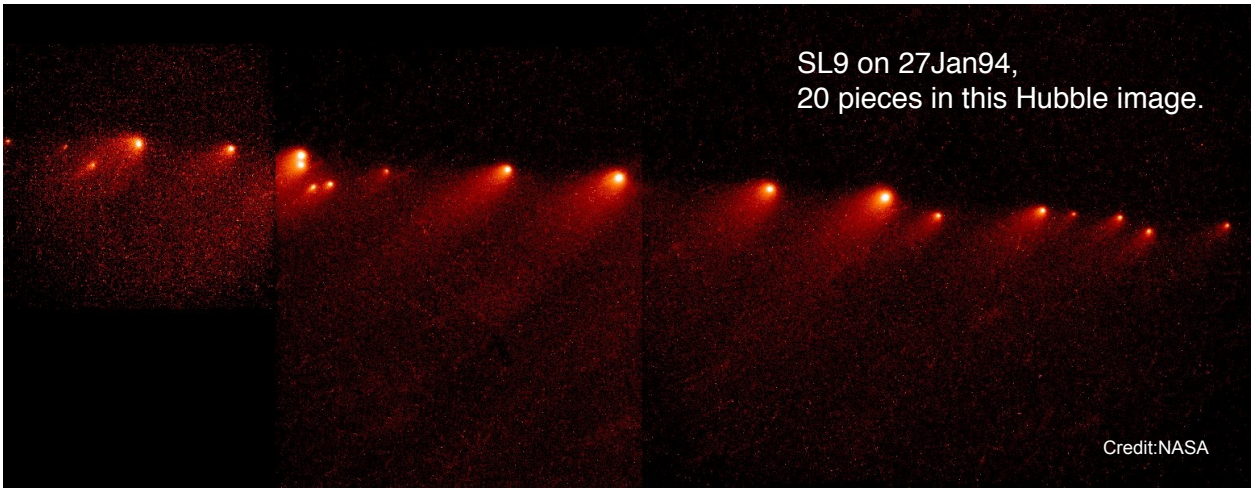
If a large extraterrestrial object - the ultimate random bolt from the blue - had not triggered the extinction of dinosaurs 65 million years ago, mammals would still be small creatures, confined to the nooks and crannies of a dinosaur's world, and incapable of evolving the larger size that brains big enough for self-consciousness require.

Stephen Jay Gould

Cosmic Collisions

HI Astronomy 111. In this module we'll cover collisions - big ones, small ones, near misses, and how often they occur.

