NASA FACT SHEET:
Asteroids, Comets, and NASA Research

http://meteorite.org/facts.htm

Asteroids and comets are believed to be ancient remnants of the earliest years of the formation of our Solar System more than four billion years ago. From the beginning of life on Earth to the recent spectacular impact of Comet Shoemaker-Levy 9 with Jupiter, these so-called "small bodies" play a key role in many of the fundamental processes that have shaped the planetary neighborhood in which we live.

Comets are bodies of ice, rock and organic compounds that can be several miles in diameter. Comets are thought to originate from a region beyond the orbits of the outermost planets. Scientists believe that gravitational perturbations periodically jar comets out of this population, setting these "dirty snowballs" on orbital courses that bring them closer to the Sun. Some, called long-period comets, are in elliptical orbits of the Sun that take them far out beyond the planets and back. Others, called short-period comets, travel in shorter orbits nearer the Sun.

When comets venture into the more intense sunlight of the inner Solar System, the ices in the comet nucleus begin to vaporize and fall away. The evolved gas forms a tenuous atmosphere around the nucleus called a coma, while the dust previously in the nucleus forms a tail that can be thousands of miles long and sometimes can be seen from Earth. While striking the early Earth billions of years ago, comets are thought to have created major changes to Earth's early oceans, atmosphere and climate, and may have delivered the first carbon-based molecules to our planet, triggering the process of the origins of life.

Most asteroids are made of rock, but some are composed of metal, mostly nickel and iron. They range in size from small boulders to objects that are hundreds of miles in diameter. A small portion of the asteroid population may be burned-out comets whose ices have evaporated away and been blown off into space. Almost all asteroids are part of the Main Asteroid Belt, with orbits in the vast region of space between Mars and Jupiter.

Some asteroids pass very close to Earth's orbit around the Sun. Scientists have found evidence that asteroids have hit our planet in the past. Usually, asteroids and smaller debris called meteoroids are too small to survive the passage through Earth's atmosphere. When these burn up on their descent, they leave a beautiful trail of light known as a meteor or "shooting star." Larger asteroids occasionally crash into Earth, however, and create craters, such as Arizona's mile-wide Meteor Crater near Flagstaff. Another impact site off the coast of the Yucatan Peninsula in Mexico, which is buried by ocean sediments today, is believed to be a record of the event that led to the extinction of the dinosaurs 65 million years ago. Fortunately for us, these big asteroid impacts are rare. A smaller rocky meteoroid or comet less than 100 yards in diameter is believed to have entered the atmosphere over the Tunguska region of Siberia in 1908. The resulting shockwave knocked down trees for hundreds of square miles.

Over the next ten years, NASA expects to spend more than $1 billion gaining a better scientific understanding of asteroids and comets. Major areas of research supported by NASA include detecting and tracking so-called Near Earth Objects (NEOs) that could possibly impact the Earth in the future, and numerous spacecraft missions to learn more about the physical properties and evolution of asteroids and comets, including returning samples of them to Earth.

GROUND-BASED RESEARCH:

DETECTING, TRACKING AND CHARACTERIZING

Earth and all the other planets and moons of our Solar System have been continuously pelted by asteroids and comets ever since their formation -- just look at the Moon's craters through a small telescope or a good pair of binoculars.

NASA supports several ground-based programs and related technology development efforts that use sensitive electronic detectors to scan the skies for undiscovered NEOs. Less than 10 percent of the estimated 2,000 or more NEOs that are larger than about a half-mile in diameter have been detected to date. (Most scientists believe that objects of this size have the potential to cause global effects should they hit the Earth.)

Major examples of these programs include the Near Earth Asteroid Tracking (NEAT) system operated by NASA's Jet Propulsion Laboratory (JPL) in conjunction with the U.S. Air Force on Mt. Haleakala, Maui, HI; the Spacewatch program run by the University of Arizona in Tucson at Kitt Peak, AZ; and the Lowell Observatory NEO Survey (LONEOS) program in Flagstaff, AZ.

