

# The Comet Chronicle

## Earthlings First Choice for Solar System News

Issue no. 1

Created for SD-NExT mission  
by Dr. M. Horejsi



### A Shocking Discovery:

## Comets Are Older Than Dirt!

In a startling discovery, NASA scientists have found that some material in comets is not only older than dirt, but also older than the Earth itself!

According to NASA mission scientist, Dr. Donald Brownlee, particles recently collected and returned by the Stardust spacecraft confirmed that comet particles are in fact the oldest materials, which formed in our Solar System!



**Calcium Aluminum Inclusions** or **CAIs**, as they are nicknamed, “may have been the first generation of solids to condense from hot gas in the early solar system,” Brownlee remarked.

This news stunned scientists worldwide as they pondered the formation of the solar system. One professor noted, “I guess I always figured that the Earth was as old as everything else. Now I see that when the solar nebula gases cooled and turned into solids, the first pieces were preserved in comets. Wow. No wonder comets are so darn dusty!”

<http://stardust.jpl.nasa.gov/news/news113.html>

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## Local Crash Causes Damage

... but no injuries reported

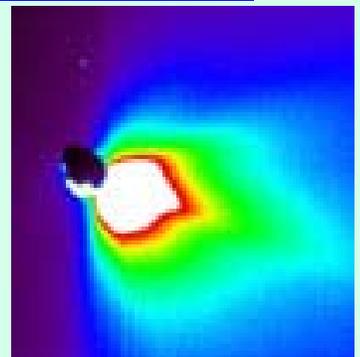
**July 4, 2004: Pasadena, California**  
Millions viewed a fiery, early morning crash as Comet Tempel 1 overtook a copper projectile jettisoned from the **Deep Impact** spacecraft. The impactor was released by the spacecraft just hours before slamming into the comet at over 36,000 km per hour. Although the comet fled the scene of the crash, scientists suspect that a fairly good-sized crater remains visible on its nucleus.

It is believed that an impact crater was formed when the projectile collided with the comet, similar to the way meteorites form craters on Earth, the Moon, and Mars. While the collision was captured on film, the extent of the damage remains unknown. Further investigation of the comet's surface in 2011 by **Stardust New Exploration of Tempel 1**, aka **SD-NExT**, is expected to reveal the extent of those damages once the dust has settled.

Deep Impact's copper impactor disintegrated within a flashing millisecond, creating an incandescent explosion.

<http://deepimpact.umd.edu/>

Silhouette of the blast emanating from comet Tempel 1. The comet nucleus is the black spot!



# Dozens of people can't tell the difference Between a *Comet and a Cow!* *Can you?*

Although comets are one of the most common objects in our solar system, most people know little about them, and they are often mistaken for other objects.



?



**It's a bird, it's a plane... it's a COW?** Comets are often mistaken for many other things in the sky: airplanes, rockets, planets – especially Venus – and not surprisingly, UFOs. To learn about comets, let's compare them to cows.

Although both cows and comets have heads and tails, the similarities start to end there. While a cow is usually only two meters long and at most a meter and a half tall, comets have a **nucleus** from 5 to 50 football fields in diameter. And worse, a comet's tail can be billions times longer than a cow's!

Cows, like humans, grow hair on their heads, but comets have a **coma** surrounding their nucleus. Even though the word coma is Latin for the word hair, a comet's "hair" is really a cloud of evaporated ices, dust and gases that emerge from the nucleus when the comet nears the Sun and heats up. The coma can be thousands of kilometers in diameter, hundreds of times that of the nucleus. Now that's some Big Hair!

While cows have only one tail, all comets have at least two tails, a **dust tail** and an **ion tail**. The dust tail is made of very small particles of

material released when the ices **sublimate** (change from a solid state straight to gas) off the nucleus and are left behind. As the comet moves through space in its orbit, the curving dust is left behind, like gleaming, minute breadcrumbs. With no trees for shade (cows get shade, but not comets), some of the vaporized particles get excited, or ionized, by the charged particles streaming from the Sun, otherwise known as the solar wind. The electrically charged, ionized comet particles begin to glow, forming the straight, bluish ion tail.