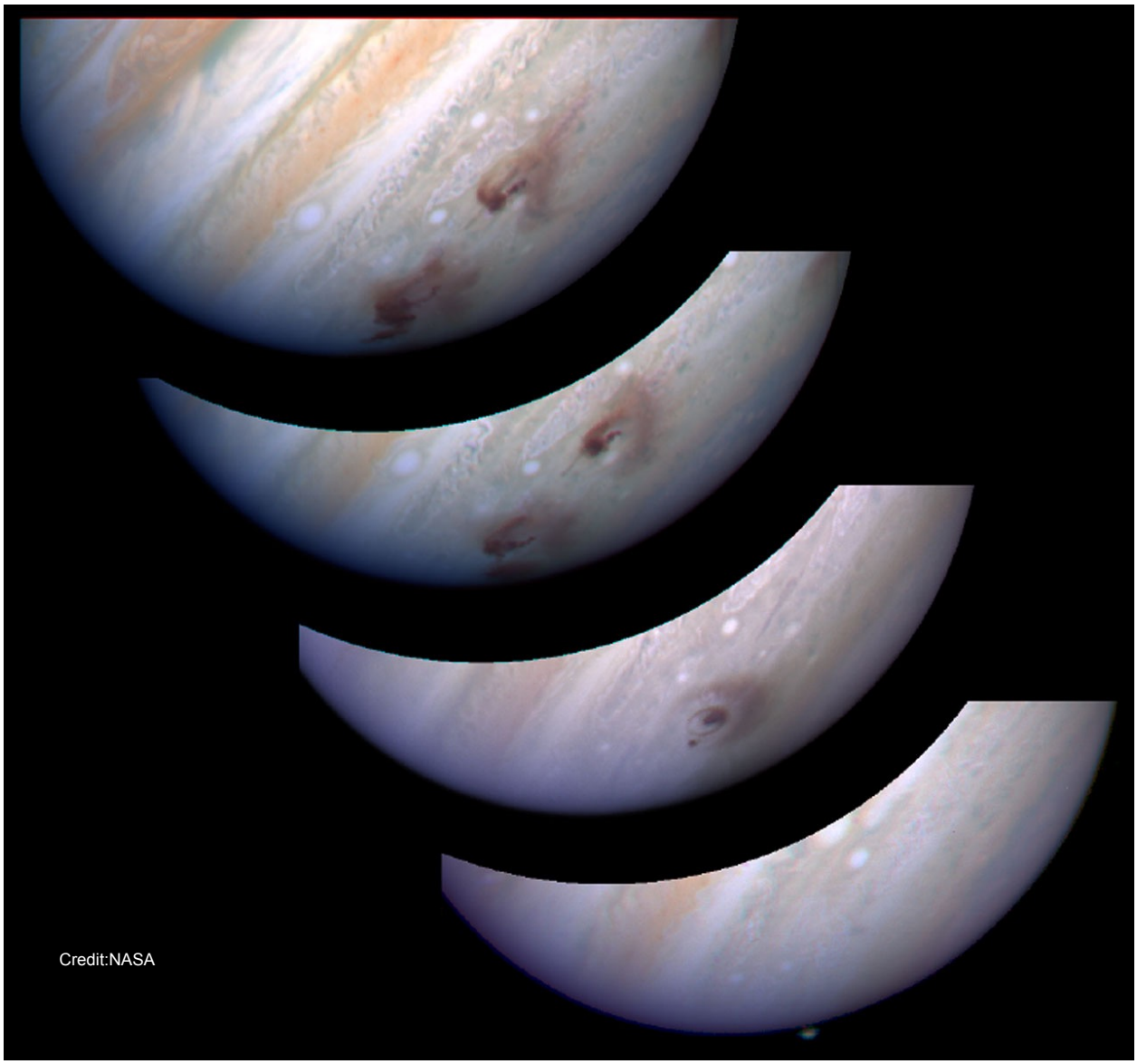


Have we ever witnessed a really major impact? We sure have. Fortunately, it wasn't on Earth. It was on Jupiter. But it was a major impact. In 1994 we watched Comet Levy-Shoemaker 9 collide with Jupiter. "SL9" is used as the abbreviation for "Levy-Shoemaker 9".

The comet originally was a single nucleus, but as it got closer to Jupiter, Jupiter's gravity broke it up into a string of 20 nuclei, each with their own coma and fledging tails. Instead of single bullet its now more like machine gun fire. The image above shows those 20 fragments.

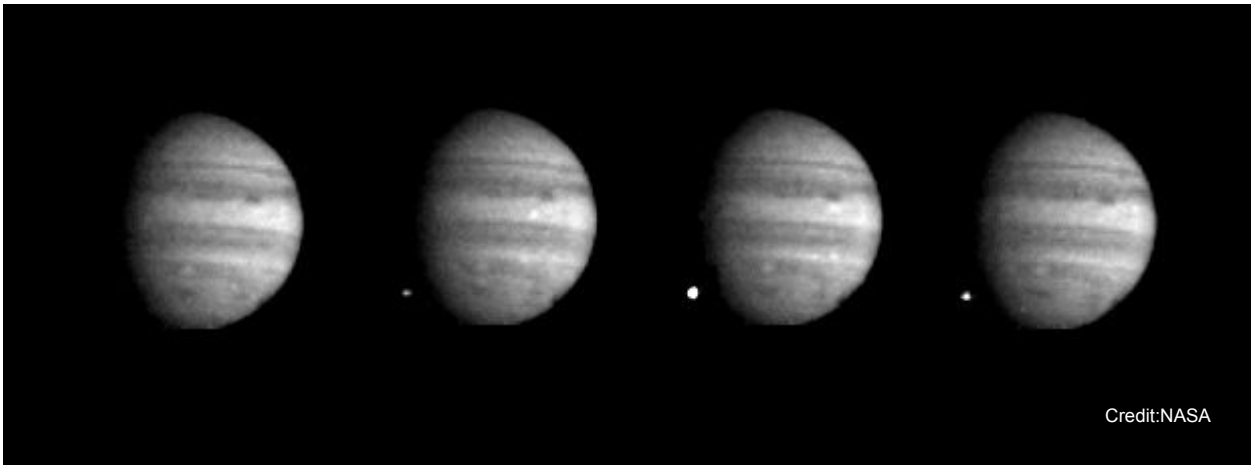
The impacts landed just on the night side of the terminator. The terminator - not the movie - is that curve separating daytime from nighttime. Since they hit on the dark side of the terminator we could not see the actual initial impact. But we could see the fireballs that erupted on the night side. We also saw the initial results in Jupiter's daytime within an hour as Jupiter rotated and the results came into our view.

