OSIRIS-REx Frequently Asked Questions

What is the OSIRIS-REx Mission?

The OSIRIS-REx mission is NASA New Frontiers mission to return a sample of an asteroid to the Earth. Mission cost is approximately $800 million (excluding the launch vehicle.)

The OSIRIS-REx mission is a partnership of the University of Arizona, NASA's Goddard Space Flight Center and the Lockheed Martin Company. Additional worldwide partners and collaborators will provide scientific instruments and support mission science.

The OSIRIS-REx spacecraft launches in 2016, rendezvous with asteroid (101955) Bennu in 2018 and returns its sample to Earth in 2023.

What does OSIRIS-REx Stand For?

OSIRIS-REx is an acronym that describes the work of the mission:

- **Origins**The mission will return a pristine sample to Earth to help us understand the origins of volatiles and organics that may have seeded life on Earth.
- **Spectral Interpretation** Instruments will map the properties of the asteroid in the search for mineral and organic substances.
- **Resource Identification** The mission will identify asteroid resources that might be used in future missions to the outer solar system, in addition to identifying resources of economic value.
- **Security** Measurements will quantify the role of the Yarkovsky Effect on this potentially hazardous asteroid, helping to secure the Earth from future asteroid impacts.
- **Regolith Explorer** The mission will explore the regolith at the sampling site in situ at sub-centimeter scales.

What will the OSIRIS-REx Mission Do?

The OSIRIS-REx mission will thoroughly characterize near-Earth asteroid (101955) Bennu. Asteroids are the direct remnants of the original building blocks of the terrestrial planets. Knowledge of their nature is fundamental to understanding planet formation and the origin of life. The return to Earth of pristine samples with known geologic context will enable precise analyses that cannot be duplicated by spacecraft-based instruments, and will revolutionize our understanding of the early Solar System.

What are the OSIRIS-REx mission's scientific objectives?

The mission's scientific objectives are:

1. Return and analyze a sample of pristine carbonaceous regolith
2. Map global properties, chemistry, and mineralogy of the asteroid
3. Investigate texture, morphology, volatile chemistry, and spectral properties of the regolith
4. Measure the Yarkovsky effect
5. Provide direct comparison to telescope-based data of the entire asteroid population.

Why asteroid (101955) Bennu?

(101955) Bennu is an exciting, accessible, volatile and organic-rich remnant from the early Solar System, as well as one of the most potentially hazardous asteroids known.

Bodies from the outer main asteroid belt are believed to be the dominant source of primordial terrestrial organics and possibly water. In the chaotic early Solar System, many collided with the young planets bringing organics and possibly water to them. Water and carbon are the building blocks of life on Earth.

Bennu likely has abundant regolith, comprised of fine gravel (4-8 mm) which is ideal for collecting a sizable sample. With this sample, scientists will be able to analyze the asteroid's composition, mineralogy, and geology to learn more about it and other asteroids.

Every six years, Bennu's orbit brings it near the Earth – less than 449,000 km (~280,600 mi). Its orbit gives Bennu one of the highest impact probabilities with Earth of any known asteroid. OSIRIS-REx will help scientists better determine the orbit of the asteroid to provide more conclusive data on what kind of threat it represents. With time, policymakers will be able to decide what (if any) steps should be taken to mitigate the risk of impact. To find the current position of Bennu, go to http://neo.jpl.nasa.gov/orbits/. For more on near-Earth asteroids and impact hazards, go to http://neo.jpl.nasa.gov/.

Mapping the characteristics of the asteroid with instruments during rendezvous (2018-2020) the OSIRIS-REx spacecraft will not only determine the optimum sampling site but also obtain important

data about composition and behavior. Scientists will determine topography, composition, and orbital characteristics.

Bennu is a B-type asteroid. B-type asteroids are carbonaceous, rich in volatiles and possible representatives of asteroids that brought seeds of life to Earth.

Telescopic observations of Bennu have allowed scientists to refine the orbit of the asteroid to a great extent, but the rendezvous with the asteroid will allow more precise determination of the forces that affect its orbit. This mission will measure the Yarkovsky effect to understand Bennu's orbit and mechanics that affect other Near Earth Object orbits.

What is a Near-Earth Object?

A Near-Earth Object is a comet or asteroid orbiting the Sun in the neighborhood of the Earth. Most asteroids reside in the asteroid belt between Mars and Jupiter. About 600,000 main belt asteroids are known. Over 8,000 near-Earth objects have been found. An object becomes an NEO because the gravitational attraction of planets (primarily the very large and massive Jupiter) have nudged it into an orbit that brings it into Earth's vicinity. Another factor is the Yarkovsky Effect.

What is the Yarkovsky effect?

In 1902, Ivan Yarkovsky suggested that the daily heating of an object rotating in space could exert a small force on the object. We know how the temperature on Earth gets warmer and warmer as the Sun rises, hitting a maximum sometime in the early afternoon. The same thing occurs on an asteroid. When the heated surface of Bennu points its hot afternoon side in the direction of its motion around the Sun - the escaping radiation acts like a tiny rocket thrust, slowing it down and sending it closer to the inner solar system. Although tiny, this constant push can change an asteroid's orbit significantly. The OSIRIS-Rex mission will carefully study the Yarkovsky effect on Bennu, which should help scientists improve their ability to predict the orbits of other threatening asteroids.