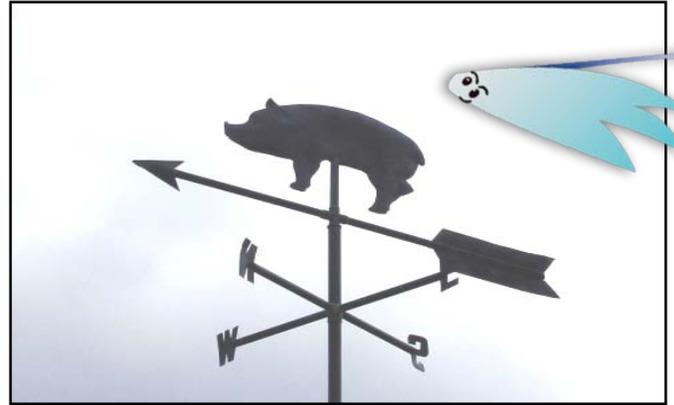
Cows and comets both leave evidence of where they have been. Cows leave behind brown disk-shaped organic matter averaging about 30 cm in diameter. Comets on the other hand leave a trail of dust stretching for millions of kilometers. In both cases, you are unlikely to see what's left behind until you're too close. In the case of comets, when the Earth moves through a comet's dust trail there is no smell, but there is a higher incidence of meteors visible at night.

Neither of the comet's tails would keep the flies away. Even though the **solar wind** can blow up

### Cows and Comets continued...

to five million miles an hour, it is too weak to even ruffle the hair on a cow's head, or a fly's, for that matter. Solar wind exerted on the comet's tail makes it point away from the Sun, just like the tail of a wind vane on top of a cow barn.

Cows live in pastures making occasional trips to the barn. Comets, on the other hand, reside at the outer reaches of our solar system in a region known as the **Oort cloud**. Comets travel around the Sun in highly elliptical orbits. The time between trips around the sun is known as the **period** of the comet. For example, the famous Comet Halley has a period of about 75 years, meaning if it



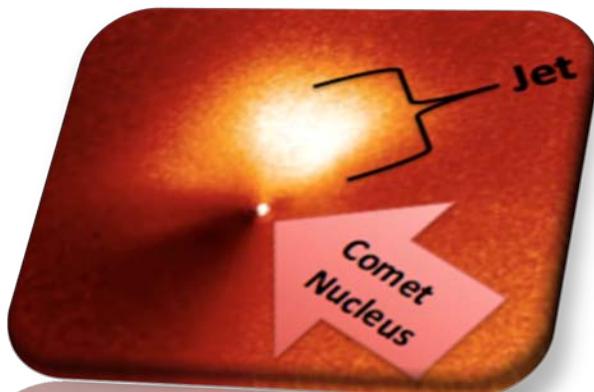
made a trip by the Sun in 1986, its next visit will be in the year 2061.

**Now** can you tell the difference between a comet and a cow?

### Powered by the Sun Gravity and Jets

Gravity is the driving force that causes a comet to travel around the Sun in a highly **elliptical orbit**. However, as the comet approaches the Sun, the heat causes compounds in the comet's nucleus to vaporize. Materials like water (**H<sub>2</sub>O**) and carbon dioxide (**CO<sub>2</sub>**) ices expand rapidly from solid to gas, exerting a force in the form of a **jet**.

The jets are like faucets spraying out into space, causing the comet to move slightly in the direction opposite of the jet. Since comets rotate, allowing the jet to point in almost any direction, predicting future location of a comet is very difficult.



Stardust New Exploration of Tempel 1

### Missing!

**Comet Shoemaker-Levy 9** was last seen near Jupiter between July 16 and July 22, 1994. The comet was behaving erratically, possibly under the influence of gravity. It was wandering from its usual path and into that of Jupiter, the largest planet in our solar system.