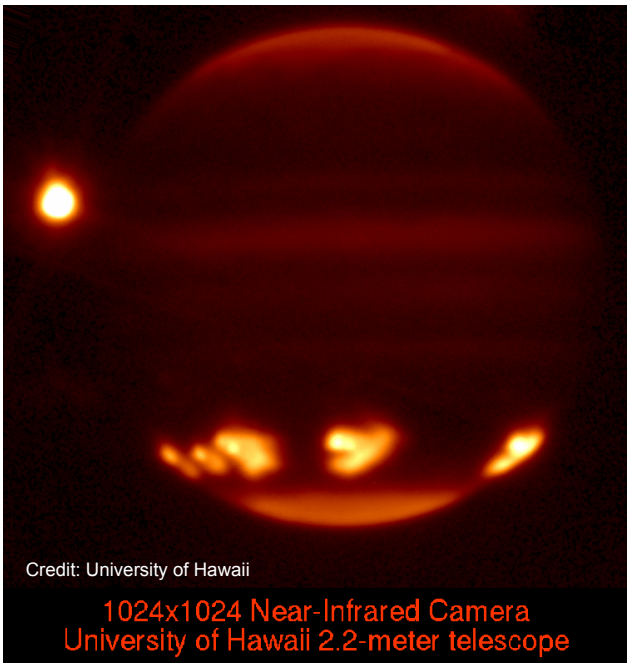
The image below shows a time sequence of Jupiter.The bottom most Jupiter is right at impact - notice the plume at the very bottom! From there every image is about 2 days apart. Notice what looks like a black eye at visible wavelengths. If this was a terrestrial planet that would be the impact crater. Of course, Jupiter is all gaseous. What you see is the results of a hole punched in Jupiter's atmosphere. Deeper lying material has been brought to the surface layers.



In 1994, every major telescope in the world was pointed toward Jupiter. That's how important it was to watch the first truly large collision in our solar system since the rise of humans. The images below are a small sampling of what those telescopes observed.

The top image shows the fireball from one of the fragments impacting Jupiter. The white region on the nightside is the impact site. At visible wavelengths the explosion grows in brightness and then based as the impact site rotates into view. The lower left image shows Jupiter at infrared wavelengths after a number of fragments had impacted, whiel the lower right image shows the situation at ultraviolet wavelengths.


Credit:NASA


Credit: University of Hawaii
1024x1024 Near-Infrared Camera
University of Hawaii 2.2-meter telescope

