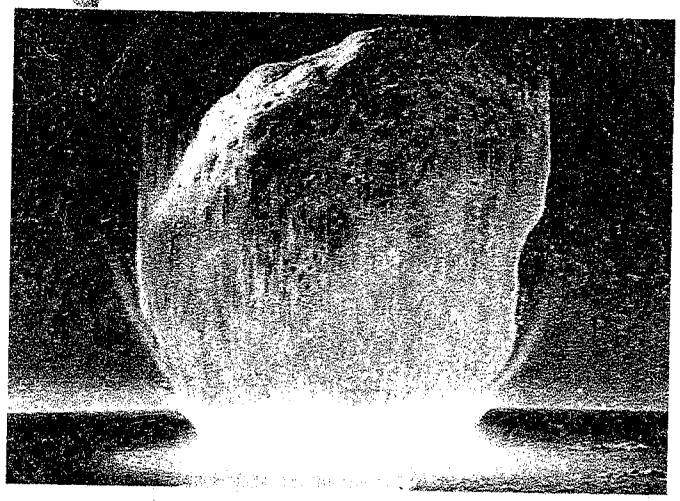
ASTEROIDS, METEORS, and COMETS:

The book of Space Rocks



Adapted by Aaron Pratt from www.NASA.gov

ASTEROIDS

An asteroid is any of numerous small planetary bodies that revolve around the sun. Asteroids are also called minor planets or planetoids. Most of them are in the asteroid belt between the orbits of Mars and Jupiter. The belt contains more than 200 asteroids larger than 60 miles (100 kilometers) in diameter. Scientists estimate that there are more than 750,000 asteroids in the belt with diameters larger than 3/5 mile (1 kilometer). There are millions of smaller asteroids. The average temperature of the surface of a typical asteroid is -100 degrees F (-73 degrees C).

The asteroid Ida is about 35 miles (55 kilometers) long. It is one of thousands of asteroids in the asteroid belt, a region between the orbits of Mars and Jupiter. Image credit: NASA

Astronomers are not sure how the asteroids originated. According to the leading theory, however, most known asteroids are the shattered remains of a smaller group of larger objects. These objects were left over from the time the planets formed. Elsewhere in the solar system, other such objects gathered together to form the planets and satellites.

Size

Asteroids vary greatly in size. The largest and first known asteroid, Ceres, was discovered in 1801. It is 580 miles (933 kilometers) in diameter. Ceres is believed to contain about 1/3 the total mass of all the asteroids. One of the smallest, discovered in 1991 and named 1991 BA, is only about 20 feet (6 meters) across.

Composition

Studies of an asteroid's reflected light as well as analyses of meteorites have provided information about the composition of asteroids. Astronomers classify asteroids into two broad groups based on their composition. One group of asteroids dominates the outer part of the belt. These asteroids are rich in carbon. Their composition has not changed much since the solar system formed. Asteroids in the second group, which are located in the inner part of the belt, are rich in minerals. These asteroids formed from melted materials.

Measuring asteroids

Until the 1990's, astronomers could determine the size of an asteroid in only three ways. In the first method, they use telescopes to determine the asteroid's distance from the sun, the amount of sunlight it reflects, and the amount of heat it gives off. The amount of sunlight or heat reaching the earth depends on the size of the asteroid and its distance from the sun. Therefore, calculations involving distance and either light or heat yield the size of the asteroid.

In the second method, astronomers use a telescope to measure an asteroid during an occultation, when the asteroid passes in front of

a star and is silhouetted against it. The third technique involves the use of radio telescopes to produce images of an asteroid.

In 1991, scientists began to use a fourth method -- close-range observation of asteroids by space probes. That year, the United States space probe Galileo took the first detailed photograph of an asteroid. The asteroid, called Gaspra, was an irregularly shaped object measuring about 12 by 7 1/2 by 7 miles (19 by 12 by 11 kilometers).