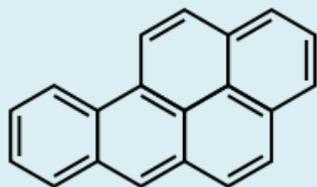
At the right is one of the last pictures taken of Comet Shoemaker-Levy 9 before its disappearance. Note that the comet was in 21 different pieces when it vanished.

Officials at NASA encourage anyone with any information about the comet to contact their local planetary scientist immediately.

<http://www2.jpl.nasa.gov/sl9/>



Have You Seen Me??



## Comets and the

## Building Blocks of Life



Are comets alive? Of course not. But recent discoveries have found **organic compounds**, or those containing carbon and hydrogen – including one compound named **lysine** that also happens to be an amino acid. And **amino acids** are the building blocks of life! So it begs the questions – Are comets alive?

For life to exist here on Earth, it requires a variety of chemical compounds assembled into the various parts of the organism. For example, your body is made of proteins built from about 22 different kinds of blocks. Each block is an amino acid, and when the amino acids are connected together in different arrangements, known as protein synthesis, the different parts of your body are created.

Other organic compounds in comets include **polycyclic aromatic hydrocarbons** or **PAHs**. On Earth, all fossil fuels (that came from... fossils), such as coal, tar and oil, contain PAHs, as do some foods we eat. PAHs can be thought of as possible seeds of life that may have arrived on a young Earth from a comet impact.

Scientists who study such things are called **astrobiologists**. At places like Yellowstone National Park, astrobiologists can study life in extreme environments such as the 100 year-old geysers located within the park to better understand what might exist in outer space.

<http://www.spitzer.caltech.edu/features/articles/20050627.shtml>

### Hot Topic-Cool Facts!



## Crystals from Comets

NASA brought home a big surprise from **Comet Wild 2: olivine crystals**. These crystals form in extremely high temperatures, odd, according to scientists, because comets are known to contain lots of ice and live most of their lives at the outer reaches of the solar system, far from the Sun.

Comets have been cold for billions of years, but their ingredients are remarkable products of both fire and ice, an odd mix of materials formed at the highest, and the lowest temperatures, existing in the early solar system.

*continued on page 5*



Image courtesy NASA/JPL

The woodcut picture above from the fourth century illustrates the fear some people had that comets held destructive power. Look closely: flames are coming from the damaged castle. Although comets are ice cold in space, an impact on Earth would certainly generate enough heat to start a fire – if such an impact occurred, there would likely be nothing left of the castle to burn! However, our solar system is a calmer place than it was at the beginning of its formation; it's extremely unlikely that a comet will come close enough to Earth to do anything more than be a brilliant vision in the night sky.

#### **Comet Crystals, continued from p. 4**

In fact, the extreme temperatures required to form the ice and rock crystals found in comets range from almost cold enough to stop time, to almost hot enough to melt iron!

If you brought a comet home for dinner, the thermostat would need to be set at 30 degrees above absolute zero (so cold that the air we breathe would be a solid!), yet some of the ingredients of the comet would have needed to spend some time in an oven with the temperature knob turned up more than seven times higher than the setting you use to bake cookies in order to form!

Being smart cookies themselves, scientists thought: How do you get olivine crystals – formed at temperatures hot enough to melt your oven – in combination with those super cold ices? Hmm.... So the model for comet formation today is that the comets – or at least some of the materials used in their construction – spent time in the hot inner regions of the solar system before taking up residence in the far outer regions.

Given how comets outgas their precious volatile ices near the toasty Sun, who can blame them for spending most their time orbiting far out where it's nice and cold (we do miss gazing at those pretty tails though...)?

