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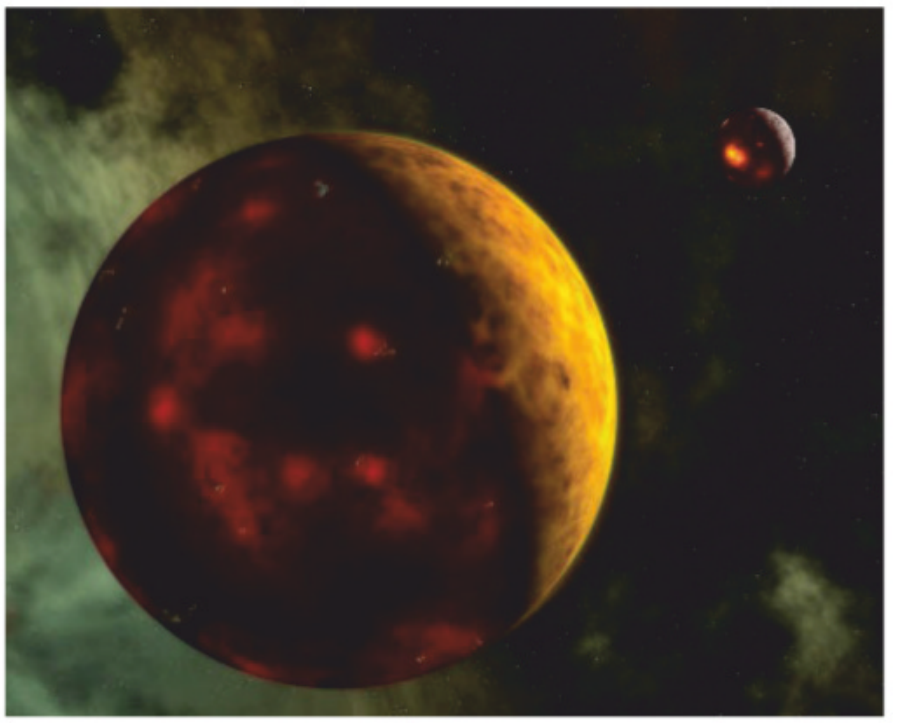
Solar system

Earth dodged snowball fate thanks to the moon

Jonathan O'Callaghan

THE sun is thought to have once been far fainter than it is today, which should have left Earth frozen as a global snowball. That it wasn't, a discrepancy known as the faint young sun paradox, has plagued astronomers, but now we might have an answer: the moon kept Earth warm.

Earth and the moon formed about 4.4 billion years ago. Models suggest the sun was up to 70 per cent dimmer until about 3.5 billion years ago. "Earth should have been frozen for at least a billion or even 2 billion years," says René Heller at the Max Planck Institute for Solar System Research in Göttingen, Germany.



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The moon formed when a large object struck Earth

Geological evidence, as well as the evolution of life, shows this didn't happen. We know Earth had water back then thanks to a mineral called zircon, some crystals of which have survived for 4.3 billion years and retain evidence of water from that time.

When the moon and Earth formed, our satellite was as little as 20,000 kilometres away, compared with an average of 380,000 km now. Earth was also rotating much faster, as quickly as once every 3 hours.

Heller and his colleagues have calculated that these two factors mean the gravitational interaction between the two bodies would have been much stronger – enough to produce tidal heating from the gravitational squeeze. This would have slightly warmed Earth and could have triggered the eruption of volcanoes, giving our planet a thicker atmosphere that could trap more heat (arxiv.org/abs/2007.03423).

"The classic example in our solar system is [Jupiter's moon] Io, which is spectacularly volcanic because of the tidal heating from Jupiter," says Rory Barnes at the University of Washington. "The moon could have turned early Earth into something like Io for tens of millions of years."

Finding out how Earth was able to hold liquid water back then could be crucial in our search for life on other worlds, says Ludmila Carone at the Max Planck Institute for Astronomy in Heidelberg, Germany. "We are not entirely sure why Earth was habitable," she says. "We have the possibility to go back in time and think about the early Earth as a kind of exoplanet."

4.4bn
The age in years of Earth and the moon

Other solutions for the faint young sun paradox include Earth having a thicker carbon dioxide atmosphere at the time, as a result of the planet being molten following the giant impact that formed the moon, trapping more heat. Another is that the planet's orbit brought it closer to the sun at times, warming it up, or that the sun had more mass at the time and was brighter than we think.

All these ideas have many unknowns, says Barnes, but while tidal heating is a good fit, it isn't perfect. The amount of energy produced directly by the moon's gravity would have been small, requiring it to cause other processes like volcanic eruptions, which we don't have any direct evidence for.

"The amount of tidal heating required to have a climatological effect is very great," says Kevin Zahnle at the NASA Ames Research Center in Mountain View, California. The moon moved away from Earth quickly, limiting the duration of the tidal heating to just 10 to 20 million years, he says – not enough to warm Earth sufficiently. Further modelling of the early Earth could help better understand the different factors at play, says Heller. ▮

Fertility

Sperm with lazy tail can swim faster

Jason Arunn Murugesu

A HUMAN sperm can move up to 70 per cent faster if it has a lazy tail, a finding that could pave the way for new fertility diagnostic tests.

Sperm cells use their tails to swim, though some don't use the whole tail, leaving a piece at the end inactive. This part only comprises about 3 to 5 per cent of a normal sperm tail, which is usually between 50 and 55 micrometres long, and doesn't actively bend like the rest of the tail. But it may be key to gaining speed.

The tail makes a shape a bit like a sine wave to propel the sperm, says Meurig Gallagher at the University of Birmingham in the UK. "The tail moves left and right, but when you get to the end, that part is also trying to move this way in the fluid," he says. "We found that when the end piece instead relaxes with the tail, it generates a shape that allows the tail to swim more efficiently."

Gallagher and his colleagues, led by Cara Neal at the University of Birmingham, devised mathematical models for how sperm swim. Unlike previous models, the team included the end section of a sperm's tail that had been historically overlooked. "Nobody has looked at the end piece because it's effectively at the limit of light microscopy," says Neal.

The researchers modelled sperm swimming in a range of environments, including in semen and in the female reproductive tract, including in cervical mucus. They found that sperm with an inactive end piece swam more efficiently and faster than sperm with tails that were completely active.

Depending on the environment, a less active tail was found to propel sperm 20 to 70 per cent faster and was between 1.5 and 4.5 times more energy efficient when swimming (*Physical Review Liquids*, doi.org/d3h3). ▮