



# THE STAR WITNESS



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## Special Feature

# Hubble Witnesses Fireworks From Comet Collision

By NASA's Amazing Space reporters  
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**O**N JULY FOURTH, 2005, not all the fireworks were on Earth. NASA's Deep Impact spacecraft helped create some spectacular celestial fireworks by crashing into comet 9P/Tempel 1, a potato-shaped object about 3 miles (5 kilometers) wide and 7 miles (11 kilometers) long.

NASA's Hubble Space Telescope had a front-row seat for the big event, providing the best visible-light view from Earth of the collision (see photos, page 2). The telescope watched as an 820-pound probe, called an impactor, punched through the comet's crusty surface. The impactor hurtled into the comet's core at 23,000 miles per hour, releasing lots of energy. The impactor, made up mostly of copper, formed a crater big enough to swallow a large stadium.

By breaking through the outer baked crust, the collision unleashed ancient

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**Deep Impact's view: The moment of collision**

IMAGE: NASA/JPL-Caltech/UMD

### **The Deep Impact spacecraft's view of its impactor hitting the comet:**

This close-up image was taken by Deep Impact's "flyby" spacecraft 67 seconds after its impactor smashed into comet 9P/Tempel 1's nucleus. The flyby craft was 300 miles away from the collision when it snapped this picture.

material that had been trapped inside the comet since its birth billions of years ago. It will take astronomers a long time, however, to analyze all the information collected about the comet and share the results.

### The mission

Scientists launched the Deep Impact spacecraft six months ago on its one-way trip to the comet. The spacecraft was as large as a mid-size sport utility vehicle and had two parts: a flyby spacecraft and the impactor (see photos, page 3). Both parts were fitted with instruments designed to record the event.

The flyby spacecraft launched the impactor and then moved out of Tempel 1's path to avoid being hit by the comet. As the impactor traveled to its planned meeting with the comet, its camera snapped images of the nucleus.

Tempel 1's nucleus is only the fourth ever seen. A comet is surrounded by dust, which makes its nucleus difficult to view. The flyby spacecraft's camera spotted the nucleus because it was very close to the comet, about 300 miles away. The instruments onboard the flyby craft took detailed images of the impact and recorded other data needed to identify the ejected material.

### A key to the past

Why were astronomers daring enough to take on a comet? They want to study the material locked beneath a comet's icy surface. For billions of years, comets have been "baked" by sunlight as they pass through the inner solar system. Their warmed surfaces develop a black, carbon-rich crust. The baked crust seals material inside the comet. By cracking through the surface crust, astronomers can learn

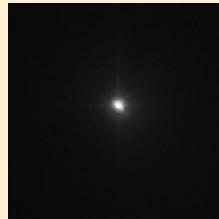
## Hubble's view of the collision

**Three minutes before impact**



These images, taken by the Hubble Space Telescope from 80 million miles away, show comet 9P/Tempel 1 before and after the Deep Impact probe slammed into it. Astronomers used these pictures to determine how much material was released from the impact.

**After impact**



**12 minutes after impact**

Innermost coma of dust appears 10 times brighter than the cloud in the pre-impact photo.



**1 hour, 4 minutes after impact**

An expanding fan of dust speeds from the comet. The fan of debris is moving at 450 miles (720 km) per hour, or about the speed of a jet airplane.



**1 hour, 28 minutes after impact**



**4 hours, 41 minutes after impact**



**19 hours, 7 minutes after impact**

The dust cloud is 2,000 miles (3,200 km) across. It is beginning to spread out into space, becoming less visible.

PHOTO SERIES: NASA, ESA, P. Feldman (JHU), H. Weaver (JHU APL)

more about a comet's makeup and structure.

Looking inside a comet also may help explain how our solar system formed about 4.5 billion years ago. Comets are an important link to our early

solar system. These celestial snowballs are the remains of material created in the coldest outer regions of our solar system. They may still contain the original building blocks of the Sun and the planets.

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## What are the parts of a comet?

The heart of a comet is its nucleus, an object made up of chunks of ice and rock that is surrounded by a cloud of gas and dust, called a coma (see illustration, page 4). The icy comet releases the gas and dust when it is warmed by sunlight. The “solar wind” pushes the coma away from the comet, forming one or more tails of gas and dust. The gas and dust surrounding a comet prevent scientists from learning more about the makeup of the nucleus. Astronomers are eager to learn whether comets exhaust their supply of gas and ice over time or keep some of it in their interiors. By breaking through Tempel 1’s surface,

scientists may find an answer to this question. They also may discover how Tempel 1’s interior is different from its surface.

### Tempel’s tale

Amateur astronomer Ernst Wilhelm Leberecht Tempel of Marseilles, France, discovered comet 9P/Tempel 1 in 1867 while using a telescope to search for comets. It is named “Tempel 1” because it was the first comet spotted by Tempel. The “9P” part of the name means that Tempel 1 was the ninth periodic comet discovered by sky watchers. Periodic comets have stable orbits and can be regularly observed from Earth.

Tempel 1 has completed more than 100 orbits around our star. The frequent trips have helped it develop a crusty layer of carbon-rich material. Little else, however, is known about the comet. Astronomers are eager to learn whether Tempel 1, which has depleted much of its outer layers of gas and ice, has kept some gas and ice in its interior.