<http://stardust.jpl.nasa.gov/news/news113.html>

#### **Sample Return Returns**

### **NASA finds “Stardust” in Stardust!**

#### **Jet Propulsion Lab, Pasadena, CA**

In yet another tremendous discovery from the **Stardust Mission**, SD-NExT spacecraft's first mission in which it gathered dust from comet Wild 2's coma, NASA scientists actually discovered actual stardust in the Stardust sample return sample!

Since comets formed in the “coldest and most distant region of the young solar system,” it was thought that most of the basic building materials of a comet would be interstellar dust and gas, and that these components would have changed very little since the birth of our solar system **4.6 billion years** ago. However, the stardust from Stardust appears to be only a minor component of the stuff that makes up the majority of a comet.

<http://stardust.jpl.nasa.gov/news/news110.html>

## -----Breaking News-----

# Impact Investigation to Reopen Comet Cold Case NASA forms CSI-like Dream Team to Investigate

NASA has announced it will reopen the July 4<sup>th</sup>, 2005 investigation into the collision between the **Deep Impact** projectile and **comet Tempel 1**. A new witness is due to view the scene of the crash on February 14, 2011 and report back. A major breakthrough in this case is that, for the first time in history, a robotic eyewitness [the **SD-NExT spacecraft**] will use the same instruments to measure the dust on two different comets. The Cometary & Interstellar Dust Analyzer, one of the instrument witnesses, is pictured to the right.

Comets have been identified as high priority targets because, according to NASA, "These primitive bodies may hold the secrets that unlock the mystery about the formation of Earth and our Solar System." The study of comets allows us to explore the mystery of life and the wonders of the universe.

Dr. Joe Veverka, from Cornell University, the world renowned comet investigator and the captain of SD-NExT's Dream Team, describes why the comet cold case was reopened. "When we see comets up in the sky they're really spectacular. But unless you get close to a comet, you can't really figure out what's going on."

[http://stardustnext.jpl.nasa.gov/mission/science\\_team.html](http://stardustnext.jpl.nasa.gov/mission/science_team.html)