In 1996, the U.S. National Aeronautics and Space Administration (NASA) launched the Near Earth Asteroid Rendezvous (NEAR) probe. The probe flew within 753 miles (1,216 kilometers) of the asteroid Mathilde in 1997. The next year, NEAR flew past the asteroid Eros at a distance of 2,378 miles (3,829 kilometers). NEAR went into orbit around Eros in February 2000. In March 2000, the probe was renamed Near Earth Asteroid Rendezvous-Shoemaker (NEAR Shoemaker) in honor of American astronomer Eugene Shoemaker. In February 2001, NEAR Shoemaker became the first spacecraft to land on an asteroid.

Craters cover the surface of the asteroid Eros. The asteroid is about 21 miles (33 kilometers) long, about 1 1/2 times the length of Manhattan Island. Image credit: NASA

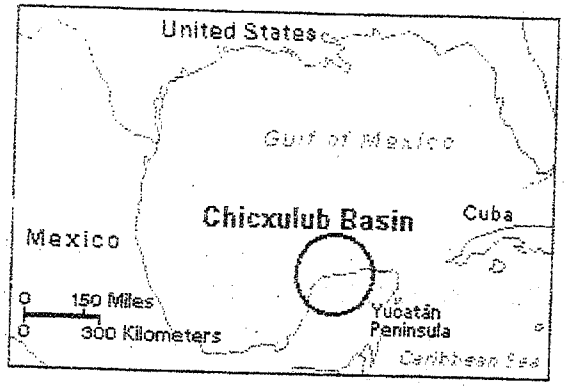
In October 1998, NASA launched a probe called Deep Space 1. The probe flew within only about 16 miles (26 kilometers) of the asteroid Braille in July 1999.

Orbits

Most asteroids follow elliptical (oval-shaped) orbits in the asteroid belt. Groups of asteroids that follow the same orbit are called Hirayama families, named after Kiyotsugu Hirayama, the Japanese astronomer who first discovered them.

Many asteroids follow orbits outside the belt. For example, a number of asteroids called Trojans follow the same orbit as does Jupiter. Three groups of asteroids -- Atens, Amors, and Apollos -- orbit in the inner solar system and are known as near-Earth asteroids. Some near-Earth asteroids cross the path of Mars, while others cross Earth's orbit.

Many scientists believe that a near-Earth asteroid collided with Earth about 65 million years ago, triggering widespread environmental changes that led to the extinction of the dinosaurs. The asteroid created a huge circular depression called the Chicxulub (CHEEK shoo loob) Basin centered in Mexico's Yucatan Peninsula. The diameter of the basin is about 190 miles (300 kilometers).

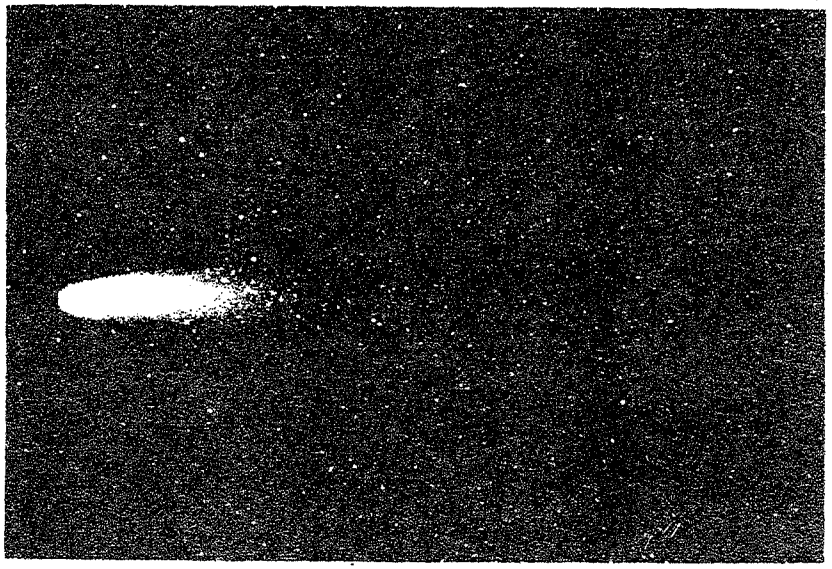


The Chicxulub Basin along the northern coast of Mexico's Yucatan Peninsula formed when an asteroid hit the earth about 65 million years ago. Debris from the impact may have led to the extinction of the dinosaurs. Image credit: World Book map

