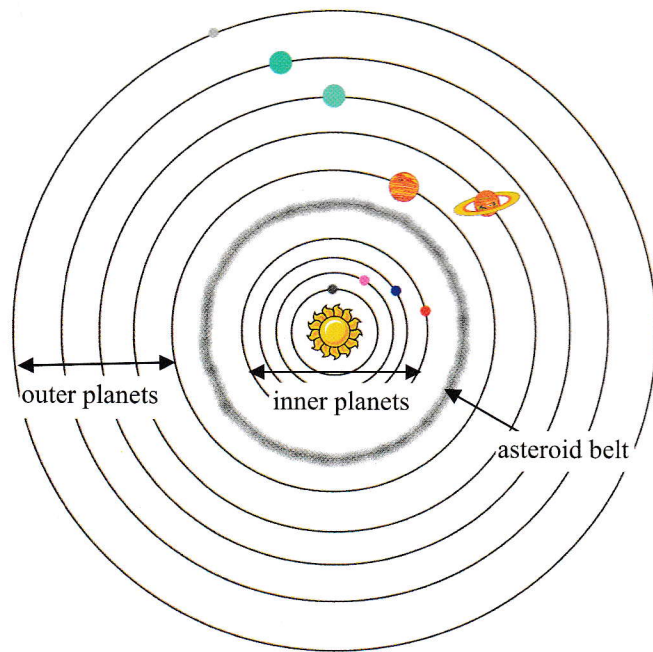
The idea that there was once a planet between Mars and Jupiter is called the **Exploded Planet Hypothesis** (hi pahth' uh sis). A hypothesis is an idea that may or may not be true. Scientists make many, many hypotheses. That's what they do best! When something is a mystery to you, but you look at clues and then form an idea of what you believe, you have formed a hypothesis! For example, suppose you left a cookie on the table.

If you came back to the table later and found your cookie was gone, you would have to form a hypothesis about what happened to it. Did someone eat it? Did Mom throw it away? Did Dad put it away? Perhaps someone opened the door, letting the wind blow in so strongly that it blew your cookie off the table, and then a giant ant came and took it back to its ant hole. Well, you can see that some hypotheses are good, and some are silly.

There are many reasons the Exploded Planet Hypothesis looks like a good hypothesis. If a terrestrial planet exploded, pieces that flew off into space would look like rocks and frozen water, or ice. That is exactly what asteroids and comets look like! Our planet is made of mostly water, so if it exploded, it would send millions of tons of water that would become ice out in space, perhaps forming huge comets. Scientists think that some of the comets and asteroids in our solar system are from this former planet that exploded. Did the water from this former planet form ice around the rocks when they were ejected into freezing cold space? We don't know for sure, but it gives support to the Exploded Planet Hypothesis.

More signs in favor of the Exploded Planet Hypothesis are the crater scars on many planets and moons. Remember that when a giant meteorite hits, it leaves a crater: a big dent in the surface. Some scientists believe that meteorites hit the planets and moons randomly over billions of years. But when one side doesn't have very many crater scars, it really bewilders them. Let me try to explain why.

Suppose you hung a big ball of clay from the ceiling and started it slowly spinning. Then, suppose you walked around and around the ball, throwing marbles at it for a year. If you did that, you would find dents all over the ball. It would be really strange if all the dents just happened to end up on

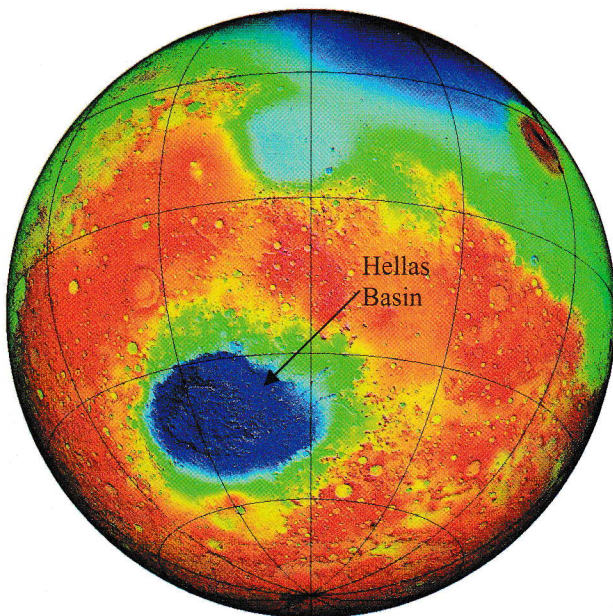


The asteroid belt separates the inner planets (Mercury, Venus, Mars, and Earth) from the outer planets (Jupiter, Saturn, Uranus, Neptune, and Pluto).



one side, with none or very few on the other side. If you had ten balls spinning and you walked about throwing marbles at them for many years, the dents would be spaced out randomly over all the balls. The longer the balls hung while you threw marbles at them, the more likely it would be that craters would be evenly spaced all over the balls. On the other hand, suppose you threw marbles for only a few minutes. If you did that, there would not be enough marble dents to be evenly spaced on each ball. Most likely, they would be more concentrated on one side than the other.

