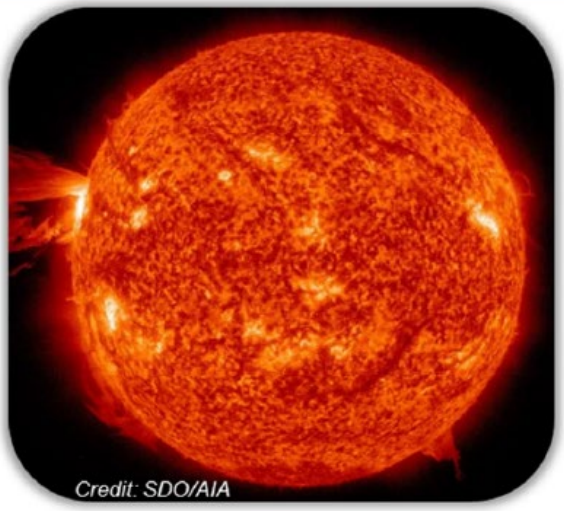

Credit: SDO/AIA

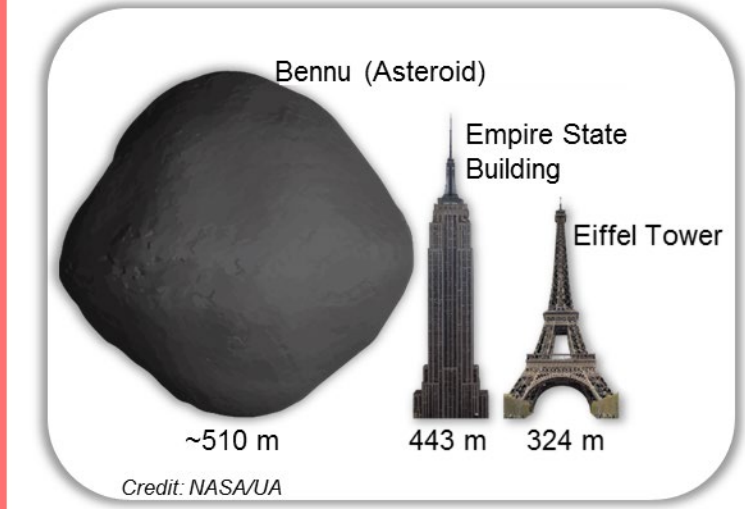

Credit: NASA/JPL

The Sun

- The Sun is ~93 million miles or ~150 million km [1 Astronomical Unit (AU)] from Earth. Its diameter is 109 times that of Earth.
- The Sun is ~4.6 billion years old and a yellow dwarf star. Its mass is made up of hydrogen (~72%), helium (~27%), and other elements such as oxygen, carbon, etc.
- In addition to heat and light, the Sun also emits particles, as both solar wind and solar flares that travel throughout the solar system.