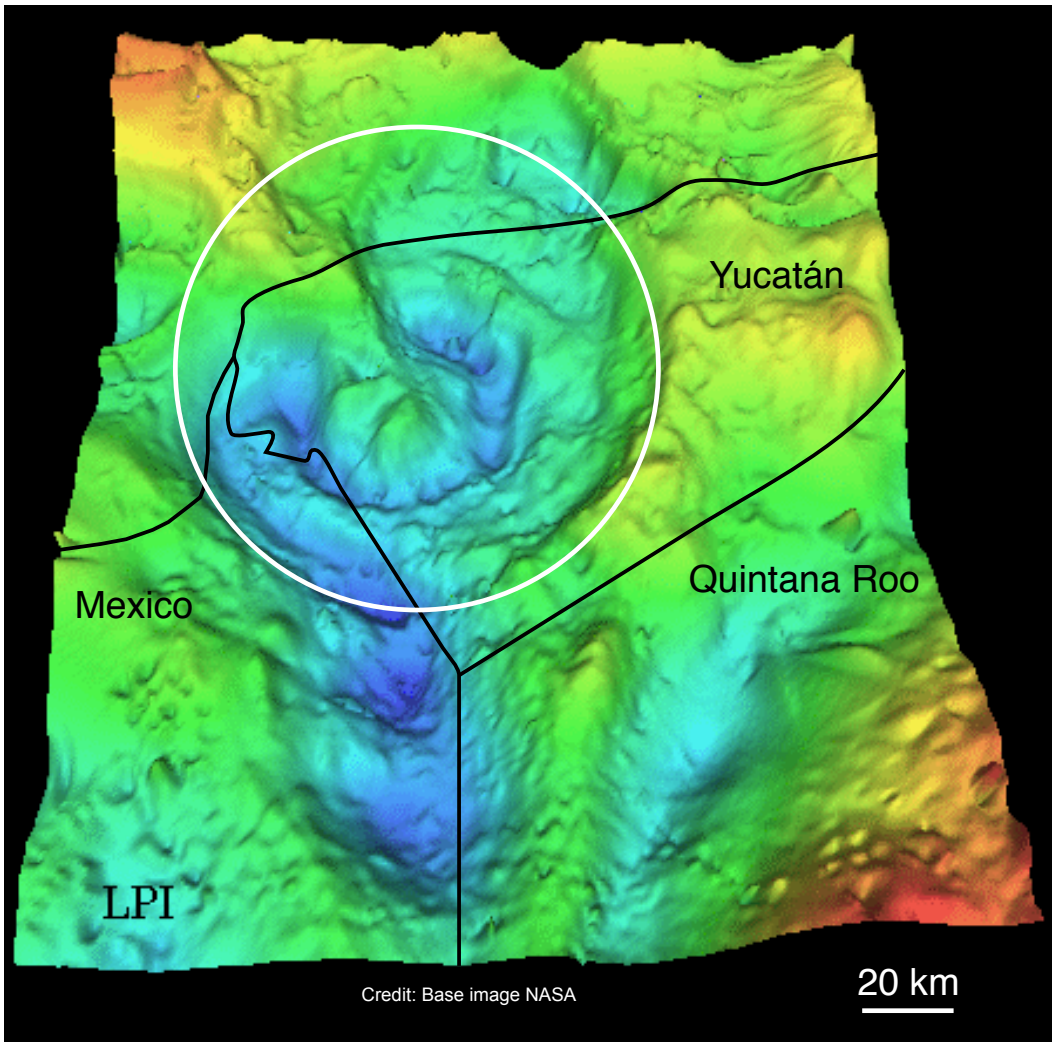

Jupiter in Ultraviolet
H
N
Q2
D/G
B
Q1
R
L
Credit:NASA

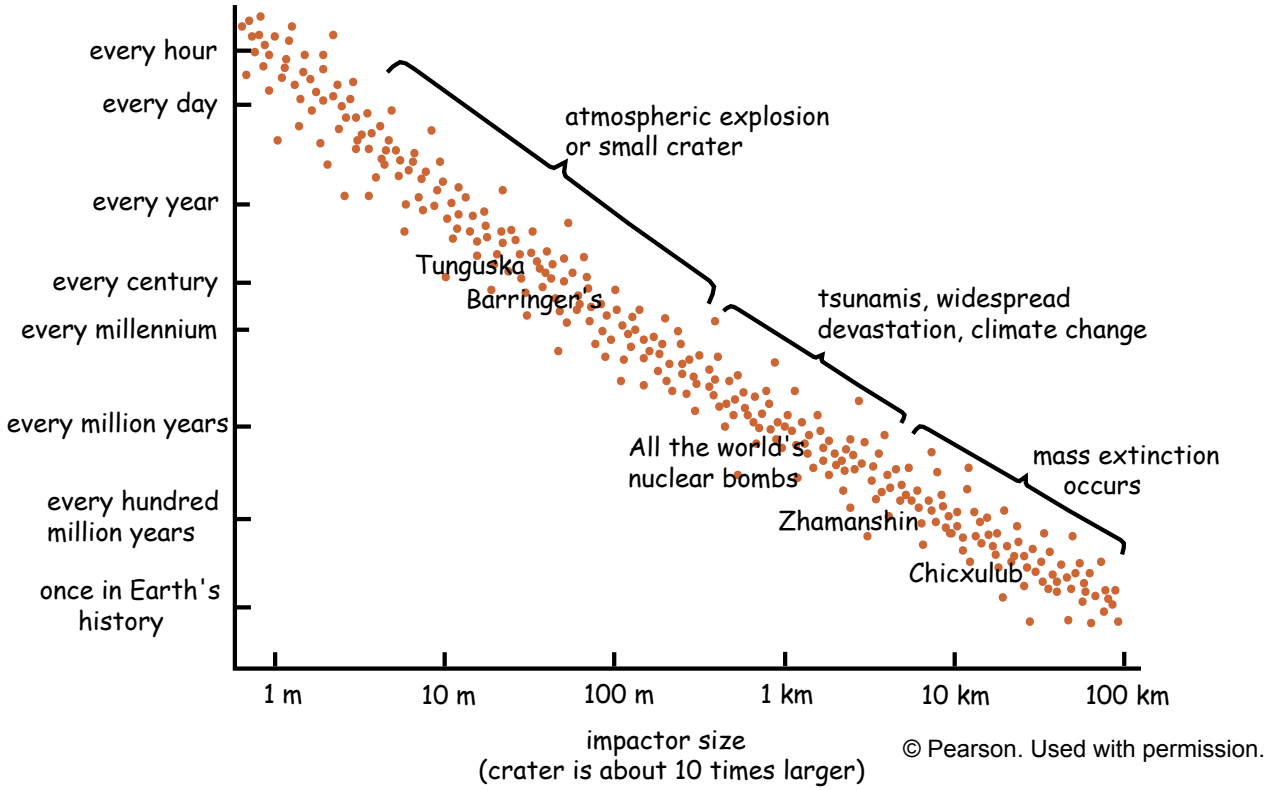
So did an impact kill the dinosaurs? A major impact clearly coincided with the mass extinction in which the dinosaurs died out, about 65 millions years ago. Some of the evidence is in the form of the element iridium - one of the rarest elements in Earth's crust because most it has sunk towards the Earth's core. Differentiation, remember from earlier in the course?

