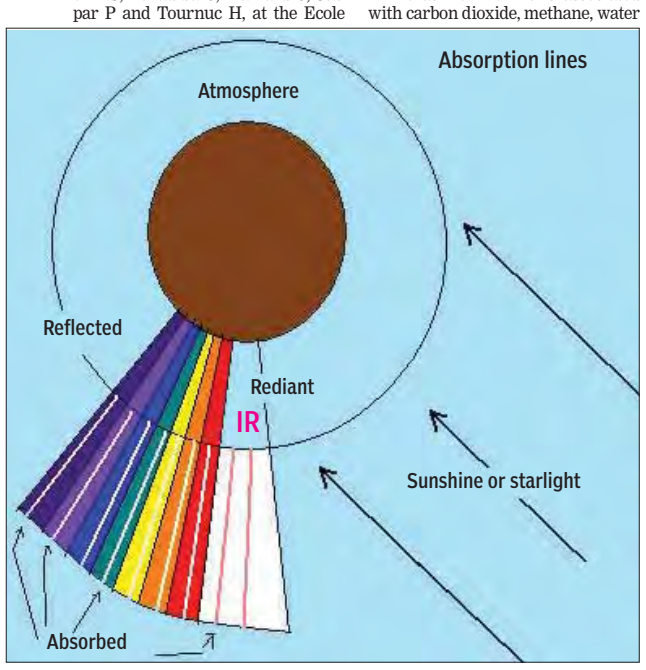
Showing signs of life

LOOKING FOR MOVEMENT MAY BE EASIER THAN FINDING CHEMICAL SIGNATURES OF LIFE IN A LAB OR IN DISTANT WORLDS, WRITES
S ANANTHANARAYANAN

While the search for "earth-like" planets makes progress, an equally interesting quest is to find evidence of life outside our universe. The indicators of life on earth, in places or at scales that are not readily in view, are based on the chemicals that are associated with life. The same methods can be used to test for life on far off planets, but we could be misled if the chemicals of other forms of life are not the same as those on earth.

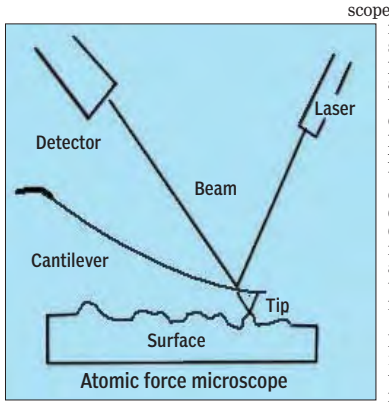
Giovanni Dietler, Sandor Kasas and Giovanni Longo, with Simone Ruggeri FS, Benadiba C, Maillard C, Stupar P and Tournuc H, at the Ecole Polytechnique, Fédérale, Lausanne, report in the journal *Proceedings of the National Academy of Sciences* a method to detect the presence of life without relying on chemicals. The method is to use a micrometer scale see-saw to detect microscopic physical movement, as an indicator of growth or locomotion, from which to conclude that there is life in the sample being tested, either to assess the efficacy of drugs in a pharmaceutical lab, or on the surface of an extraterrestrial place.

Life as we know it is associated with carbon dioxide, methane, water and ozone. Finding all these, or even most of them, in a planet in the solar system or even elsewhere in space would be taken as a *first-rate indicator* of life. Our space probes that are sent to the planets have arrangements to analyse the soil and atmosphere when they get there. Even here on earth, we can look for the signs of chemicals on distant planets by analysing the spectrum of the light that has passed through a planet's atmosphere while it is reflected to earth. And also the spectrum of Infra red light or heat that the planet radiates. As particular chemicals in the atmosphere absorb specific frequencies of light, or infra red waves, we can make out that these chemicals were there by the frequencies that seem to be greatly reduced in the spectrum of the light that comes to us.



The mix of the four signature chemicals on earth has changed over the ages, as life evolved from single-celled creatures to plants, dinosaurs, birds and mammals. Finding signature chemicals on a planet would hence indicate both a strong possibility of life as well as, possibly, the state of evolution.

These methods of detection would work, of course, for life of the kind that we know of here on earth. But there could be other forms of life, which would not lead to the build-up of just these or all these chemicals. While life on earth is carbon-based, there could, in principle, be organic-type molecules based on silicon, too. Not that it is likely, as silicon-based life would need to exist at a high temperature, and metabolic processes would need to be different, if at all possible. But there could be other chemical bases for self-replicating organisms that resemble life. And then, even if the life forms were similar to those on earth, there may be different forms of circulation of by-products, without signature chemicals in the atmosphere. Looking at all this, although finding the right chemicals on a planet would be a strong indicator of life, not finding them would not rule out the possibility.