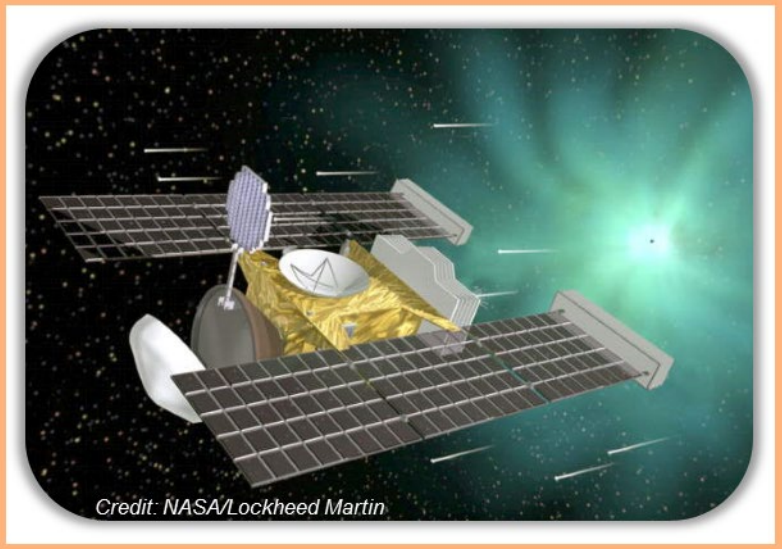
Comet Wild 2

- Comets are icy, dusty objects that are likely leftovers from the gas, dust, ice, and rocks that formed the solar system ~4.6 billion years ago.
- At the time of the Stardust encounter, Comet Wild 2 had likely only traveled close to the Sun in its last 5 orbits so it stayed relatively unchanged for over 4 billion years.
- Comet Wild 2 was in the right place at the right time for Stardust to approach and successfully collect samples.


Bennu (Asteroid)
Empire State Building
Eiffel Tower
~510 m
443 m
324 m
Credit: NASA/UA

Asteroid Bennu

- Bennu was selected from over 500,000 known asteroids in the solar system due to its size, composition, and location.
- Telescopic observations suggest that Bennu is a rare “B-type” asteroid that is primitive (old), contains volatiles and organic molecules (such as amino acids) and is carbon-rich.
- Bennu orbits the Sun every ~1.2 years and has a rotation period of 4.3 hours. It comes very close to Earth every 6 years.


Credit: NASA/Lockheed Martin

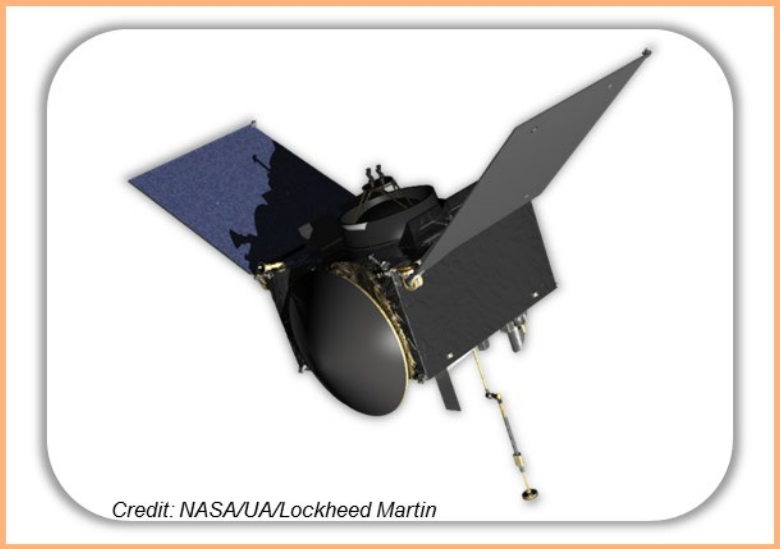

Credit: NASA/Lockheed Martin

Mission Timeline

- *Launch Date:* February 7, 1999
- *Sample Collection of Interstellar Dust:* February – May 2000; August – December 2002
- *Sample Collection from Comet Wild 2:* January 2, 2004 (spacecraft flew through the coma or cloud of dust & debris surrounding the comet)
- *Return to Earth:* January 15, 2006

