Terrestrial Life May Have Been Exported Out of the Solar System On Earth-Grazing Bodies

By Abraham Loeb on October 17, 2019

The launch of the space dog, Laika, onboard *Sputnik 2* on the 3rd of November 1957 was a historic milestone, the first demonstration that humans are capable of shipping life into space. But as often the case, human hubris should be moderated by a broader perspective. Mother Nature accomplished the same task many times over, when terrestrial rocks were launched into space as a result of asteroid impacts on Earth, with some rocks carrying living organisms - as tiny astronauts - in their bellies. And other planets reciprocated. Two decades ago, we learned that a particular Martian rock recovered on Earth, ALH84001, was never heated above 40 degrees Celsius (104 degrees Fahrenheit) after being ejected from the surface of Mars, raising the possibility that we are all Martians if life was transferred to Earth from early Mars. Given the existence of this package-delivery system for biological organisms, it is natural to wonder whether a terrestrial package might have been sent out of the Solar system by Nature long before *Voyager 1 and 2* were launched?

Most asteroid impacts are not capable of ejecting terrestrial rocks that move fast enough to leave the Solar system. But many Solar system bodies spend most of their time in the Oort cloud, at distances up to 100,000 larger than the Earth-Sun separation, where they are loosely bound to the Sun. Some of these appear episodically as long period comets with eccentric orbits that bring them close to the Sun, where they can get kicked gravitationally by planets all the way out of the Solar system - like a ball running through a Pinball machine. For those rare ones that are ejected by the Earth, the Earth-Sun system acts as a gravitational slingshot.

In order for them to get kicked fast enough to leave the Solar system, the objects need to graze the Earth. But if they come close enough so that they pass through the Earth's atmosphere at an altitude of 50-100 kilometers above the ground, they could scoop up life from the atmosphere like a spoon passing through the foam topping a cup of coffee. Whereas the abundance of microbes in the uppermost atmosphere is poorly constrained, it is well known that microorganism colonies exist at high elevations as they were collected on sounding rockets at altitudes of 48-77 kilometers.

In a new paper with my undergraduate student, Amir Siraj, we calculated that over the lifetime of the Earth, there could have been tens of life-exportation events of the type described above. A similar number of events are expected to be associated with boulders that originated outside the Solar system before they crossed the Earth's atmosphere. This number of events could increase by orders of magnitude if life existed above an altitude of 100 kilometers during the Earth's history as a result of enhanced atmospheric turbulence or volcanic activity. Of course, these bodies cannot pass too close to the ground and yet escape, as the friction on air would slow them down and burn them up.

It is well known that fighter pilots can barely survive maneuvers with accelerations exceeding 10$\boldsymbol{g}$, where $\boldsymbol{g}$ is the gravitational acceleration that binds us to Earth. The above-mentioned Earth-grazing objects scoop microbes at accelerations of millions of $\boldsymbol{g}$. Can the organisms survive the jolt? Possibly. Microbes such as *Bacillus subtilis, Caenorhabditis elegans, Deinococcus radiodurans, E. coli and P. denitrificans,* were shown to survive accelerations that are just a few times smaller. As it turns out, these mini-astronauts are far better suited for joining a space ride than our very best human pilots.

Even though the future of our space program lies with electronics that can be hardened by design to withstand the harsh bombardment by cosmic-rays and interstellar particles, it is humbling to realize that Nature already accomplished without planning a version of our most ambitious technological goals long before we conceived of them. While we are in the process of launching state-of-the-art spacecrafts like *New Horizons* out of the Solar system, we are also finding evidence for natural interstellar traffic. Cosmic history is mind boggling. The newly discovered interstellar comet, 2I/Borisov, entered the last leg of its trip towards the Solar system by passing the nearest star to the Sun when the first humans left Africa.

ABOUT THE AUTHOR

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(Credit: Nick Higgins)