Atomic force microscope

One more indicator of life that is considered is an indirect one, the creation of a smooth and undulating topography in a planet that supports life, as opposed to a jagged and rocky one that does not. Studies of soil erosion and movement of landmasses on earth have shown that while rivers, rainfall, freezing of water and winds do cause the break-up of rocks to smaller fragments, the chief cause of creating loose, transportable soil, which moderates discontinuities in the landscape, are *biotic*, or biologically driven processes, like animal burrowing, growth of roots and microbial action. These effects also tend to synchronise with seasonal temperature variations and maintain the topography.

But for all this, topography alone cannot assure biotic origin as other processes are also capable of creating a smooth and soil-covered terrain. In the Atacama Desert of Chile, there is a hyper-arid region called the *central depression*, where biotic processes are simply not supported. But salt weathering does break down bedrock and the rock surfaces receive inputs of windblown soil sediment. And the landscape is rounded and soil-mantled!

Detecting movement

The Lausanne scientists have adapted the existing *atomic force microscope* to sense motion at the scale of the activity of bacteria, to act as a detector of direct and non-chemical signs of life. The idea is that if there is something living in there, then it is going to move, either move some limb or carry out a biological process of feeding, excretion or growth. The atomic force microscope is a tiny protrusion, just micrometres in dimension that swings free from a holder. The protrusion is thus a lever fixed at one end, or a *cantilever*. At the free end there is a tip, of the order of nanometres, which protrudes down to scan the surface being examined. The unevenness of the surface causes the lever to move up or down, and the movement is detected by a laser beam that reflects off the lever. The arrangement is able to sense undulations of fractions of a nanometre.

In the adaptation by the Lausanne group, the cantilever is moved not by forces on the tip but by movement of bacteria that are deposited on the lever itself. In trials carried out, the dimensions allow about 500 bacteria to perch on the lever. The movement of even a few of them affects the load on the lever and it swings up or down — to be detected by the laser beam sensor. Over a period of time, the printout of the laser beam trace can reveal if there is movement going in the culture on the lever. "The system has proven accurate with detecting bacteria, yeast, and even cancer cells," a press release from the EPFL says.

An immediate application of the arrangement would lie in the testing of drug preparations. An array of cantilevers could be covered with bacteria or cancer cells and different drug compounds could be tried out at the same time. Where the drugs are effective, there would be a rapid decrease and then cessation of movement. This would be a fast and convenient method to test a range of candidate curative agents and speed up drug development.

The same arrangement could also be made part of the test equipment of landing crafts on planets or comets. "As it relies on motion rather than chemistry, the cantilever sensor would be able to detect life forms in mediums that are native to other planets, such as the methane in the lakes of Titan," the press note says.

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CATALYSTS OF LIFE

THE DISCOVERY OF RIBOZYMES HAS CHANGED THE WAY WE THINK ABOUT THE ORIGIN OF LIFE ON EARTH BECAUSE RNA PARTICLES, UNLIKE PROTEINS, ARE CAPABLE OF REPLICATING THEMSELVES, SAYS **TAPAN KUMAR MAITRA**

Thermodynamics allows us to assess the feasibility of a reaction but says nothing about the likelihood that the reaction will actually occur at a reasonable rate in a cell. To ensure that the activation energy requirement is met and the transition state is achieved, a catalyst is required, which is always an enzyme in biological systems. All protein enzymes are chains of amino acids in a genetically programmed sequence that are sensitive to temperature and pH. They are also exquisitely specific, either for a single specific substrate or for a class of closely related compounds.

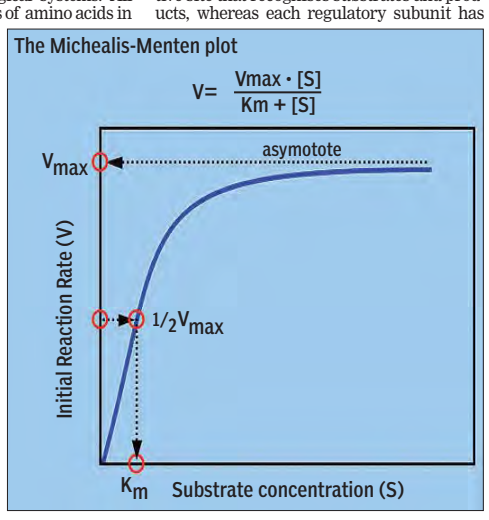
The actual catalytic process takes place at the active site, a critical cluster of amino acids responsible for substrate binding and activation and for the actual chemical reaction. Binding of the appropriate substrate at the active site induces a more stringent fit between enzyme and substrate, thereby facilitating substrate activation.