Mission Timeline

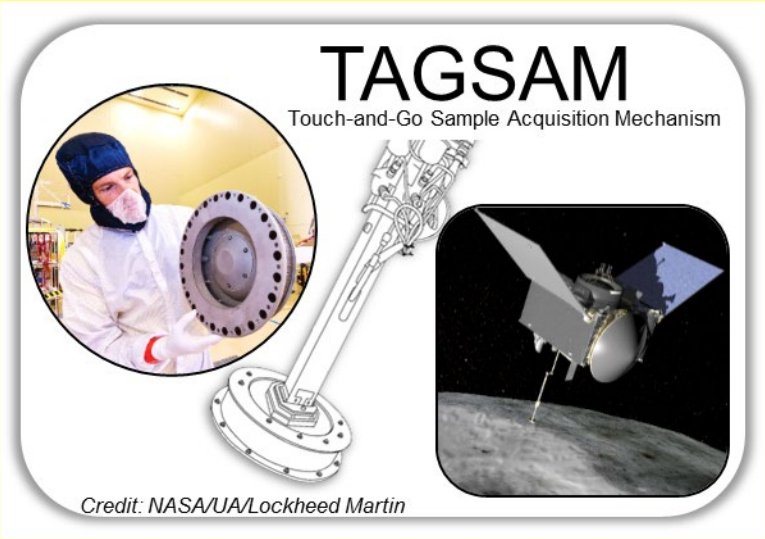
- *Launch Date:* August 8, 2001
- *Sample Collection:* Orbited a unique point called a Lagrange point (L1), between the Earth and the Sun for 884 days collecting solar wind.
- *Return to Earth:* September 8, 2004
- Upon return to Earth, the Genesis sample return capsule had a hard landing as the parachute did not deploy. Despite the hard landing, the samples were recovered and can be cleaned using ultrapure water.



Credit: NASA/UA/Lockheed Martin

Mission Timeline

- *Launch Date:* September 8, 2016
- *Arrival at Bennu:* December 3, 2018
- *Sample Collection:* July 2020
- *Departure from Bennu:* March 2021
- *Return to Earth:* September 2023


TAGSAM
Touch-and-Go Sample Acquisition Mechanism
Credit: NASA/UA/Lockheed Martin

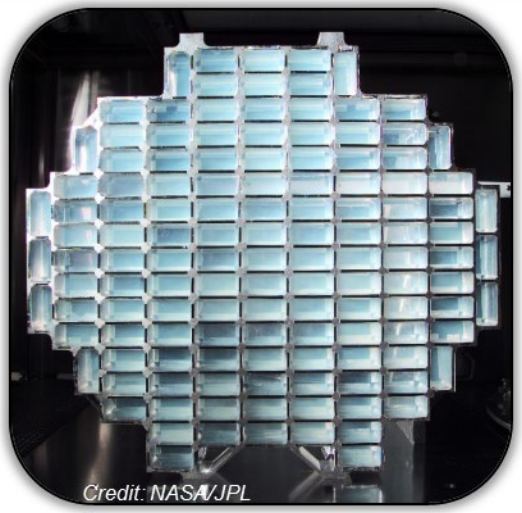

Credit: NASA/JSC/ARES

Sample Collector: TAGSAM

- TAGSAM *(Touch-and-Go Sample Acquisition Mechanism)* includes a sampler head that is on the end of a 3.35 meter (11 foot) arm.
- Once the sampler head makes contact with the surface, a burst of pure nitrogen gas will push regolith (rocks and dust) into the sample chamber.
- Surface contact pads on the exterior of TAGSAM will also collect fine-grained material.

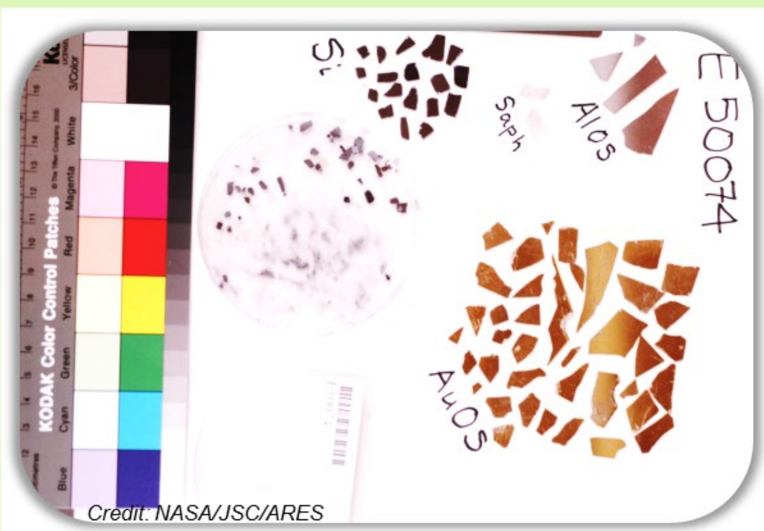
Sample Collectors

- There were 5 bicycle-tire-sized collector arrays designed to collect different types of solar wind.
- Each array was made up of ~55 hexagonal (6-sided) wafers that were ~10 cm (~4 inches) in diameter. The thickness of the wafers varied by collector array.
- Wafers were made from 15 different types of material chosen based on purity and ability to capture and return solar wind.