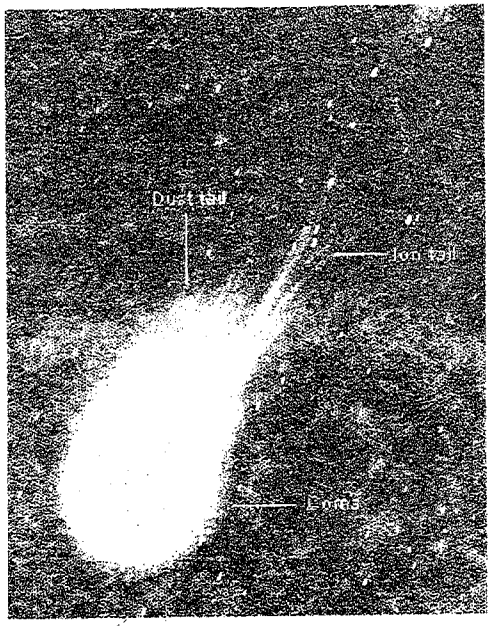
In 1908, an object exploded about 6 miles (10 kilometers) above the Tunguska River area of Siberia. The object may have been a comet's nucleus or a large meteorite -- sometimes referred to as a small asteroid. Debris from the explosion flattened forests and burned an area about 50 miles (80 kilometers) across.

The gravitational pull of Jupiter and other large planets causes asteroid orbits to change very slowly. Orbital changes lead to collisions that create smaller asteroids and fragments, increasing the chance of more collisions. Some small fragments reach Earth's surface as meteorites.

COMETS



A comet (KOM iht) is an icy body that releases gas or dust. Most of the comets that can be seen from Earth travel around the sun in long, oval orbits. A comet consists of a solid nucleus (NOO-klee-us) surrounded by a cloudy atmosphere called the coma and one or two tails. Most comets are too small or too faint to be seen without a telescope. Some comets, however, become visible to the unaided eye for several weeks as they pass close to the sun. We can see comets because the gas and dust in their comas and tails reflect sunlight. Also, the gases release energy absorbed from the sun, causing them to glow.



Halley's Comet becomes visible to the unaided eye about every 76 years as it nears the sun. Image credit: Lick Observatory

Astronomers classify comets according to how long they take to orbit the sun. Short-period comets need less than 200 years to complete one orbit, while long-period comets take 200 years or longer.

Astronomers believe that comets are leftover debris from a collection of gas, ice, rocks, and dust that formed the outer planets about 4.6 billion years ago. Some scientists believe that comets originally brought to Earth some of the water and the carbon-based molecules that make up living things.

Parts of a comet

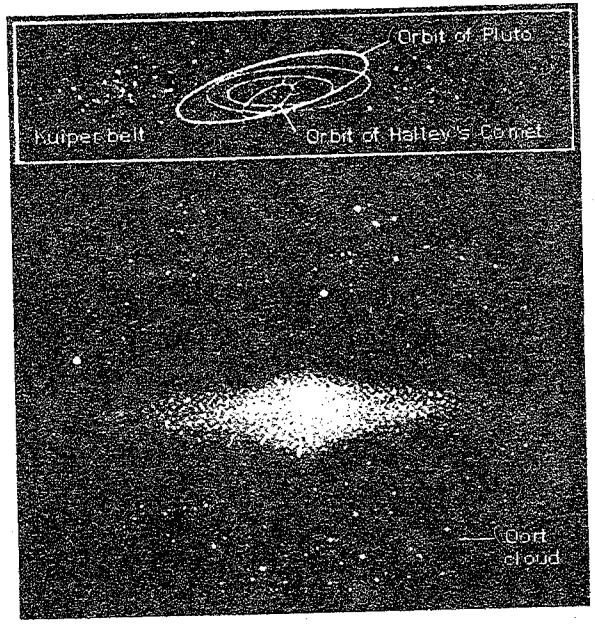
The nucleus of a comet is a ball of ice and rocky dust particles that resembles a dirty snowball. The ice consists mainly of frozen water but may include other frozen substances, such as ammonia, carbon dioxide, carbon monoxide, and methane. Scientists believe the nucleus of some comets may be fragile because several comets have split apart for no apparent reason.

