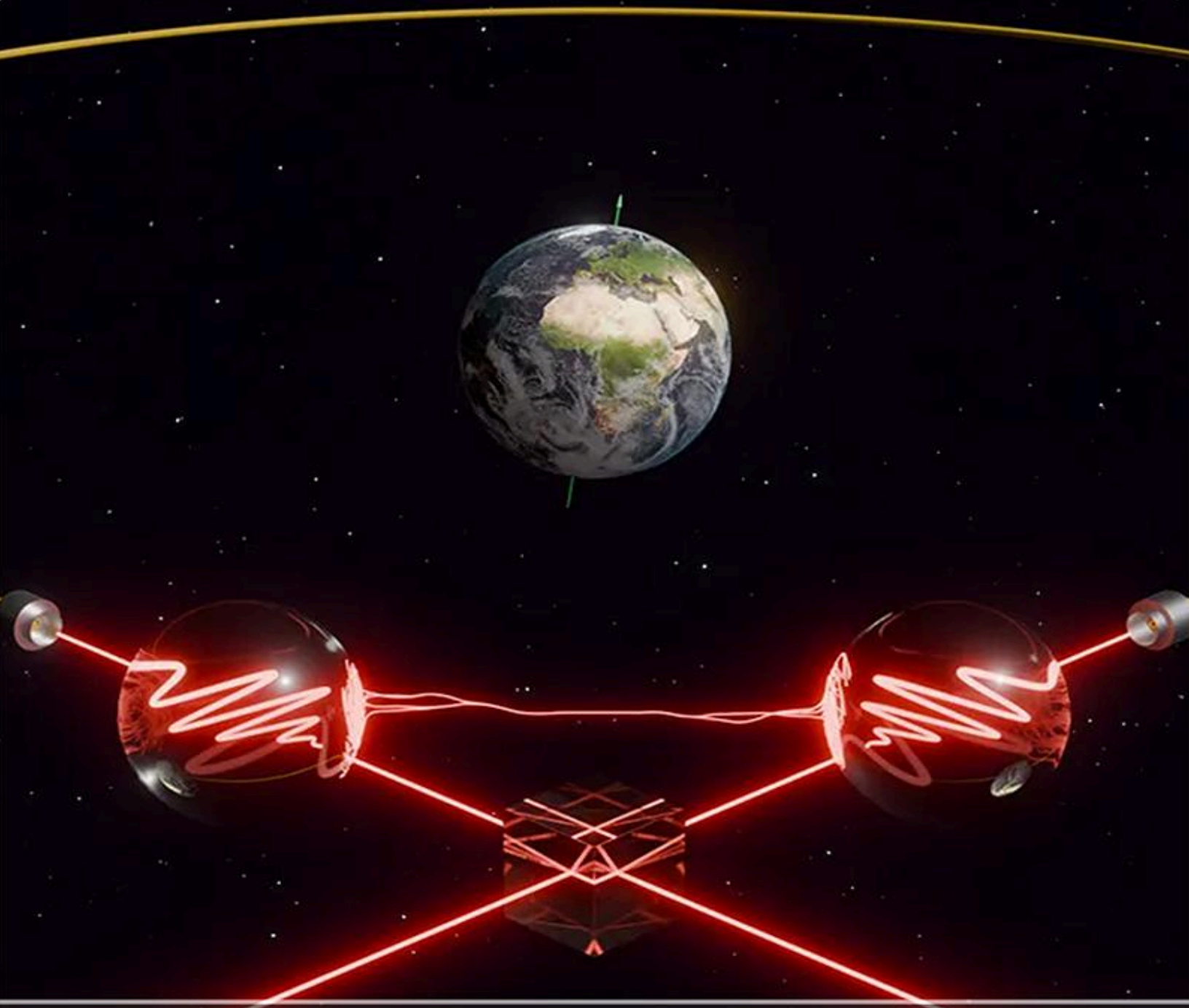
This Month in STEM

October 2024 Edition



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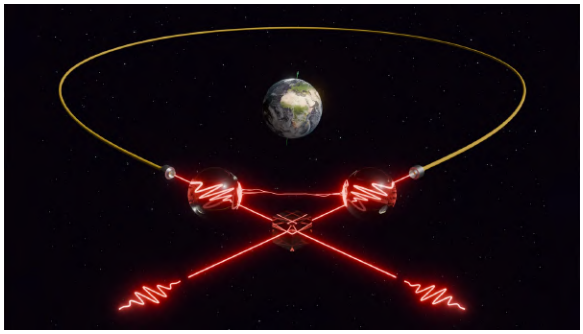