What do we know about (101955) Bennu?

(101955) Bennu is a near-Earth object. It completes an orbit of the Sun every 436.604 days (1.2 years). This orbit takes it close to the Earth every six years. Although the orbit is reasonably well known, scientists continue to refine it. It is critical to know the orbit of Bennu because recent calculations produce about a 1 in 2000 chance of impact with Earth in the year 2182. Part of the OSIRIS-REx mission is to refine our understanding of the forces on Bennu's orbit and to refine the calculations of the future threat to Earth.

Telescopic observations have revealed some basic properties of Bennu. They indicate that Bennu is very dark. Such asteroids are considered “primitive”, having undergone little chemical alteration since the beginning of the solar system.

Why a sample return mission?

What we know of asteroids, we have learned through telescopic observations and from laboratory analysis of meteorites, the recovered fragments of asteroids that fall to Earth. Telescopic observations can tell scientists a lot about these very dim objects, including their mass, density, rotation and likely composition. From meteorite analyses, researchers can determine composition, density, mass and create models of the parent bodies and their formation and history.

Telescopic observations, lab analyses and models can be linked by bringing a physical sample of an asteroid back to the lab. From such studies, scientists will be able to confirm the facts with an actual field check!

Finally, bringing a sample to Earth will allow scientists to study Bennu using instruments and techniques that are far more sophisticated than could ever be flown on present-day spacecraft. Samples will be also archived for future study by advanced instruments that can only be dreamed of today.

What are the characteristics of the spacecraft and what is its payload?

Lockheed Martin will build the spacecraft and use proven technologies and designs from Stardust, a NASA sample return mission that flew past a comet in 2004. Other partners will build the science instruments for the mission.

Spacecraft Details

- The OSIRIS-REx spacecraft is approximately 2 m (6.6 ft) on each side.
- Active solar arrays are 8.5 square meters (91 square feet).
- Solar energy charges Li-ion batteries, which power the OSIRIS-REx spacecraft and instruments.
- The Sample Return Capsule (SRC) is the same as used in the Stardust mission.
- Innovative sampling methods using the Touch and Go Sample Acquisition Mechanism (TAGSAM):
    - Approaches surface at 0.1 m/second (3.93 inches/second),
    - fluidizes regolith and collects sample in approximately 5 seconds,
    - collects a minimum of 60 g (2.1 ounces),
    - has continuous imaging of sampling,
    - verifies sample amount by measuring change in the spacecraft inertia

Instruments

A suite of instruments flies on board the spacecraft to provide information necessary to carry out the science and select the sampling site.

- OSIRIS-REx Camera Suite (OCAMS)

  This suite consists of Poly Cam, MapCam, and SamCam, which provide long-range acquisition of Bennu and imaging of its surface down to millimeter ranges, along with global mapping, sample-site characterization, and sample acquisition documentation. The University of Arizona is building OCAMS.

- OSIRIS-REx Laser Altimeter (OLA)

  Provides global and topographic mapping of candidate sample sites. The Canadian Space Agency is building OLA.

- OSIRIS-REx Visible and IR Spectrometer (OVIRS)
  Provides mineral and organic spectral maps and local spectral information of candidate sample sites from 0.4 – 4.2 microns. NASA Goddard Space Flight Center is building OVIRS.

- OSIRIS-REx Thermal Emission Spectrometer (OTES)

  Provides mineral and temperature data of candidate sample sites from 5 - 50 microns. Arizona State University is building OTES.

- REgolith X-ray Imaging Spectrometer (REXIS)

  A student collaboration experiment x-ray (0.3-7.5 keV) telescope provides global mapping of elemental abundances and documentation of sampling site. MIT and Harvard are building REXIS.

What precautions will be taken to lower the probabilities of bringing home contaminated material?

NASA has stringent protocols to ensure that its missions do not transport threatening materials to Earth. An international treaty governs NASA's activities related to planetary protection. NASA's OSIRIS-REx mission follows these protocols and all related requirements to prevent contamination of the Earth and other Solar System bodies. These protocols include requirements for both the spacecraft and for any returned samples. For more information see http://planetaryprotection.nasa.gov/.

Many tons of material from asteroids, comets and beyond land on Earth every day. As they pass through the atmosphere, they are called meteors. Although meteors do heat up as they pass through the Earth's atmosphere, their interiors remain cold even while the outside is hot. Consequently, meteorite interiors are not sterilized as they travel through Earth's atmosphere.

Exposure to radiation and heat in interplanetary space can sterilize materials. The OSIRIS-REx mission target asteroid, (101955) Bennu, is very old and has had many close approaches to Earth. Scientists believe that these encounters have rearranged its structure, moving materials from its interior to its surface and back. Because Bennu is so dark the surface gets quite warm (up to 170° F). As the asteroid moves through space, its surface has been subjected to enough heat and solar and galactic radiation to kill many Earth organisms. So even if conditions were right for life to originate on Bennu (which is highly unlikely), it would have been irradiated, cooked, and have few places to hide.

Where can I get more information?

Visit the OSIRIS-REx website at **www.asteroidmission.org**