As a comet nears the inner solar system, heat from the sun vaporizes some of the ice on the surface of the nucleus, spewing gas and dust particles into space. This gas and dust forms the comet's coma. Radiation from the sun pushes dust particles away from the coma. These particles form a tail called the dust tail. At the same time, the solar wind -- that is, the flow of high-speed electrically charged particles from the sun-converts some of the comet's gases into ions (charged particles). These ions also stream away from the coma, forming an ion tail. Because comet tails are pushed by solar radiation and the solar wind, they always point away from the sun.

Most comets are thought to have a nucleus that measures about 10 miles (16 kilometers) or less across. Some comas can reach diameters of nearly 1 million miles (1.6 million kilometers). Some tails extend to distances of 100 million miles (160 million kilometers).

The life of a comet

Scientists think that short-period comets come from a band of objects called the Kuiper belt, which lies beyond the orbit of Pluto. The gravitational pull of the outer planets can nudge objects out of the Kuiper belt and into the inner solar system, where they become active comets. Long-period comets come from the Oort cloud, a nearly spherical collection of icy bodies about 1,000 times farther away from the sun than Pluto's orbit.



Comets that pass near the sun come from two groups of comets near the outer edge of the solar system, according to astronomers. The disk-shaped Kuiper belt contributes comets that orbit the sun in fewer than 200 years. The Kuiper belt lies beyond Pluto's orbit, which extends to about 4.6 billion miles (7.4 billion kilometers) from the sun. The Oort cloud provides comets that take longer to complete their orbits. The outer edge of the Oort cloud may be 1,000 times farther than the orbit of Pluto. Image credit: World Book diagram by Terry Hadler, Bernard Thornton Artists

Gravitational interactions with passing stars can cause icy bodies in the Oort cloud to enter the inner solar system and become active comets.

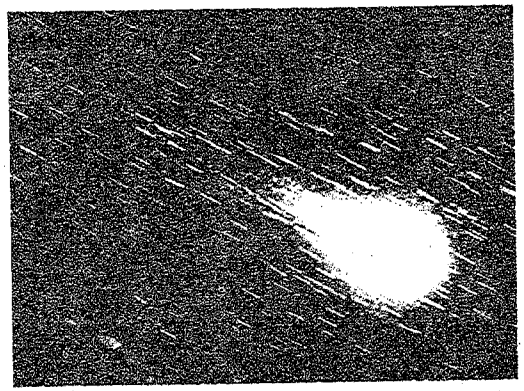
Comets lose ice and dust each time they return to the inner solar system, leaving behind trails of dusty debris. When Earth passes through one of these trails, the debris become meteors that burn up in the atmosphere. Eventually, some comets lose all their ices. They break up and dissipate into clouds of dust or turn into fragile, inactive objects similar to asteroids.

The long, oval-shaped orbits of comets can cross the almost circular orbits of the planets. As a result, comets sometimes collide with planets and their satellites. Many of the impact craters in the solar system were caused by collisions with comets.