Image: Marco Di Vita

Quantum Mechanics can finally confirm the Earth is, in fact, spinning!

Ansh Sharma

It has for long been known that Earth indeed does spin. It has also for long been known that quantum particles are extremely complex in nature, and very hard to understand. In an effort to unite the two, scientists recently were able to confirm the Earth's spin using quantum entanglement. If you had your doubts on its rotation before, hopefully they will now be eradicated.

Scientists at the University of Vienna did this by shooting photons into optic fiber at the speed of light, and in two different directions- those being either clockwise or anticlockwise. Due to quantum mechanics, the two waves would entangle with each other. An easy way to explain this is by taking two strings and tying knots around them very quickly. Assume each one of these knots was actually interference of light. This would make the strings highly dependent on each other, as pulling one string loose would undo the knot for both strings together, even if the first string was untouched. In the same sense, pairs of photons created interdependence as they went around opposite directions of the optic cable, thus entangling and acting dependent on each other.

However, the Heisenberg Uncertainty principle suggests that we actually do not know which path it took, and that the pair of photons actually superimposed on each other and created a state of superposition where the photons were everywhere all at once. Since the Earth does have a spin however, this path of photons were actually distinct due to the rotational motion of the Earth which meant that the particles were not in sync and interfered with each other, creating quantum interference.

While this has no real impact in the life of anyone reading this article, it is still interesting to note how with every passing day our understanding of quantum mechanics, the most incomplete field in the 'Theory of Everything' grows everyday, especially with relating it to the physics of our planet. One day, someone will be able to use all this accumulated knowledge and finally find a theory for quantum gravity, until then it is up to us to wait around, or actually go ahead and do it!

Flexible Circuits Made with Silk and Graphene on the Horizon

Stella Kang

Silk, a precious textile that used to indicate authority and wealth, had always been considered a highly valued commodity for its elasticity, durability, and strength. Being used for musical instruments, fishing lines, and bow strings, silk has served humans in many different ways throughout history. Today, silk still serves us as a highly valued commodity, directing us in a whole new direction for microelectronics and computing.

Silk protein has been implemented in designer electronics, but its use is currently limited because silk fibers are a messy tangle of spaghetti-like strands. Now, a research team led by scientists at the Department of Energy's Pacific Northwest National Laboratory has tamed the tangle. They report in the journal Science Advances that they have achieved a uniform two-dimensional (2D) layer of silk protein fragments, or "fibroins," on graphene, a carbon-based material useful for its excellent electrical conductivity.

"These results provide a reproducible method for silk protein self-assembly that is essential for designing and fabricating silk-based electronics," said Chenyang Shi, the study's lead author. "It's important to note that this system is nontoxic and water-based, which is crucial for biocompatibility."

To do this, the team carefully controlled the reaction conditions, adding individual silk fibers to the water-based system in a precise manner. Through precision laboratory conditions, the team achieved a highly organized 2D layer of proteins packed in precise parallel β-sheets, one of the most common protein shapes in nature. Further imaging studies and complementary theoretical calculations showed that the thin silk layer adopts a stable structure with features found in natural silk. An electronic structure at this scale – less than half the thickness of a strand of DNA – supports the miniaturization found everywhere in the bio-electronics industry.

