**Conflicting theories for the origin of the Moon**

**Levels:** 5-6 **NoS achievement aims:** Understanding about science   
**Topic:** Space **Contextual strands:** Planet Earth and beyond

**Rationale**

There are different views on the origin of the Moon. Investigation results can be interpreted in different ways which are sometimes conflicting. Critical thinking and matching evidence with theories are skills that are highly valued in science.

**What you need**

Copies of the information on four theories of the Moon’s formation, and 14 pieces of evidence that support or refute those theories. (pages 2 -4 here

**Focus**

* Why do scientists think that the solar system has not always been as it is today?
* What are the past and current views of how the solar system was formed?
* Why is it unusual that Earth is the only terrestrial planet that has a Moon?
* What sort of information could help scientists explain when and how the Moon was formed?
* What technologies do scientists use to make careful observations about space objects such as the Moon?
* Why do you think scientists might continue to debate different theories about how the Moon formed?

**Exploration**

1. As a class, discuss each theory of the Moon’s formation.
2. In groups, assign a theory to each group.
3. Get each group to choose the pieces of evidence that support or refute that theory. (This may require further research.)
4. Have each group present their findings to the class, giving reasons for their decisions about whether each piece of evidence (or combinations of evidence):
   * supports their theory
   * refutes their theory
   * has an uncertain/irrelevant relationship to the theory.
5. After all groups have presented their findings, discuss with the class the pieces of evidence that seem to support two or more theories.
6. Get the students to decide which is most likely to be the leading theory for the formation of Earth’s Moon and why.

**Reflection**

* Why can’t scientists tell how the Moon formed just by making careful observations?
* Why have scientists changed their minds in recent years about the most likely theory of the origin of the Moon?
* How did you go about sorting out, and making sense of, this massive amount of often conflicting or ambiguous evidence?
* Why is it important to consider alternative theories when analysing a new piece of evidence?
* Which theory of the origin of the Moon is currently the one that the majority of scientists favour? Why?

### Four theories for the origin of the Moon and fourteen pieces of evidence

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| **Four theories for the origin of the Moon:** | **This theory proposes that …** |
| A. **Fission from Earth** | The Moon was spun off from Earth when Earth was young and rotating rapidly on its axis. |
| B. **Formation at the same time as Earth** | The Earth and Moon and all other bodies of the solar system condensed independently out of the huge cloud of cold gases and solid particles that constituted the primordial solar nebula. Much of this material finally collected at the centre to form the Sun. |
| C. **Formation far from Earth (the ‘Capture’ theory)** | The Moon formed at a different place in the solar system and when the orbits of Earth and the Moon carried them near each other, the Moon was pulled into permanent orbit about Earth. |
| D. **Giant impact** | The Earth was struck by a body about the size of Mars, very early in its history. The catastrophic impact blasted portions of Earth and the colliding body into Earth’s orbit, where debris from the impact eventually coalesced to form the Moon. |

**Fourteen pieces of evidence**

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|  | **Evidence** | **Scientists’ thoughts about this evidence** |
| 1 | The density of the Moon is the same as that of the rocks just below the crust – that is the rocks of the upper mantle of Earth. | *Similar rock densities indicate similar origins.* |
| 2 | About one third of the bulk of Earth is made up of the iron core at its centre but only 2–4% of the mass of the Moon comes from an iron core. | *a) Earth’s iron could have already drained into the core by the time the giant impact happened.*  *b) Iron from the colliding object could have ended up in the core of the Earth.* |
| 3 | Rocks recovered from the Moon during the Apollo space programme have less of the types of elements that boil off at high temperatures than the rocks of Earth. For example, Moon rocks contain no water but volcanic rocks on our planet do have water in them. | *The lack of volatile elements in moon rocks indicates that it was heated to a high temperature by, for example, an impact OR differences in rock composition could indicate that the Moon originated elsewhere.* |
| 4 | Moon rocks show signs of all having been melted at some time in the ancient past, but this is not typical of Earth’s rocks. | *The Moon was formed very hot, possibly entirely molten.* |
| 5 | Techniques used by scientists to tell the age of ancient rocks reveal that Earth and its Moon are roughly the same age, 4.5 billion years old. | *This is evidence of similar origins OR of Moon formation when the Earth was very young.* |
| 6 | The Moon does not have an overall magnetic field like Earth, but some of its surface rocks show signs that there may have been a magnetic field early in the Moon's history | *a) The Moon had a common origin with Earth, which gained extra iron from the impacting object.*  *b) Scientists do not yet understand the significance of the Moon’s loss of a magnetic field.* |
| 7 | The non-radioactive, stable rocks of Earth and its Moon have a very different composition of isotopes (different chemical forms) of oxygen from those of all meteorites ever analysed. | *Earth and Moon formed at the same distance from the Sun; possibly they grew up together.* |
| 8 | Earth has a tilt and is not oriented on exactly the same ecliptic plane as most other planets in the Solar system. (Think of this plane as an invisible ‘plate’ on which nearly all planets lie as they orbit the Sun). However, Earth does orbit in the same direction as the other planets and, like them, has a nearly circular orbit. | *Impact with an object the size (mass) of Mars would significantly and permanently alter Earth’s orbit.* |
| 9 | Calculations suggest Earth has never spun fast enough to throw off a moon-like body. | *Earth’s rotational speed (angular momentum) would have to be four times faster than it is now – which models show to be very unlikely.* |
| 10 | Comets are space bodies that are captured when they wander too close to a star like our Sun and get caught in its gravitational field. They have highly elliptical orbits. | *The chance of the Moon being captured by Earth in a similar way would require a highly unlikely combination of circumstances – even if a Moon-like object came near Earth, it would be more likely to pass by, or collide with it, than get captured; a successful capture would have resulted in an elongated comet-like orbit.* |
| 11 | The average thickness of Moon’s rocky crust is 70 kilometres, compared to Earth’s average of 20–60 kilometre thickness of crust over the continents and 8–10 km over the Ocean basins. | *The Moon’s greater crustal area (for its size) could indicate the addition of crustal rocks thrown out from Earth as the result of an impact.* |
| 12 | The Moon’s crust is thinner on the side nearest Earth. | *The Moon was close to Earth when its mantle cooled. (Earth’s gravitational field pulled slightly more mantle Earth-wards before it ‘set’, so the crust is thinner on that side.)* |
| 13 | Impact craters show the Moon has been bombarded with many colliding objects. Because there is no free water on the Moon, these craters do not erode away as they would on Earth. | *Evidence of large impacts indicates that gigantic projectiles were around in the distant past. If one hit the Earth, enough material could have been lifted into orbit to form the Moon.* |
| 14 | Pictures taken during comet *Shoemaker-Levy*’s 1994 collision with Jupiter showed huge effects that spread far into space beyond the planet. Compared with Jupiter's huge size, the comet was relatively small and it broke up into a number of fragments that all collided separately. | *The pictures show what can happen when a space object collides with a planet; scientists who had predicted that the effects would be catastrophic were correct.* |