An enzyme-catalysed reaction proceeds via an enzyme-substrate intermediate. Most enzymes follow Michaelis-Menten kinetics, characterised by a hyperbolic relationship between the initial reaction Velocity and the Substrate Concentration. The upper limit on velocity is called V_{max3} and the substrate concentration needed to reach one-half of the maximum velocity is termed the Michaelis constant, K_m. The hyperbolic relationship between V and S can be linearised by a double-reciprocal equation and plot, from which V_{max} and K_m can be determined graphically or by computer analysis.

Enzyme activity is influenced not only by substrate availability but also by products, alternative substrates, substrate analogues, drugs and toxins, most of which have an inhibitory effect. Inhibition may be either reversible or irreversible, with the latter category involving covalent bonding of the inhibitor to the enzyme surface. A reversible inhibitor, on the other hand, binds to an enzyme in a reversible manner, either at the active site (competitive inhibition) or elsewhere on the enzyme surface (non-competitive inhibition).

Enzymes must be regulated to adjust their activity levels to cellular needs. Substrate-level regulation involves the effects of substrate and product concentrations on the reaction rate. Additional control mechanisms include allosteric regulation and covalent modification. Most allosterically regulated enzymes catalyse the first step in a reaction sequence and are multi-subunit proteins with multiple catalytic subunits and multiple regulatory subunits.

Each of the catalytic subunits has an active site that recognises substrates and products, whereas each regulatory subunit has one or more allosteric sites that recognise specific effector molecules. A given effector may either inhibit or activate the enzyme, depending on which form of the enzyme is favoured. The most common covalent modifications include phosphorylation and dephosphorylation, as exemplified by the enzyme glycogen phosphorylase, and proteolytic cleavage, as occurs in the activation of the zymogen forms of proteolytic enzymes secreted by the pancreas.



Although it was long thought that all enzymes were proteins, we now recognise the catalytic properties of certain RNA molecules called ribozymes. These include some rRNA molecules that are able to catalyse the removal of their own introns, RNA components of enzymes that also contain protein components, and perhaps even the RNA components of assembled ribosomes.

The discovery of ribozymes has changed the way we think about the origin of life on earth because RNA molecules, unlike proteins, are capable of replicating themselves.

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N-power the greenest option

ENVIRONMENTALISTS HAVE BEEN URGED TO DITCH THEIR HISTORICAL ANTAGONISM AND EMBRACE A BROAD ENERGY MIX, WRITES **STEVE CONNOR**

Nuclear power is one of the least damaging sources of energy for the environment and the green movement must accept its expansion if the world is to avoid dangerous climate change, some of the world's leading conservation biologists have warned. Rising demand for energy will place ever greater burdens on the natural world, threatening its rich biodiversity, unless societies accept nuclear power as a key part of the "energy mix", they said. And so the environmental movement and pressure groups such as Friends of the Earth and Greenpeace should drop their opposition to the building of nuclear power stations.

In an open letter to be published next month in the journal *Conservation Biology*, more than 65 biologists, including a former UK government chief scientist, support the call to build more nuclear power plants as a central part of a global strategy to protect wildlife and the environment. The full gamut of electricity-generation sources, including nuclear power, must be used to replace the burning of fossil fuels such as oil, coal and gas if the world is to have any chance of mitigating severe climate change, their letter says. It has been signed by several leading British academics including Lord May of Oxford, a theoretical biologist at Oxford University and former chief scientific adviser; Professor Andrew Balmford, a conservation biologist at Cambridge; and Professor Tim Blackburn, an expert in biodiversity at University College London.

As well as reducing the sources of carbon dioxide, the chief manmade greenhouse gas implicated in climate change, the expansion of nuclear power will leave more land to support biodiversity and so curb the extinction of species, they say.

Recognising the "historical antagonism towards nuclear energy" among environmentalists, they write, "Much as leading climate scientists have recently advocated the development of safe, next-generation nuclear energy systems to combat climate change, we entreat the conservation and environmental community to weigh the pros and cons of different energy sources using objective evidence and pragmatic tradeoffs, rather than simply relying on idealistic perceptions of what is 'green'."

It is too risky to rely solely on renewable energy sources such as wind and solar power for replacing fossil fuels because of problems to do with scalability, cost, materials and land use, they explain. "Nuclear power — being far the most compact and energy-dense of sources — could also make a major, and perhaps leading, contribution… It is time that conservationists make their voices heard in this policy area," they say. A golf-ball-sized lump of uranium would supply the lifetime's energy needs of a typical person, equivalent to 56 tanker trucks of natural gas, 800 elephant-sized bags of coal or a renewable battery as tall as 16 "super" skyscraper buildings placed one on top of the other, they say.