The encounter with the Deep Impact probe did not change Tempel 1’s course. So, the comet will continue to orbit the Sun every 5.5 years.

### A visible impact

Besides the Hubble telescope, an array of other space-based observatories

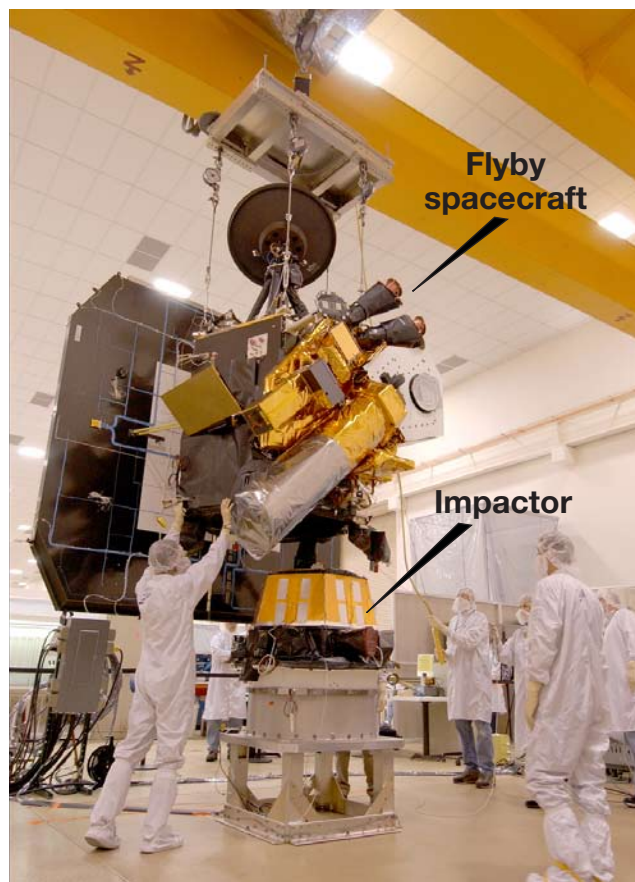
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## The Deep Impact spacecraft

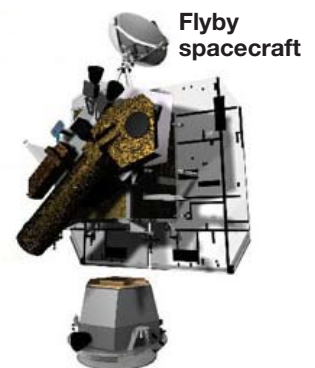
“Deep Impact,” shown in a “cleanroom” at right, was as large as a mid-size sport utility vehicle. The spacecraft was made up of two parts: a flyby spacecraft and an 820-pound impactor.

Both the spacecraft and the impactor had cameras to take pictures of the comet and the impact.

The spacecraft released the impactor about a day before the scheduled meeting with comet Tempel 1. The impactor, traveling at 23,000 miles an hour, collided into the comet early July 4, 2005. The collision created a large crater on Tempel 1 and unleashed material that had been trapped inside the comet for billions of years.



IMAGES: Ball Aerospace & Technologies Corp.



Impactor (enlarged below)



Impactor's copper dome helped make a crater

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viewed this once-in-a-lifetime event, including the ultraviolet Galaxy Evolution Explorer, the infrared Spitzer Space Telescope, and the Chandra X-ray Observatory. Many ground-based observatories also witnessed the smashup.

The views obtained by all of the observatories provided a treasure trove of information about the comet. The cameras aboard the Deep Impact flyby craft, for example, provided a close-up view of the comet, from about 300 miles away (see photo, page 1). From its distance of 80 million miles away, Hubble captured a wider view of the encounter, before, during, and after the impact (see photos, page 2). Hubble's view measured changes in the comet's brightness. By analyzing those changes, astronomers determined how much material was released from the impact. This information will help astronomers learn about Tempel 1's makeup. ★

## Anatomy of a comet

Comet Hale-Bopp (image, below left) is used as an example of a typical comet. Image below, right, is an artist's conception of a comet's nucleus.

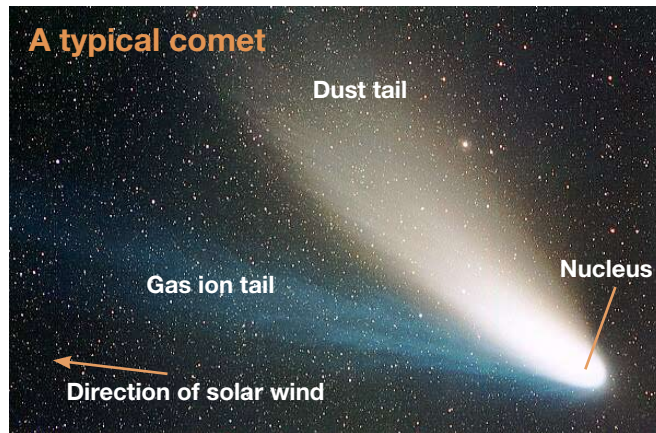


IMAGE: Alessandro Dimai



Artist's conception  
(STScI Graphics Dept.)

SEE MORE Hubble images and read more  
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NASA's award-winning educational Web site for  
K-12 students and teachers.

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