The whole of the Moon

Half a century on from the Apollo 11 mission, how well do you really know our lunar friend, its moonquakes and Moon dust?

By Marcus Chown

This year marks the 50th anniversary of the first Moon landing. When Neil Armstrong climbed down the ladder from the Apollo 11 lunar module and became the first person to step onto another world, it was arguably the most significant moment in the history of life since the first fish crawled out onto the land almost 400 million years ago. To commemorate that momentous event, here are 10 things you may not know about the Moon.

1. The Moon is falling

Why doesn't the Moon fall down? The answer, first recognised by Isaac Newton, is that it is falling down. It just never reaches the ground.

To illustrate why the Moon orbits the Earth, Newton used this analogy: imagine a cannon that fires a cannonball horizontally across the ground. Gravity causes its trajectory to curve downwards and, after perhaps 100 metres, it hits the ground. But imagine a much bigger cannon that fires a much faster cannonball. It travels further – maybe a kilometre – before its downward-curving trajectory intercepts the Earth. Now, imagine a gigantic cannon – the mother of all cannons – which fires a cannonball at 28,080 kilometres an hour. At this enormous speed, the fact that the Earth is a ball is of key importance. As fast as the cannon ball curves down towards the Earth, the Earth's surface curves away from the cannon ball. The cannon ball therefore never hits the ground. It falls forever in a circle.

This, reasoned Newton, is what the Moon is doing – perpetually falling in a circle. As Douglas Adams so perceptively observed in *Life, the Universe and Everything*: "The knack of flying is learning how to throw yourself at the ground and miss."

Proof that Newton was right comes from the International Space Station. Surprisingly, gravity at its altitude is about 90 per cent of what it is on the surface of the Earth. The astronauts are weightless not because they are beyond gravity but because they are falling. And, a person in free-fall, as Einstein recognised, feels no gravity.

2. Although the Moon is 400 times smaller than the Sun, it appears the same size in the sky

The reason is that the Moon is 400 times closer than the Sun. The coincidence, means that, when the Moon passes between the Earth and Sun, it blots out the solar disc.

But consider how lucky we are to be able to witness

The Moon seen from the International Space Station

ESA/NASA

such "total eclipses of the Sun". Although there are 200-odd known moons in the Solar System, there is not another planetary surface from which such a spectacular phenomenon can be seen. And we are lucky not only to be in the right place but also to be alive at the right time.

By bouncing laser light off reflectors left on the Moon by the Apollo astronauts and timing the round-trip, astronomers have found that the Moon is receding from the Earth at about 3.8 centimetres a year (it therefore falls in a circle from a slightly greater height each year). The Moon therefore appeared bigger in the past and will appear smaller in the future. Consequently, there were no perfect total eclipses before about 150 million years ago and there will be no more after another 150 million years. Total eclipses have been possible for barely more than 5 per cent of the age of the Earth, and, for half the reign of the dinosaurs, they did not happen.

3. Once upon a time the Moon was 10 times closer

Shortly after the Earth's birth 4.55 billion years ago, huge space rocks – the building blocks of planets – were still careering around. One such "planetisimal", a rock the size of present-day Mars, struck our planet. The magma ocean that covered the Earth was splashed off into space, forming a ring.

The evidence for this scenario came from rocks gathered by Apollo astronauts. They show that lunar material is very like the Earth's mantle, and it is drier than the driest terrestrial rocks, as if the water was once driven out by heat. All these things are compatible with a mega-collision.

The problem is that for a Mars-mass object to create the Moon and not shatter the Earth, it must have dealt the Earth a glancing blow at an unusually low speed. The "Big Splash" theory can be made to work, however, if the Mars-mass body, dubbed "Theia", shared the same orbit as the Earth. It was the planet that stalked the Earth.

The ring around the Earth created by Theia's impact was short-lived and its material quickly cooled and congealed into our satellite. At its birth, the Moon was 10 times closer to our planet than it is today. The tides it raised in the Earth's oceans sapped the Moon of orbital energy and caused it to recede over billions of years to its current location.

4. The Moon is not dead

The Moon seems stone-cold dead, its grey, crater-strewn desolation untouched by the hand of change. But, for cen-

turies, people have reported strange lights on the Moon at a rate of one every few months. On 18 June 1178, for instance, five monks at Canterbury Cathedral reported an explosion on the Moon. The mysterious lights are known as Transient Lunar Phenomena (TLPs).