Now suppose you had all ten balls slowly spinning around, and then one ball suddenly exploded into pieces that went violently and forcefully flying about the room. Most of the other balls would get hit, but they would mostly be hit on one side, the side facing the exploding ball. The balls closest to the exploded ball would probably have the deepest dents.



This is an image of Mars, showing the huge Hellas Basin. The colors are false; they are used to illustrate differences in the surface of the planet.

that planet would have hit Mars at such an outrageous speed that it would have caused pieces of Mars to launch into space.

This is exactly what we see with our planets and moons! They have a great many more dents on one side than on any other side. This is true of earth and its moon, Mars, Mercury and many of the moons orbiting Jupiter, Saturn, Uranus and Neptune. In fact, the planet closest to the asteroid belt, Mars, has extremely deep craters. There is a crater on Mars (called Hellas Basin) that is bigger than the United States of America! If the asteroid belt was a planet that exploded, you would expect Mars to have had the most violent meteorite hits, resulting in the largest craters.

Do you recall that pieces of Mars have been found on the earth? We call them Martian meteorites. How did those get to the earth? If the planet next to Mars exploded, gigantic chunks of

that planet would have hit Mars at such an outrageous speed that it would have caused pieces of Mars to launch into space. Now, of course, if a planet exploded, pieces of it would certainly hit the earth as well. They would probably hit the earth at the same time that the Martian meteorites were hitting the earth, because they all formed as a result of the same explosion. Well, do you remember the thousands of meteorites I told you about in Antarctica? There are thousands of meteorites there all together, with only a few being from Mars. It's possible that most of those meteorites hit the earth as a result of the same event. We will never know for sure while we live on the earth how they got there, but it is the job of good scientists to find explanations for such things. The Exploded Planet Hypothesis might just be the correct explanation!



Some scientists say that the Exploded Planet Hypothesis couldn't be true because there are not enough asteroids in the asteroid belt to make up a whole planet. However, if we counted all the comets and other debris in our solar system that look like they came from a planet, this exploded planet would be much bigger than the earth!

If the Exploded Planet Hypothesis is correct, why did the planet explode? Some scientists think it was because a huge volcano erupted. Yellowstone National Park is built upon a gigantic, "super volcano." This volcano is so big that if it erupted, at least three states would have to be evacuated! See if you can find Yellowstone on a map of the United States (look in the northwest corner of Wyoming).

I doubt that the super volcano under Yellowstone will ever erupt in your lifetime, but if it did, it would mean big trouble. It would probably not cause the earth to explode, but it would cause a lot of damage. If a planet once existed where the asteroid belt is now, and if that planet had a super volcano that was even larger than the one under Yellowstone National Park, it is possible that such a large eruption could have caused the planet to explode.

Of course, if this planet once existed, there is another possible cause for its explosion. Some believe the planet between Mars and Jupiter exploded because a gigantic object, maybe a huge comet or asteroid, hit the planet. If a big asteroid or comet can cause huge craters such as the Hellas Basin on Mars, an even bigger asteroid or comet could cause a crater so deep that it would tear the entire planet apart!

The asteroid belt is a very fascinating part of the solar system. It is a wonderful mystery that is fun to try and solve. The Bible tells us that right now, we see only a little bit of the truth, but when Jesus returns, we will see everything with perfect understanding. That will be a terrific time, and all of our questions will be answered. All the mysteries of the universe will be solved.



This is an artist's idea of what it would look like if a large asteroid collided with a planet.

## What Do You Remember?

What is another name for a comet? What does a comet leave behind it as it orbits the sun? What happens when a comet's dust particles enter our atmosphere? What do people call meteors? What is a meteor called when it hits the earth? Where have many meteorites been found? From which planet did some of the meteorites come? Where is the asteroid belt located? What is the Exploded Planet Hypothesis? Can you give some reasons that this might be a correct hypothesis?