In fiscal year 1998, these NASA programs are funded at $3 million, a threefold increase over recent levels; future budgetary requirements and technology research plans are under review. NASA also is discussing greater collaboration in this area with the U.S. Air Force Space Command, as well as solutions to how to improve coverage of the sky as seen from the Southern Hemisphere. The overall goal of this effort is to detect 90 percent of the most hazardous NEOs within the next decade.

NASA also funds a variety of ground-based research designed to characterize the composition, size, shape and other basic properties of asteroids and comets. These scientists use many of the world's most advanced telescopes and most powerful radars at sites ranging from the Keck facility atop Mauna Kea in Hawaii to the massive Arecibo radar in Puerto Rico, which was upgraded recently by NASA and the National Science Foundation in part for this task.

NASA's overall work in this area soon will be coordinated by a new NASA office, bringing a central focus to this diverse activity. NASA-supported researchers also have been asked to follow a new protocol for reporting potentially hazardous NEOs to the public, based on the principles of verification and consensus. Detailed orbital data should be shared with fellow researchers within 24 hours of receipt, with a subsequent effort to reach consensus on the object's long-term orbital path within 48 hours. NASA officials are beginning discussions with related researchers around the world to develop more comprehensive guidelines that can be applied on an international basis in the future.

HOW MUCH OF A HAZARD?

The most dangerous asteroids, those capable of causing major regional or global disasters, are extremely rare. These bodies impact the Earth only once every 100,000 years on average. Comets in this category are thought to impact even less frequently, perhaps once every 500,000 years or so.

The risk from NEO impacts increases with the size of the projectile. The greatest risk is associated with objects larger than a half-mile to a mile (1-2 kilometers), which are large enough to perturb the Earth's climate on a global scale by injecting large quantities of dust into the stratosphere. Such an event could depress temperatures and the amount of surface sunlight around the globe, leading to loss of food crops and related problems. An ocean impact could trigger large ocean waves, or tsunamis.

Such global catastrophes are qualitatively different from other more common hazards that we face daily, given that these common events occur with much greater frequency but affect fewer people. No individual person should worry about being struck by a comet or asteroid. The daily threat to an average person from disease, car accidents, home accidents and from other natural disasters is much higher.

For further information on this topic, see the NASA Ames Research Center's Asteroid & Comet Impact home page.

It is entirely feasible that we could divert a large asteroid or comet that may collide with Earth from its orbit using existing technologies. The potential response depends on the lead time. If we can predict the event long in advance, by at least 10 to 100 years, then conventional rockets and explosives would probably be adequate, even for bodies as large as a half-mile. However, if we discover the object only a few years before impact, these technologies might not be adequate. Such a response would be coordinated in the United States by the departments of Defense and Energy, and likely would include international partners.

SPACECRAFT MISSIONS

PAST MISSIONS

Vega 1 & 2- USSR Venus/Comet Halley Flyby:
Both flew past Venus in June 1985, dropping off landers and balloons to investigate the planet's middle atmosphere, on their way to flybys of Comet Halley on March 6 and March 9, 1986, respectively.

Sakigake - Japan:
Flew past Comet Halley on March 1, 1986.

Giotto - European Space Agency:
Flew past Comet Halley on March 13, 1986.

Suisei - Japan:
Flew by Comet Halley on March 8, 1986.

Hubble Space Telescope and Galileo:
The Wide Field Planetary Camera on Hubble photographed the collision of Comet Shoemaker-Levy 9 with Jupiter in July 1994, while NASA's Galileo spacecraft observed the impacts while cruising toward its later December 1995 entry into orbit around the planet.