Studying comets

Scientists learned much about comets by studying Halley's Comet as it passed near Earth in 1986. Five spacecraft flew past the comet and gathered information about its appearance and chemical composition. Several probes flew close enough to study the nucleus, which is normally concealed by the comet's coma. The spacecraft found a roughly potato-shaped nucleus measuring about 9 miles (15 kilometers) long. The nucleus contains equal amounts of ice and dust. About 80 percent of the ice is water ice, and frozen carbon monoxide makes up another 15 percent. Much of the remainder is frozen carbon dioxide, methane, and ammonia. Scientists believe that other comets are chemically similar to Halley's Comet.

Scientists unexpectedly found the nucleus of Halley's Comet to be extremely dark black. They now believe that the surface of the comet, and perhaps most other comets, is covered with a black crust of dust and rock that covers most of the ice. These comets release gas only when holes in this crust rotate toward the sun, exposing the interior ice to the warming sunlight.

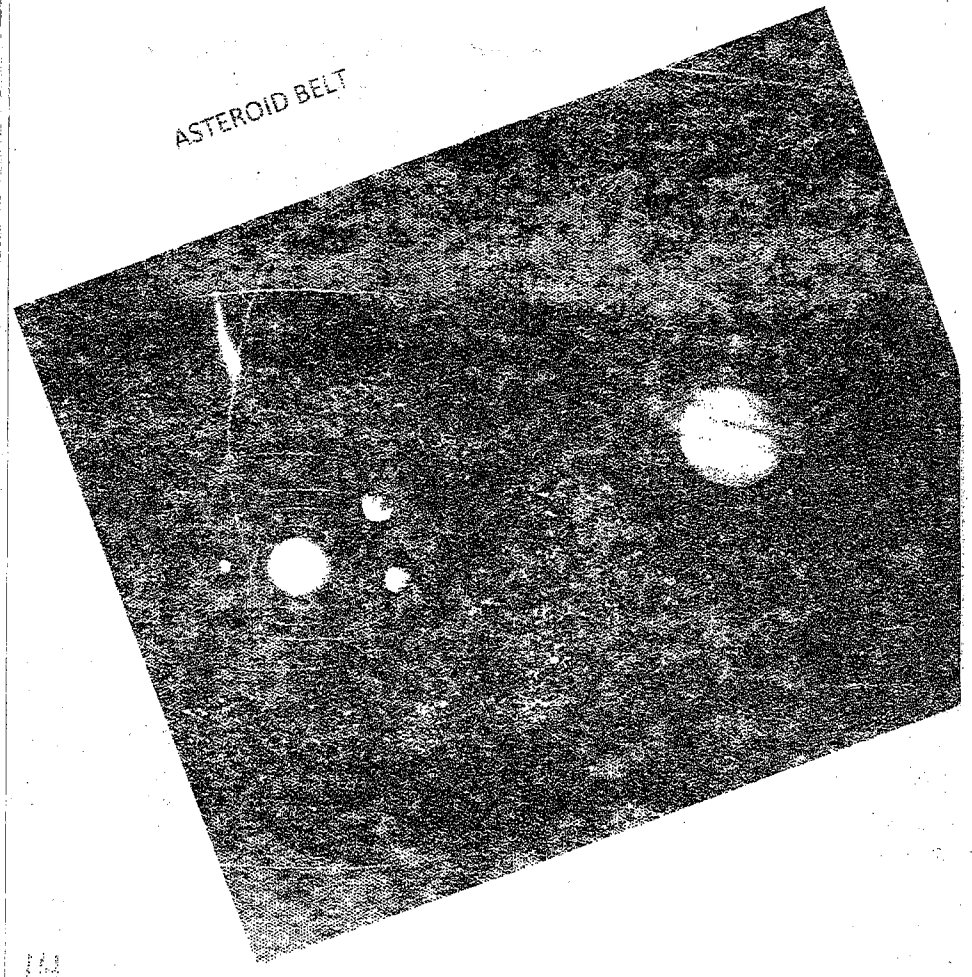


The space probe Giotto passed near Halley's Comet on March 14, 1986. Giotto returned dramatic close-up images of the comet, including this one. Image credit: European Space Agency