The image above shows what is called the iridium layer. The index finger is touching the actual layer - the white-ish stuff. This thin layer is found around the globe. This means the layer must have been laid down everywhere at the same time. This global layer is also rich in iridium, about 100 times greater than what you find normally in Earth's crust. Hence its name. Now, and this is a key part, iridium remains abundant in most asteroids and comets. It's like something came in and deposited a layer of material enriched in iridium 65 million years ago - precisely when the dinosaurs died out. Hmmmm. All coincidences? Unlikely.

The second piece of evidence was the discovery of an impact crater large enough and of the right age to have deposited such a layer and thus be the smoking gun for the dino-killer.
An image and map of the crater region is shown below. Its now partially submerged in the Gulf of Mexico near the Yucatan Peninsula. Radioactive dating of glass-like material, which only forms under enormous pressure, say from a shock wave, found near the crater shows the crater is about 65 million years ago. The crater is about 200 kilometers wide, which is a major impact, certainly capable of wiping out large life on Earth. Hmmmm. More coincidences? Unlikely.

Most geologists and paleontologists now agree that an asteroid did hit the Earth leading to the extinction of the dinosaurs and a majority of the world's species at the time.


Yucatán
Mexico
Quintana Roo
LPI
Credit: Base image NASA
20 km



OK, so we've seen impacts on Jupiter. We have strong evidence of an impact wiping out the dinosaurs. But how real is an impact on Earth today? Examine the plot above. It shows the how frequently an impactor of a given size smacks Earth.

Small ones of 1 meter diameter hit Earth's atmosphere every hour. Most burn up or land in the oceans. Medium ones of 50 meters diameter hit the Earth every few hundred years. A good example is Meteor Crater in Arizona which hit about 50,000 years ago; see it in-person sometime. Another recent example of a medium one is Tunguska which happened in 1908; we'll take a deeper look at that one in a moment.

Large ones of 1 kilometer happen every few million years. These cause tsunamis, widespread devastation, and climate change from all the debris that will be thrown into the atmosphere. Huge ones of 20 kilometers and up occur once every few hundred million years. these cause mass extinction events. They fundamentally alter the biological evolution of a planet. We already have an example with our dino-killer some 65 millions years ago.

So impacts do happen. It's just a question of the size and time scale on which they occur.

Let's look a bit at at the 1908 Tunguska event. The map below, in french, shows the location of the impact. The image shows an example of the devastation. It would be catastrophic if an event of this sort occurred over a city. The map shows this event occurred in the depths of Siberia where there are no cities. The shock wave from this event was recorded all across

Credit: Wikipedia, Public Domain

Europe. In fact, the shock wave traveled around the world several times and the echoes were recorded. People didn't know where it was until they triangulated the shock wave data. It wasn't until 20 years later that the first researchers found ground zero. All of the trees in the immediate area were just laid down like sticks, just wham.

There is no impact crater. This leads most to conclude it was an icy comet, not a rocky or metal asteroid, that came in. The comet gets superheated as it comes in through the atmosphere and completely explodes before touching the ground. Its an air explosion. The radius of the forest devastation and the strength of the shock wave data suggest the comet was about 10 to 20 meters in diameter.

It always amazes me what people catch on their cameras. The image above is from 1972 - mobile devices didn't exist! The image show a narrow miss if a 10 megaton object whizzing through our atmosphere above Grand Teton National park in Wyoming. If that object had hit or exploded, that would have been an event.

Today we have the technology to tracking the medium to larger Near-Earth Objects, or NEOs as they're known. We're cataloging and calculating the orbits of such NEOs to assess the danger from impactors.

Thanks! Bye Bye.