UPCOMING SPACE-BASED MISSIONS

NEAR EARTH ASTEROID RENDEZVOUS (NEAR): The first launch in NASA's Discovery Program of lower-cost, highly focused planetary science missions, NEAR was launched in February 1996 and has since become is the first spacecraft powered by solar cells to operate beyond the orbit of Mars. On June 27, 1997, NEAR flew by the asteroid 253 Mathilde. It found Mathilde to be composed of extremely dark material, with numerous large impact craters, including one nearly six miles deep. A subsequent deep-space maneuver in July 1997 brought NEAR back around Earth for a slingshot gravity assist that put the spacecraft on a trajectory for its main mission: a rendezvous with the Manhattan-sized asteroid 433 Eros. NEAR will arrive at Eros on January 10, 1999, and become the first spacecraft ever to orbit an asteroid. It will study Eros from as close as nine miles for at least a year, until early 2000. NEAR was built and is managed by the Johns Hopkins University Applied Physics Laboratory, Laurel, MD.

DEEP SPACE 1 (DS1): The first mission in NASA' s New Millennium program, DS1 is an experimental probe designed to test 12 advanced spacecraft and science instrument technologies so that they can be confidently used in space science missions of the 21st century. Scheduled to launch in October 1998, this five-foot-high spacecraft will be powered by solar electric propulsion, which has been described in many futuristic science fiction works but is only now being used as the primary propulsion system for a deep space mission. Other technologies being tested include autonomous optical navigation, which allows the spacecraft to find its way in the Solar System and make its own decisions about where it needs to go next to stay on track. Trajectory details are still being designed, but the mission will likely include an asteroid flyby to help test a miniaturized science instrument called the Integrated Camera and Imaging Spectrometer.

STARDUST: This technically daring Discovery Program mission will fly a spacecraft to within 100 miles of the nucleus of Comet Wild-2 to capture actual comet dust particles in a material called "aerogel" and return the sample to Earth for analysis. A direct sample of a known comet has been long sought by planetary scientists because comets are thought to be nearly pristine examples of the original material from which the Sun and planets were born 4.6 billion years ago. This JPL-managed spacecraft is now being assembled and is on schedule for launch in February 1999, with the sample due back on Earth in 2006.

MUSES-C: This innovative mission led by Japan will use new flight technology, including solar electric propulsion, to send a spacecraft to asteroid 4660 Nereus to deliver the smallest robotic space rover ever developed to the asteroid's surface. The spacecraft will also fire projectiles into the asteroid surface, collect the samples that are ejected, and return them to Earth for laboratory analysis. The tiny rover being produced by engineers at JPL, called MUSES-CN, is so small it can be held in the palm of your hand. This ambitious collaboration between the U.S. and Japan is an opportunity for two spacefaring nations to combine their expertise to achieve major science and technology goals in a cost-constrained environment. The mission is scheduled for launch in 2002.

COMET NUCLEUS TOUR (CONTOUR): This Discovery Program mission will take images and comparative spectral maps of at least three comet nuclei and analyze the dust flowing from them. CONTOUR is scheduled for launch in July 2002, with its first comet flyby to occur in November 2003. This flyby of Comet Encke at a distance of about 60 miles (100 kilometers) will be followed by similar encounters with Comet Schwassmann-Wachmann- 3 in June 2006 and Comet d'Arrest in August 2008.

DEEP SPACE 4 - Champollion: The goal of this mission is to perform the first landing of scientific instruments on a cometary nucleus and demonstrate technologies for collecting extraterrestrial samples to Earth. A launch in 2003 will send a solar electric-powered carrier spacecraft to a rendezvous with Comet Tempel 1 in December 2005. After mapping the comet's nucleus from orbit, the carrier spacecraft will release the Champollion lander, which will use advanced autonomous navigation to maneuver to the chosen landing site. At touchdown, an explosive, deployable harpoon will anchor the lander to the comet for drilling and sample retrieval. With its sample gathered, the lander will detach from the anchor, and take off and return to the carrier. The carrier may also carry a separate vehicle designed to return the sample to Earth.