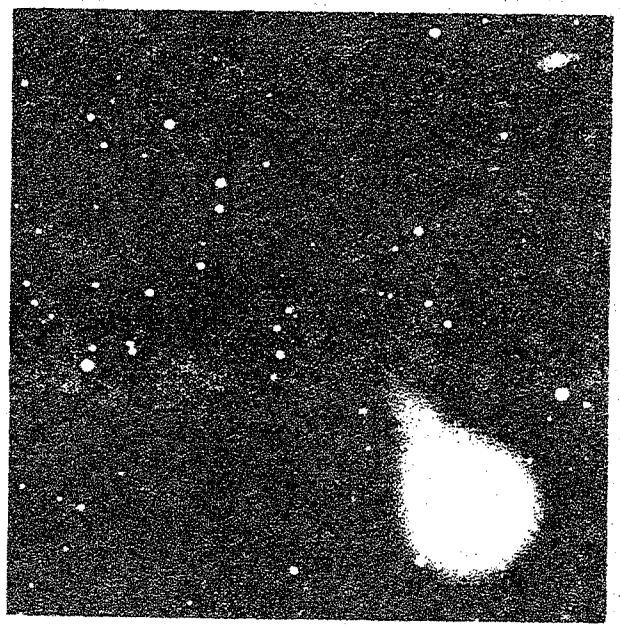
Another comet nucleus that has been seen by spacecraft cameras is that of Comet Borrelly. During a flyby in 2001, the Deep Space 1 spacecraft observed a nucleus about half the size of the nucleus of Halley's Comet. Borrelly's nucleus was also potato-shaped and had a dark black surface. Like Halley's Comet, Comet Borrelly only released gas from small areas where holes in the crust exposed the ice to sunlight.

In 1994, astronomers observed a comet named Shoemaker-Levy 9, which had split into more than two dozen pieces, crashing into the planet Jupiter. One of the most active comets seen in more than 400 years was Comet Hale-Bopp, which came within 122 million miles (197 million kilometers) of Earth in 1997. This was not an especially close approach for a comet. However, Hale-Bopp appeared bright to the unaided eye because its unusually large nucleus gave off a great deal of dust and gas. The nucleus was estimated to be about 18 to 25 miles (30 to 40 kilometers) across.

In 2004, the U.S. spacecraft Stardust passed near the nucleus of Comet Wild 2 and gathered samples from the comet's coma. Stardust was scheduled to return the samples to Earth in 2006. Also in 2004, the European Space Agency launched the Rosetta spacecraft, which was to go into orbit around Comet Churyumov-Gerasimenko in 2014. Rosetta carried a small probe designed to land on the comet's nucleus.



METEORS



A meteor is a bright streak of light that appears briefly in the sky. Observers often call meteors shooting stars or falling stars because they look like stars falling from the sky. People sometimes call the brightest meteors fireballs. A meteor appears when a particle or chunk of metallic or stony matter called a meteoroid enters the earth's atmosphere from outer space. Air friction heats the meteoroid so that it glows and creates a shining trail of gases and melted meteoroid particles. The gases include vaporized meteoroid material and atmospheric gases that heat up when the meteoroid passes through the atmosphere. Most meteors glow for about a second.

Most meteoroids disintegrate before reaching the earth. But some leave a trail that lasts several minutes. Meteoroids that reach the earth are called meteorites.

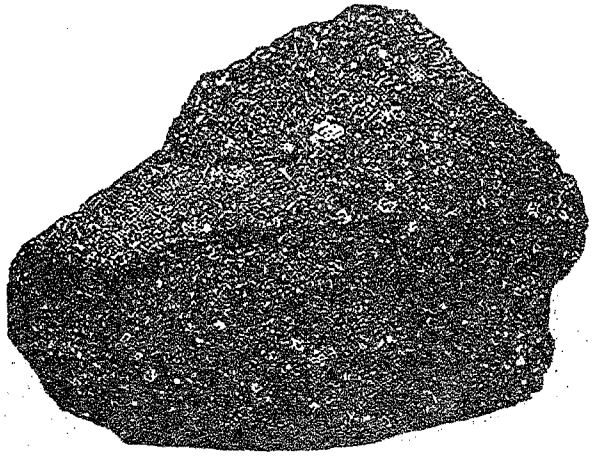
Millions of meteors occur in the earth's atmosphere every day. Most meteoroids that cause meteors are about the size of a pebble. They become visible between about 40 and 75 miles (65 and 120 kilometers) above the earth. They disintegrate at altitudes of 30 to 60 miles (50 to 95 kilometers).