Credit: NASA/JPL

Sample Collector

- The collector is double-sided. One side captured interstellar dust and the other cometary particles.
- Each side of the collector contains 130 blocks (2cm x 4cm) of **aerogel** (bluish-colored material) used to capture particles.
- **Aerogel** is made up of over 99% air. It was ideal for catching the small, fast moving (~6 km/s) particles without damage from impact or heat.


E 50074
Al O5
Saph
Si
Au O5
KODAK Color Control Patches
Blue
Cyan
Green
Yellow
Red
Magenta
White
3/Color
Credit: NASA/JSC/ARES

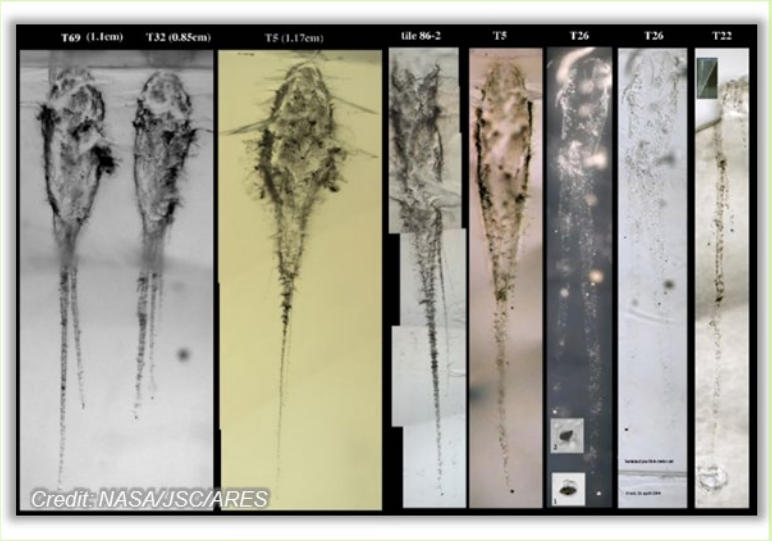

Credit: NASA/UA/Lockheed Martin

Solar Wind

- Collected solar wind is embedded within the wafers and is atomic in scale.
- Four categories of solar wind were collected: 1) *coronal hole (high speed solar wind);* 2) *interstream (slow speed solar wind);* 3) *coronal mass ejection*; and 4) *bulk solar wind (all types).*
- Samples are curated (documented, preserved, and distributed to scientists for study) by the Astromaterials Research and Exploration Science (ARES) Division at NASA's Johnson Space Center in Houston, TX.

