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Without the Moon, Would There Be Life on Earth?

By driving the tides, our lunar companion may have jump-started biology--or at least accelerated its progression

By Bruce Dorminey on April 21, 2009

The ocean tides mirror life itself. Their ebb and flow pay homage to the cyclic nature of the cosmos along even the most secluded seashores. But is life itself also ultimately a fluke of the tides?

If so, life may ultimately owe its origins to our serendipitously large moon. The sun and wind also drive the ocean's oscillations, but it is the moon's gravitational tug that is responsible for the lion's share of this predictable tidal flux.

Our current Earth–moon system, according to the prevailing theory of lunar formation, reflects our solar system's early game of planetary billiards, when colliding planetary embryos created entirely new versions of themselves—in the case of our own planet, a disproportionately large natural satellite in close orbit.

It all started some 4.5 billion years ago when, as theory has it, our nascent Earth was blindsided by a Mars-size planetary embryo, believed to have spun Earth into its initial fast rotation of roughly 12 hours per day. The molten mantle thrown into orbit after the catastrophic lunar-forming impact quickly coalesced into our moon. Within a few thousand years, Earth cooled to an object with a molten surface and a steam atmosphere. Life emerged some 700 million years later, or about 3.8 billion years ago.

But four billion years ago a cooling Earth already had an ocean, but remained barren. The moon was perhaps half as distant as it is now, and as a result, the ocean tides

At an average distance of 235,000 miles (380,000 kilometers), the moon is currently receding from Earth at a rate of 1.5 inches (3.8 centimeters) per year. As it does, Earth's own spin rate is slowing. And, in the process, roughly 10^{20} joules of gravitational energy is shed into the oceans annually.*

Over the eons, all that energy has had an evolutionary impact.

"The oceans' tidal flow helps transport heat from the equator to the poles," says Bruce Bills, a geodynamicist at the NASA Jet Propulsion Laboratory in Pasadena, Calif. "Without the lunar tides, it's conceivable that climate oscillations from the ice age to the interglacial would be less extreme than they are. Such glaciations caused migrations of animal and plant species that probably helped speed up speciation."

Bills also points out that such tidal heat transfer could have also mitigated climate fluctuations. The problem in determining which "tidal forcing" scenario is correct, he says, is that climate researchers currently lack data spanning extremely long timescales. Even so, Peter Raimondi, an ecologist at the University of California, Santa Cruz, says the tools of evolution are also driven by the tides' influence on these intertidal regions.

"In a rocky intertidal area," Raimondi says, "it's very clear there are strong evolutionary pressures brought on by a changing environment over a short spatial scale. Without our moon, our marine environment would be much less rich in terms of species diversity."

But is the influence of the lunar tides actually responsible for life itself?

If life originated around deep ocean hydrothermal vents (so-called black smokers), then the lunar tides played a minor role, if any, says James Cowen, a biogeochemical oceanographer at the University of Hawaii at Manoa. If, however, life originated in tidal waters, he says, then tidal cycles could have played a major role.

*CORRECTION (4/23/09): An earlier version stated that three terawatts (3 TW) are

Both DNA and RNA—the messengers of life as we know it—almost certainly were selected and evolved from a large diverse group of protonucleic acid molecules. But for DNA and RNA to evolve from this group of protonucleic acid structures, first they had to be able to replicate. That involved organizing their copying via cyclic assembly and dissociation.

"A lot of origin-of-life reactions involve getting rid of water," says Kevin Zahnle, a planetary scientist at the NASA Ames Research Center at Moffett Field, Calif. "So you look for means to concentrate your solutions. One way to do that is to throw water up on a hot rock, then have the waters recede and evaporate."

Molecular biologist Richard Lathe of Pieta Research, a biotech consultancy in Edinburgh, Scotland, contends that some 3.9 billion years ago, fast tidal cycling caused by the influence of our moon enabled the formation of precursor nucleic acids.

Lathe says that a 12-hour Earth day would have produced high tides "a little faster than every six hours."

He believes these lunar tides would have moved many miles inland, beyond the crashing waves driven by the sun or surface winds, and onto a vast, flat sandscape. Today, this sort of ocean cycling pervades the sandy flats surrounding France's famed tidal island of Mont-Saint-Michel, abutting the English Channel.

In the early Earth environment, Lathe notes that such fast lunar tidal oscillations would result in the highly saline low-tide environment that protonucleic acid fragments would have needed to associate and assemble complementary molecular strands.

Having bonded in pairs at low tide, these newly formed molecular strands would then dissociate at high tide, when salt concentrations were reduced, providing what Lathe terms a self-replicating system. Lathe believes that DNA would ultimately have arisen from such protonucleic acids.

ocean-bearing terrestrial planets without benefit of a significant nearby lunar neighbor? Would their prospects for life be diminished due to lack of tides?

"Odds of nucleic acids forming on Earth without the lunar tides would be much lower," Lathe says. By this accounting, he says that Mars, with its two puny moons, Deimos and Phobos, could not have formed life.

Within our own solar system, the moons of Jupiter have turned the idea of tidal influence on its head. On Jupiter's icy moon Europa, tidal heating, caused by the flexing of the satellite under the gravitational pull of the giant planet, is believed to maintain a large liquid water ocean below its frozen surface.

"Europa must have big tides, so it's my favorite for microbial life," says Max Bernstein, an astrochemist and program scientist at NASA Headquarters in Washington, D.C. "Europa is considered by many as the best place to find life in the solar system."

But even with strong tides, any evolutionary ambitions of microbes on Europa would soon be stymied by their harsh habitat. That is one reason why so much time and energy still goes into unraveling the mystery of life's origins on our own planet.

Our disproportionately large nearby moon certainly gave Earth an early tidal nudge. But unlike Venus and Mars, our moon's gravitational influence also helped ensure that Earth's spin axis and climate remained stable over long timescales. That's arguably just as important as our oceans' tidal ebb and flow.

Still, as Bruce Lieberman, a paleobiologist at the University of Kansas in Lawrence, points out: "I suspect that eventually life would have made land without the tides. But the lineages that ultimately gave rise to humans were at first intertidal."

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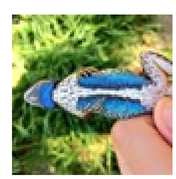

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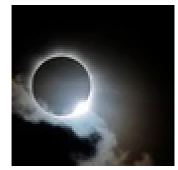

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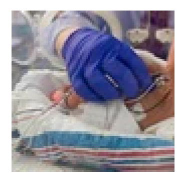

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