Meteoroids travel around the sun in a variety of orbits and at various velocities. The fastest ones move at about 26 miles per second (42 kilometers per second). The earth travels at about 18 miles per second (29 kilometers per second). Thus, when meteoroids meet the earth's atmosphere head-on, the combined speed may reach about 44 miles per second (71 kilometers per second).

Meteor showers

The earth meets a number of streams (trails) or swarms (clusters) of tiny meteoroids at certain times every year. At such times, the sky seems filled with a shower of sparks. Streams and swarms have orbits like those of comets and are believed to be fragments of comets.

The most brilliant meteor shower known took place on Nov. 12-13, 1833. It was one of the Leonid showers, which occur every November and seem to come from the direction of the constellation Leo.



Meteorites

There are three kinds of meteorites, stony, iron, and stony-iron. Stony meteorites consist of minerals rich in silicon and oxygen, with smaller amounts of iron, magnesium, and other elements. One group of stony meteorites, called chondrites, are pieces of the same material from which the planets formed. Another group of stony meteorites, the achondrites, were once part of a parent body, such as an asteroid, that was large enough to have melted and separated into an iron-rich core and a stony crust. Achondrites come from the outer crust; stony-iron meteorites, from the inner crust; and iron meteorites, from the metallic core. Iron meteorites consist mostly of iron and nickel. Stony-iron meteorites have nearly equal amounts of silicon-based stone and iron-nickel metal.

The size of meteorites varies greatly. Most of them are relatively small. The largest meteorite ever found weighs about 66 short tons (60 metric tons). It fell at Hoba West, a farm near Grootfontein, Namibia. However, much larger bodies, such as asteroids and comets, can also strike the earth and become meteorites.

:teorites reach the earth's surface because they are the right size travel through the atmosphere. If they are too small, they will integrate in the atmosphere. If they are too large, they may ɔlode before reaching the earth's surface. One such object ɔloded about 6 miles (10 kilometers) above the Tunguska River in eria in 1908, leaving a 20-mile (32-kilometer) area of felled and ırched trees.

ɔusands of small meteorites have been found in Antarctica, ɔviding a rich supply of specimens for scientists to study. entists study meteorites for clues to the types of material that med the planets.

pact craters and basins

ıen large bodies such as asteroids and comets strike a planet, ɜy produce an impact crater or impact basin. Impact craters are wl-shaped depressions that measure up to about 10 miles (25 ɔmeters) in diameter. They have shallow, flat floors and uplifted ıters. Impact basins are larger, and inside their rims there are one more rings on the planet's surface.

entists have found more than 120 impact craters and basins on ɜ earth. One of the most famous, the Meteor Crater in Arizona, is out 4,180 feet (1,275 meters) across and 570 feet (175 meters) ep. It formed nearly 50,000 years ago when an iron meteorite ıighing 330,000 short tons (300,000 metric tons) struck the earth.

ɔst impact craters and basins larger than the Meteor Crater are avily worn away or have been buried by rocks and dirt as the rth's surface changed. The largest known of these is the Chicxulub HEEK shoo loob) Basin centered in Mexico's Yucatan Peninsula.

The diameter of the basin is about 190 miles (300 kilometers). Rock samples obtained by drilling into the basin indicate that an asteroid struck the earth there about 65 million years ago. This was about the time the last dinosaurs became extinct. The impact hurled much debris into the sky. Many scientists believe this debris caused climate changes that the dinosaurs could not survive.