The combination of silk and graphene significantly improves wearability and implantability of health sensors as it forms a sensitive, tunable transistor. Additionally, the PNNL team sees its potential to serve as a key component of memory transistors or "memristors," in computing neural networks, allowing computers to mimic how the human brain functions. Indeed, the researchers are planning to use this starting material and technique to create their own artificial silk with functional proteins added to it to enhance its usefulness and specificity.

Image: NASA

Stranded Astronauts on the ISS

Oliver Stroyberg

Two astronauts, Sunita Williams and Barry Wilmore, have a long-extended stay at the ISS due to a malfunction with their spacecraft. What was meant to be an 8-day mission turned out to be an 8-month mission.

They were part of a mission launched by Boeing in their "Starliner" craft. The "Starliner" craft is part of a program that Boeing, SpaceX and NASA are involved in for commercializing space travel. This was Boeing's first attempt at a manned space mission, compared to SpaceX has launched 9 manned missions already (this is not the two companies' first manned missions to space though, this is only in the contracts that have been written by NASA).

The malfunction in the spacecraft had to do with the engine. There were helium leaks which led to malfunctions in the thrusters. This meant that the spacecraft was deemed unsafe and so the astronauts will be returning with SpaceX's next mission in February 2025. This lines up with the program's values of creating safe space travel that will one day be available for commercial use.

Williams and Wilmore will still be able to work before they return to Earth. They are planning on doing more scientific work and maintenance and have discussed the possibility of performing spacewalks.

Image: Boeing

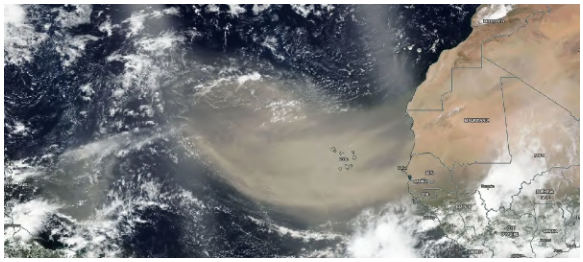


Image: NASA

Saharan Dust Transforms into Nutrient-Rich Iron for Marine Life During Atlantic Journey

Ean Cole

Each year, strong winds carry millions of metric tons of Saharan dust across the Atlantic Ocean, significantly impacting marine ecosystems. A recent study reveals that as the dust travels, chemical reactions in the atmosphere alter the iron in the dust, making it more soluble and accessible to marine organisms.

Phytoplankton, microscopic marine plants crucial for the ocean's carbon cycle, rely on iron for photosynthesis. Dust from the Sahara is a major source of iron for iron-starved ocean regions. As the dust is exposed to acids and ultraviolet radiation during its transatlantic journey, the reactive iron minerals become more soluble, providing essential nutrients to marine life when the dust settles in the ocean.

Scientists Timothy Lyons and Jeremy Owens studied core samples from the Atlantic seafloor to determine the chemical changes in the dust over the past 120,000 years. They found that dust closer to Africa contained more reactive iron than dust farther west near North America. This suggests that as the dust travels across the ocean, much of its reactive iron is consumed by phytoplankton before reaching the seafloor.

The study highlights the important role of Saharan dust in sustaining marine life, from phytoplankton to fish like Atlantic skipjack tuna, which are attracted to areas where dust settles. Although some uncertainties remain, such as the potential influence of other sources like wildfire smoke, the research provides valuable insights into how atmospheric processes enhance the nutrient content of dust, supporting life in the oceans.

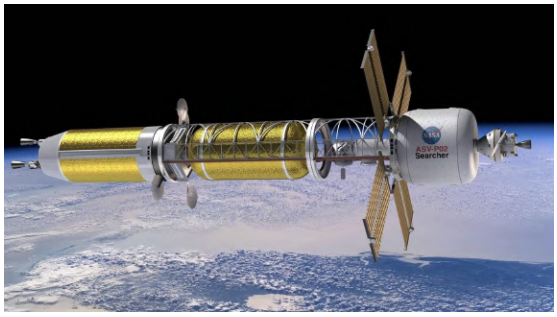


Image: NASA

Nuclear rockets could travel to Mars in half the time, but designing the reactors that would power them isn't easy.