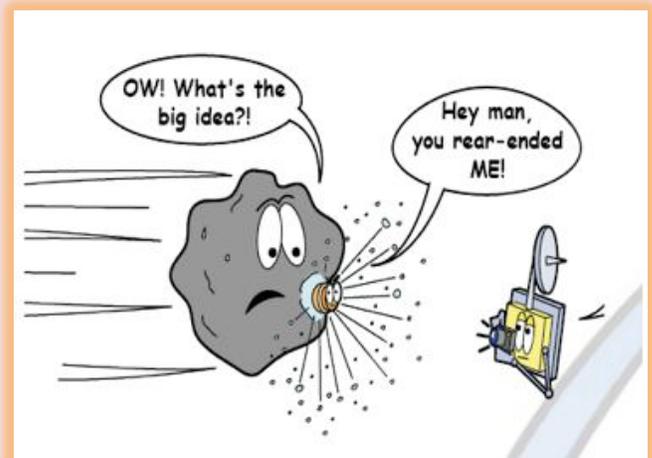


Jochen Kissel with  
The Cometary & Interstellar Dust Analyzer

## Scene of the Crime:



Comet Tempel 1 minutes after  
running over the Deep Impact impactor



Images courtesy NASA/JPL-Caltech

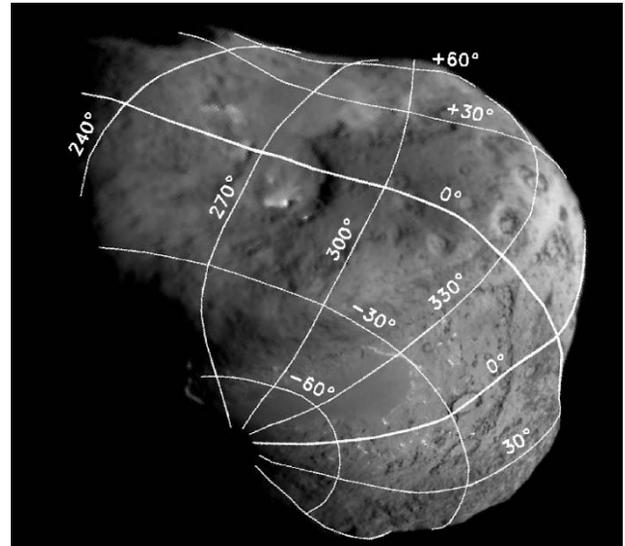
# NASA's Most Wanted

## On the trail with the SD-NExT CSI Team

You won't find yellow crime scene tape outlining the Deep Impact crater on Comet Tempel 1, so where will scientists know where to look? It will take a mess of math and problem solving to plan the upcoming encounter if NASA expects to hit the spot.

Scientists first have to predict the location and position of the crater on the spinning comet nucleus. Then, the navigation team must maneuver the spacecraft just right for the pictures to be taken. A few more challenges? The comet spins like a top and the rate changes over time. There is just enough fuel on the spacecraft, but no reserves, so the mission navigation teams have to get it just right.

Yikes!



Forensic Space Scientists create a grid to map the crime scene  
NASA/UM/Cornell/Peter Thomas and Tony Farnham

### ***Why all the interest in comets? Check it out!***

#### **Comet Rap Sheet**

##### **Comets:**

1. Provide **volatile** light elements to the planets.
2. May have played a role in forming oceans and atmospheres.
3. Are the most **organic**-rich (think carbon, the backbone of life!) bodies in the solar system.
4. May be the oldest, most primitive bodies in the solar system.
5. Are the building blocks of planetary systems around other stars.
6. Provide ready-formed molecules possibly involved in the origin of life on Earth.
7. Preserve the earliest material record from the **nebula** that formed the Sun and the planets.
8. Impacted the Earth and other planets causing major changes in climate – and possibly hastened the extinction of the dinosaurs.

## The Team

The CSI team investigating this impact contains many faces returning from both the Stardust and Deep Impact missions, as well as many new ones. Jessica Sunshine, pictured below, was co-investigator of Deep Impact, and now is



deputy director of DIXI. Scientists, engineers, spacecraft navigators and educators make up this cutting edge team designed to get to the bottom of the Deep Impact crater.



# Stardust-NExT



Inspired by

## Previous Comet Missions

According to science team members from the Deep Impact Mission, there was no shortage of surprises from their 2006 encounter. Scientists first predicted that the gasses escaping from the impact hole in the comet nucleus would differ substantially from those released naturally on the comet's surface, but, the gasses were about the same **composition**. However, different parts of the comet's nucleus released different kinds of gases-- something that wasn't expected!

Another revelation was that the grains excavated from the crater were much smaller than expected – even more surprising was that there were no large rocks at all! Comet Tempel 1, does not appear to be very dense. Further, there were huge, smooth regions that look like flows. “We have no explanation for what made them,” Dr. M. A’Hearn, Co-Investigator for the mission

reposted. Finally, there were lots of round holes resembling impact craters on the nucleus, “but the surface of a comet erodes away so fast that once again, the explanation [for what causes them] escapes us.”

On February 14<sup>th</sup> (*Valentine's Day*),  2011, the SD-NExT team will have some answers. The mission will look for changes that occurred since the comet last passed by the Sun, continue mapping and modeling the comet's nucleus begun in 2005, and study areas of the smooth flow and exposed water ice.

Rampant speculation abounds throughout the science community as the SD-NExT team prepares for another exciting encounter. However, until the data from the Tempel 1 crime scene streams back to Earth, in essence, the gun's still smoking but the jury's still out.

### Editorial

All right, *Chronicle* fans, gaze on at the beauty to the left, comet Hale-Bopp in 1997. Not just another pretty face in the night sky, is it? Spy those tails; imagine the nucleus at the forefront of the coma. You know where the Sun must be compared to the comet now, don't you?

Stay tuned for more *Comet Chronicles!*