These were dismissed as fantasy until, in 2002, Arlin Crotts of Columbia University in New York found that most occur at just six locations. All are places where the lunar crust has been violently fractured, either by asteroid or comet impacts within the last few hundred millions of years or by the flurry of mega-impacts which occurred 3.8 billion years ago, causing lava to well out of the Moon's interior and form the lunar "seas", or Maria.

Seismometers left on the Moon have recorded several hundred "moonquakes". And Crotts speculates that TLPs occur when they cause gas from deep in the lunar interior to vent explosively through fissures and cracks. A mere half tonne of gas escaping into the vacuum would be enough to create a cloud a few kilometres across that persists for between five and 10 minutes. TLPs have common features: they cover at least one square kilometre; they last from a minute to a few hours; and they involve a brightening, dimming or even blurring of the lunar surface.

If Crotts is right, the Moon is a more dangerous place for humans than anyone suspected.

5. There is no photograph of the first man on the Moon

NASA, by its own estimates, spent about $25 billion sending humans to the Moon, in excess of $100 billion in today's money. But, incredibly, the American space agency missed arguably the biggest photo opportunity of all time. It failed to obtain a photograph of the first man on the Moon, Neil Armstrong. The second man, "Buzz" Aldrin, did not take one of him.

This is not quite true. There is one photo of Armstrong on the Moon – with his back to the camera. Also, in Armstrong's iconic photo of Aldrin on the lunar surface, the small white figure of Armstrong can be seen reflected in Aldrin's helmet visor. And, of course, there are the fuzzy black-and-white TV images beamed back to Earth. But that is it. The first human to stand on another world was essentially un-photographed.

Aldrin was not actually to blame. For most of the two hours and 31 minutes he and Armstrong were on the lunar surface, Armstrong had the camera. The astronauts carried the camera mounted on their chest. It had no viewfinder and they had to guess what was visible through the lens.

Before the Apollo 11 mission, Armstrong and Aldrin had each been given a camera to practice with at home. However, the Moon poses unique challenges. Whereas on Earth sunlight is scattered by air molecules, softening its harshness, and spreading it even into the shadows so they are not completely black, the Moon is airless. A photographer must contend with dazzling brightness alternating with utter blackness. Not an easy task.

6. Moon dust smells of gunpowder

In Arthur C. Clarke's *A Fall of Moondust*, the dust cruiser, "Selene", sinks with all its passengers in a sea of lunar dust. In 1961, when the novel was published, there was a real fear that the Moon was covered in a deep layer of dust into which any spacecraft would sink without a trace. Although such fears proved unfounded, the Moon is covered with a thin layer of fine dust.

NASA missed the biggest photo opportunity of all time

Moon dust coated the spacesuits of the Apollo astronauts. It got into every nook and cranny in their spacecraft and smelt of gunpowder. Today, knowing that tiny "nanoparticles" can lodge in the lungs, causing breathing problems, there is a fear that moon dust could be toxic.

Moon dust is created when sand-grain-sized "micrometeorites" slam into the lunar surface, shattering and heating the rock. The resulting dust particles are like tiny melted snowflakes, quite different from smooth terrestrial sand grains. Being so jagged, they snag on clothing. Their shape causes them to reflect sunlight differently depending on their orientation, explaining the astronauts' observation that the lunar surface, far from being grey, shimmers with beautiful colours, from brown to gold to silver.

The continual bombardment by micro-meteorites turns over the lunar "soil" about every 10 million years. So, although the footprints left by astronauts will last a long time compared with on Earth, they will not last for ever.

Sadly, the only geologist to go to the Moon – Harrison Schmitt on the final mission, Apollo 17 – was allergic to moon dust. He must have sneezed all the way home.

7. One man is buried on the Moon

A hundred billion people are buried on the Earth but only one person is buried on the Moon. His name is Gene Shoemaker. He was the American geologist who found shocked quartz crystals at the 1.2-kilometre diameter Barringer Crater in Arizona. Since these would have been created by a violent impact, he proved that the crater was not volcanic

in origin, as many thought, but had instead been formed by the impact of a chunk of space rock 30 to 50 metres across about 50,000 years ago.