Prakhar Chhabra

NASA believes it can have humans on Mars within a decade, but traveling 140 million miles by conventional rocket could take seven months. Current chemical propulsion systems are too slow to make the trip in a reasonable span. In response, NASA has been working on Nuclear Thermal Propulsion (NTP) technology that would allow for return trips to take just half the time. NTP heats propellant by splitting uranium atoms via nuclear fission to release energy & provide thrust. Aerojet claims the system is significantly more effective than chemical rockets in terms of acceleration and can cut mission durations.

That technology is being developed as part of a joint effort by NASA and the Defense Advanced Research Projects Agency (DARPA) as part of their Demonstration Rocket for Agile Cislunar Operations (DRACO) program. The aim is to fly a prototype by 2027 to demonstrate the technology with flight tests using high-assay, low-enriched uranium (HALEU) fuel. It is safer and less of a proliferation risk than using highly enriched uranium, yet provides the power levels needed for space travel. NTP has uses even beyond Mars missions -- it can help enable a new class of space vehicles that are more agile and maneuverable to defend against threats to orbiting satellites above the Earth.

There are several reasons for using NTP compared to chemical propulsion. These NTP engines are not only faster but more efficient, too: The thrust and specific impulse (a measure of the propellant efficiency) produced by an NTP are significantly higher than those of other engine types. Such a combination of features represents a unique set that positions NTP as ideal for long-duration missions to far targets, such as Mars, where ability and speed are both equally vital.

Researchers are currently developing models and simulations to optimize NTP engine designs. These simulations will help engineers address the technical challenges of safely starting up and operating the engine in space. With ongoing research, NTP could play a vital role in future crewed Mars missions and other deep space explorations.

Indigenous Communities in Brazil Struggle as Amazon Fires Rage

Tia Southwell

The Amazon rainforest is facing one of its most devastating fire seasons in two decades, with more than 62,000 square kilometers burned in 2024 alone. The fires, mostly started illegally by loggers, miners, and farmers looking to exploit the land, are encroaching on indigenous territories and protected reserves. For the indigenous people like the Caititu community, the fight to save their homes has become deeply personal.

Raimundinha Rodrigues Da Sousa, who leads the Caititu indigenous fire brigade, describes the relentless and life-threatening battle against the fires. “It is a very aggressive fire that kills everything that comes its way,” she says. Her team, working with limited resources, struggles to extinguish flames that quickly reappear. They regularly find evidence of deliberate arson, such as gasoline bottles and matches near the site of the fires. The physical toll is immense, with Raimundinha’s father, Ademar, suffering respiratory issues due to the constant smoke.

These fires not only destroy vast areas of forest but also release significant amounts of carbon dioxide, turning the Amazon, once a crucial carbon sink, into a major emitter. The fires, exacerbated by Brazil’s worst-ever drought, are ravaging the region's biodiversity and the indigenous people’s way of life. The drought has also dried up riverbeds, cutting off communities from essential resources like water and food. In some areas, river travel has become impossible, forcing villagers to trek across cracked, dry riverbeds in extreme heat to access water supplies.

For many, including indigenous leaders like Chief Ze Bajaga, these fires represent a broader crisis of humanity's disregard for nature. Bajaga believes the fires are driven by greed, with those responsible “no longer wanting the wellbeing of humanity or nature.” As the fires rage on, the message from the indigenous people of the Amazon is clear: the destruction of their land is not just an environmental catastrophe but a profound threat to their survival.

Image: Marco Di Vita

Earth Captured a Second Moon

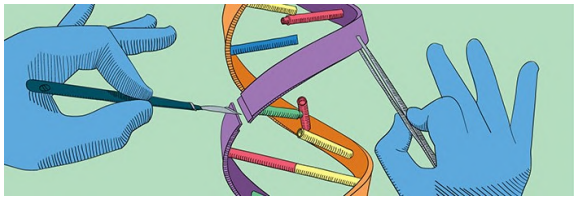
Emre Cincor

One of the key characteristics of our planet is our sole satellite, the Moon, decorating our night skies. However, for a short period of time, it seems like our Moon is having a little sibling. According to the calculations of NASA scientists, our planet should have captured a "second moon." This "mini-moon," is the tiny asteroid 2024 PT5, which usually orbits the Sun as part of a small asteroid belt that follows Earth. While our planet's satellite has accompanied us for the better part of 4 billion years, its new sibling won't even stay with us until the end of the year.