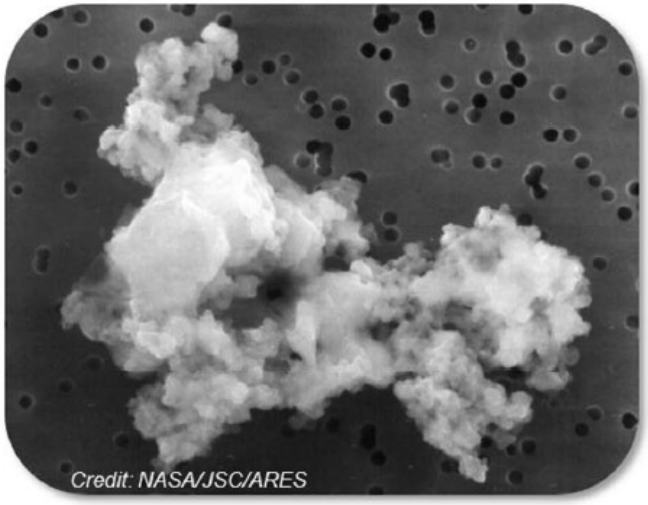
Asteroid Regolith Samples

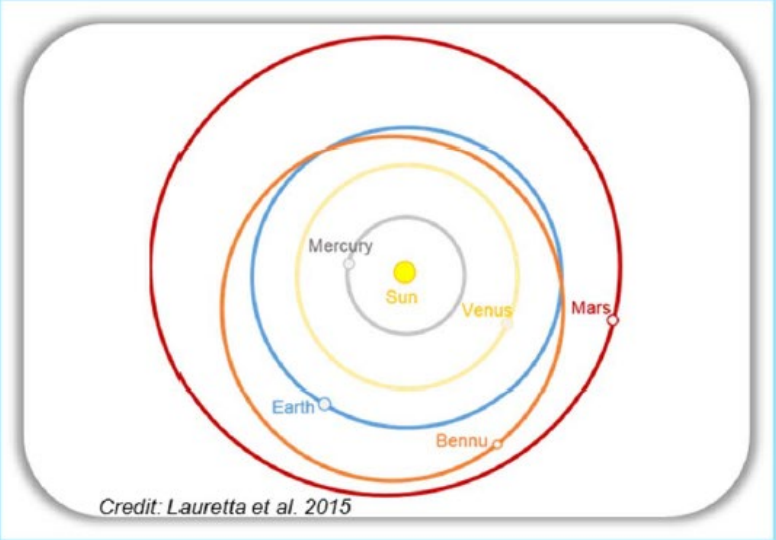
- TAGSAM can take in dust and rocks measuring less than 2 cm (3/4 of an inch).
- OSIRIS-REx aims to collect at least 2.1 ounces (60 grams) of sample material, but the TAGSAM sample head can hold up to 4.4 pounds (2 kilograms).
- Upon their return, the samples will be curated (documented, preserved, and distributed to scientists for study) by the Astromaterials Research and Exploration Science (ARES) Division at NASA's Johnson Space Center in Houston, TX.


T69 (1.1cm)
T32 (0.85cm)
T5 (1.17cm)
tile 86-2
T5
T26
T26
T22
Credit: NASA/JSC/ARES

Comet Particle Samples

- Collected particles formed tracks in the **aerogel**. At the end of some tracks, the captured particles can be seen.
- Comet Wild 2 samples are tiny, less than 100μm (100 microns or 0.0039 of an inch) in size.
- Samples are curated (documented, preserved, and distributed to scientists for study) by the Astromaterials Research and Exploration Science (ARES) Division at NASA’s Johnson Space Center in Houston, TX.


Credit: NASA/JSC/ARES


Mercury
Sun
Venus
Mars
Earth
Bennu
Credit: Lauretta et al. 2015

Spacy is Dusty!

- The “empty” space between objects in our solar system actually contains dust.
- Stardust collected interstellar dust (from other stars), on its way to Comet Wild 2.
- The samples from Comet Wild 2 and the interstellar dust provide information about the formation and early history of our solar system and insight into modern stars.

Bennu: Orbit and Relevance

- Bennu is considered a Potentially Hazardous Asteroid (PHA). PHAs are asteroids that are predicted to come close to Earth.
- The OSIRIS-REx mission will help scientists better understand factors affecting the orbit of Bennu to more accurately predict its projected orbit and that of other PHAs.
- Studying the surface and samples from Bennu will help scientists make connections between carbonaceous meteorites and asteroids, gain insight into the origin of life, and learn more about early solar system history.


Credit: NASA/JPL

Salvaging the Science

- Upon return to Earth, the Genesis sample return capsule had a hard landing.
- Even though the collectors were broken, scientists from JSC recovered the fragments containing solar wind. Samples continue to be studied today.
- The collected Genesis samples provide information about the chemical makeup of the solar nebula our solar system was born from and facilitate a better understanding of the origins of the sun and planets.