In the 1960s, Shoemaker was involved with the training of the Apollo astronauts. He campaigned to send a scientist to the Moon and finally got his way when Schmitt was included on Apollo 17.

Shoemaker spent much of his later years searching for impact craters around the world, and discovered several. In 1997, during one expedition in Australia, his car was involved in a head-on collision on a remote road a few hundred kilometres north-west of Alice Springs. Two years later, some of his ashes were carried to the Moon and deposited by the "Lunar Prospector" space probe.

8. The best place to look for the first lifeforms on Earth is on the Moon

About 800 million years ago, an asteroid the size of Key West hit the Moon. It created the striking 93-kilometre Copernicus crater, and splattered debris far and wide. The Earth has come under similar bombardment – in fact, our planet is a bigger target. But, whereas the signs have been erased on Earth by the continual reworking of the crust, this has not happened on the lunar surface. The Moon's face is a history book that tells us about the remote past of the Earth.

If the Earth tips over, the Moon pulls it upright again

The biggest impacts on the Moon and the Earth – far bigger than Copernicus – occurred 3.8 billion years ago. During this "Late Heavy Bombardment", Jupiter and Saturn worked in concert to stir up the asteroid or comet belts and send our way bodies the size of Los Angeles. So big were the impacts that they punctured the lunar crust, causing lava to well up and flood the giant Mare basins, believed at one time to be lunar seas.

Inevitably, some of the impacts on Earth ejected debris, which hit the Moon. So, just as on Earth we find meteorites from the Moon and Mars, on the Moon we should discover meteorites from the Earth. This raises the intriguing possibility of finding, preserved inside lunar rocks, biological material and even fossil microorganisms from the dawn of life on Earth – evidence long ago erased by terrestrial geological activity. Paradoxically, we may have to go to the Moon to find out about our ultimate origins.

9. Without the Moon we would not be here

The Moon is a quarter of the diameter of the Earth, effectively making the pair of bodies a double planet. In fact, the Earth has the biggest satellite relative to its size of any planet in the Solar System. And its unusually big Moon appears to have been hugely important for life on Earth.

Planets spin on their axes and, like spinning tops, have a tendency to wobble and tip over. But the strong gravity of the Earth's giant Moon stabilises the planet's spin. If the Earth tips over, the Moon pulls it upright again. Since such wobbles vary the amount of sunlight reaching the ground, the Moon keeps the Earth's climate relatively stable. By contrast, Mars, which has no big moon, suffers catastrophic fluctuations in its climate. Life on Earth could never have evolved without a stable climate over billions of years.

Our big Moon also played a role in the transition of life from the oceans to the land since the large tides it pulls, twice a day leave large tracts of the ocean margins high and dry. Long ago, stranded fish evolved lungs. Ultimately, this drove the colonisation of the land.

All this has implications for the chances of us finding life elsewhere in our galaxy. If it is necessary for a planet to have a big moon like the Earth – and our Solar System shows how rare such satellites are – then E.T.s are going to be even rarer than we expected.

10. If we didn't have the Moon, science might have arisen 1,000 years earlier

Our Moon has not only been important for life on Earth, it has driven science as well. Total solar eclipses, by blotting out the Sun, make stars visible close to the solar disk. A century ago, on 29 May 1919, this permitted the observation of the bending of starlight by the gravity of the Sun, a key prediction of Albert Einstein's theory of gravity.

Such "gravitational lensing" made a superstar of Einstein. And it was not simply because he had shown Newton's theory of gravity to be wrong but because the world badly needed good news. And, mere months after a catastrophic war in which 10 million had perished, the prediction of a German scientist had been confirmed by Arthur Eddington, an English scientist.

But our Moon may have had an even bigger effect on science – by delaying it. In his 1972 essay "The Tragedy of the Moon", Isaac Asimov speculated on what might have happened if the planet Venus had a giant Moon instead of the Earth. The argument of the American science fiction writer was that, if people had looked up at Venus in the night sky and seen it orbited by a visible moon, the "geocentric" idea of the Earth as the centre of creation would never have been viable. The Church could not have been able to silence those who thought otherwise and science would have arisen 1,000 years earlier. ●