"According to the latest data available from NASA's Jet Propulsion Laboratory Horizons system, the temporary capture will start at 15:54 EDT (19:54 UTC) and will end at 11:43 EDT (15:43 UTC) on November 25," says Carlos de la Fuente Marcos, mini-moon expert and professor in Universidad Complutense de Madrid.

"The object that is going to pay us a visit belongs to the Arjuna asteroid belt, a secondary asteroid belt made of space rocks that follow orbits very similar to that of Earth at an average distance to the sun of about 93 million miles (150 million kilometers)," Marcos told Space.com last week. "Objects in the Arjuna asteroid belt are part of the near-Earth object population of asteroids and comets."

It might seem extraordinary that a second moon is suddenly joining our planet, however, it turns out that these "gravitational capture events" are actually quite common. "Some Arjuna asteroid belt objects can approach Earth at a close range of around 2.8 million miles (4.5 million kilometers) and a relatively low velocity of less than 2,200 miles per hour (3,540 km/h)," which allows them to be captured by the planet's gravitational field, as Marcos explained. However, he also pointed out that asteroid 2024 PT5 will not follow a full orbit around the Earth. Marcos describes a true satellite as a "customer buying goods inside a store" and objects like 2024 PT5 as "window shoppers." It is also important to mention that 2024 PT5 isn't the first asteroid to be captured by the Earth and transformed into a mini-moon. Astronomers have previously documented two prior "short captures" and the rarer variants, "long-capture events."



Revolution in Medicine: UK Approves First Gene-Editing Treatment for Blood Disorders

Doralice Chen Maturi

It is estimated that 15,000 people in the UK have sickle cell disease. Presently, the only long-term cure for this condition is a bone marrow transplant, but optimal outcomes are only achieved from a closely matched donor. There is also a risk of rejection and complications associated with transplants which are also only available to a small fraction of people living with the conditions.

In a more recent advancement of gene editing technology, the Medicines and Healthcare Products Regulatory Agency (MHRA) approved Casgevy, a gene therapy treatment for sickle cell anemia and transfusion-dependent β-thalassemia.

The mutation that causes sickle cell disease is a point mutation in the hemoglobin beta gene (HBB). This mutation replaces a negatively charged glutamate amino acid with a neutral valine amino acid at the sixth position of the beta-globin chain. As a result, a structurally abnormal hemoglobin called hemoglobin S (HbS) is created. This mutation means that the usual disc-shaped and flexible red blood cells are instead crescent or "sickle"-shaped and thus unable to move easily through blood vessels and deliver oxygen.

Symptoms of this disease include vaso-occlusive crises– episodes of moderate to severe pain, typically in the limbs or back, which can last for days or weeks. Other health complications include chronic pain, stroke, lung problems, eye problems, infections, and kidney disease.

Casgevy is a gene therapy that uses the Nobel Prize-winning gene editing technology CRISPR. The process involves editing the patient's bone marrow stem cells to express the foetal version of haemoglobin before transplanting the edited stem cells back into the patient. In most people, foetal haemoglobin expression is switched off and the non-foetal version is expressed when infants. The increase in the expression of foetal haemoglobin compensates for the non-functional adult haemoglobin produced in those with sickle cell anemia or thalassemia. These edited stem cells are still the patient's cells meaning there is no risk of rejection, unlike the previous treatment of blood transfusions.

The MHRA approval means that Casgevy can be sold in the UK, and doctors are able to legally prescribe it to patients aged 12 or over with sickle cell disease, or transfusion-dependent β-thalassemia.

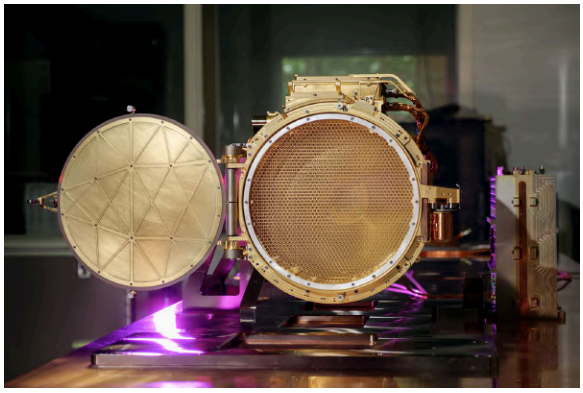


Image: NASA

Exploring Europa: NASA's Next Big Mission

Caterina Cioni

Fast forward to 2031. The NASA spacecraft Europa Clipper has arrived on Jupiter after a six-year journey. It's gliding through the dark expanse around Europa, one of Jupiter's moons. Imagine, a robotic spacecraft zooming past a frozen world where towering plumes of water vapor might erupt from the icy crust. Europa's frozen surface hides something extraordinary underneath a vast ocean of salty water, potentially capable of sustaining life.

The mission? Find out if Europa's ocean has the right chemistry for life. Europa Clipper won't just be taking photos of space; it's got nine scientific instruments designed to study everything from the ice shell to the possible water plumes that may shoot up through the cracks.

The big goal is to see if there's any chance life could exist under that ice…crazy, right?

Europa Clipper's price tag of $5 billion makes it one of NASA's most ambitious missions, and it's taking serious risks. Radiation from Jupiter could damage its circuits, and every time it zooms in for a flyby, the spacecraft will be dodging invisible bullets of radiation. But with a sturdy design, some fancy solar panels, and a vault of radiation-resistant electronics, Clipper's got a good chance of surviving the trip.

Why the obsession with Europa? It's simple. Scientists have been looking for life on Mars forever, but Europa's icy ocean has more potential for life than anyone imagined. If Europa Clipper finds anything that hints at life or even the conditions to support it, it could change everything we know about the search for life in space.

So while we may not be sending humans out there anytime soon, Europa Clipper is taking on the next best adventure: to a moon that could rewrite what it means to be "alive" in the solar system. Keep an eye out, this might just be the beginning of the next great space discovery!

Image: Emmet Livingstone

Empowering Local Scientists: A Key to Sustainable Conservation in the Congo Basin

Franco Ferreira

Amongst the most ecologically diverse regions, the Congo Basin presents perhaps one of the severest crises on the planet. While perils such as deforestation and poaching take center stage, a more furtive but nonetheless destructive problem is practically the complete lack of indigenous scientists to study and protect biodiversity in the region.

Most scientific research undertaken in the Congo Basin is by foreign lead researchers. This sets up a disconnect with those trying to help with conservation, and communities that depend on the ecosystems within the basin. Given the few Congolese researchers, this leads to certain insights being lost from people who live among such environments, which may hamper the effectiveness of conservation efforts.

More often than not, conservation strategies devoid of local scientists in the Congo Basin are bereft of the requisite context for long-term, sustainable solutions. Management cannot be informed by short-term or externally led research for every complex ecosystem.

Foreign researchers tend to focus on narrow ecological goals without considering how those would interface with the more direct concerns of local livelihoods and/or governance issues that would render conservation projects less sustainable. As a result, protection efforts for the Congo's biodiversity have become fragmented at best, sometimes ineffective, and at times even counterproductive as they do not integrate with the realities faced by the local populations.

More funding of Congolese universities and scientific institutions would mean that the research infrastructure was much stronger to create a long-term pipeline for a new generation of scientists. Over time, such initiatives would ensure that the obligation for the conservation of biodiversity in the Congo rested with the very people who had the greatest stake in its future: its own citizens. But the future of the Congo's biodiversity rests equally on the nurturing of a robust, self-sustaining network of Congolese scientists.