The letter was organised by Professor Barry Brook of the University of Tasmania and Professor Corey Bradshaw of the University of Adelaide. The two co-authored a paper in the January issue of *Conservation Biology* outlining the scientific case of nuclear power in terms of environmental protection. Of seven major technologies for generating electricity, nuclear power and wind energy had the highest benefit-to-cost ratio, they concluded.

"Tradeoffs and compromises are inevitable and require advocating energy mixes that minimise net environmental damage. Society cannot afford to risk wholesale failure to address energy-related biodiversity impacts because of preconceived notions and ideals," they said.

Professor Corey said, "Our main concern is that society isn't doing enough to rein in emissions… Unless we embrace a full, global-scale assault on fossil fuels, we'll be in increasingly worse shape over the coming decades — and decades is all we have to act ruthlessly. Many so-called green organisations and individuals, including scientists, have avoided or actively lobbied against proven zero-emission technologies like nuclear because of the associated negative stigma," he said.

"Our main goal was to show — through careful, objective scientific analysis — that on the basis of cost, safety, emissions reduction, land use and pollution, nuclear power must be considered in the future energy mix," he explained.

The letter aimed to convince people of the potential benefits of nuclear power in a world where energy demand would increase as the climate began to change because of rising levels of greenhouse gases, Professor Corey added. "By convincing leading scientists in the areas of ecological sustainability that nuclear has a role to play, we hope that others opposed to nuclear energy on purely 'environmental' — or ideological — grounds might reconsider their positions," he said.

THE INDEPENDENT

PLUS POINTS

Nearing Pluto

The solar system's mysterious "ninth planet" is set to be revealed as never before. The National Aeronautics and Space Administration's *New Horizons* is finally drawing close to Pluto almost nine years after setting off on the three-billion-mile journey from earth.


An artist's concept of the New Horizons spacecraft encountering a Kuiper Belt object beyond Pluto.

Pluto is around 3.67 billion miles from the sun and, when it was discovered in 1930, it was the planet furthest from the solar system's centre. But in 2006 it was relegated to being a "dwarf planet" in the Kuiper Belt, the group of objects beyond the region of planets such as earth.

The belt and the Oort Cloud, another band of icy objects that is even further away, are among space's final frontiers and both are thought to be the source of comets.

New Horizons was launched on 19 January 2006 and has spent the 1,873 days between then and now "hibernating" to preserve its electrical components. It had 18 hibernation periods, the most recent ending 162 million miles from Pluto, when the signal telling scientists of its activity took almost five hours to reach earth. From 15 January it will begin examining the planet and it is hoped that its images will be even better than those beamed back by the Hubble Space Telescope.

Project scientist Dr Hal Weaver, from the Applied Physics Laboratory at Johns Hopkins University in Maryland, USA, said the project was "a journey to a new class of planets we've never seen, in a place we've never been before". He added, "For decades we thought Pluto was this odd little body on the planetary outskirts; now we know it's really a gateway to an entire region of new worlds in the Kuiper Belt, and *New Horizons* is going to provide the first close-up look at them."

Topsy-turvy world

When it comes to housing, every little bit helps – and for a tortoise, the bigger the shell the larger the animal and the more able the fiercely territorial land-dwelling creature is able to fight off rivals. Predators, droughts and even food shortages can be kept at bay. This accepted evolutionary narrative has been turned on its head, however, with the revelation that larger tortoises are less adept at righting themselves when they are flipped on to their backs.

Scientists have long known that if you upturn a tortoise, it will find its feet again, thanks to a clever combination of shell shape and leg and neck manoeuvres, but according to a new study, larger Hermann tortoises found in the Mediterranean are less capable of finding their feet than their smaller, more nimble relatives.

Self-righting is a serious business for armoured animals, including ocean-going turtles and cockroaches, because they often spend time in rocky areas and are liable to get stuck on their backs, legs flailing. However, it's an even deadlier matter for the Hermann tortoise, which is often overturned by belligerent males during fights over breeding grounds.


If you upturn a tortoise, it will find its feet again, thanks to a clever combination of shell shape and leg and neck manoeuvres... but...

According to the study, led by Ana Golubovic, a researcher from the University of Belgrade, Hermann tortoises, which are found in Italy, France and the Balkans, can "easily lose their balance and end up on their backs" when covering rocky ground, or in encounters with predators; but contrary to accepted wisdom, the study found that there was "reduced righting performance in larger specimens, compared to smaller ones, in both sexes". To discover this, Golubovic's team conducted rigorous fieldwork and flipped 118 Hermann tortoises on to their backs to see how quickly they would recover. This meant travelling across Macedonia, Montenegro and Serbia to track down suitable animals – adults that the team ranked as "highly active".

The study, published in the *Journal of Comparative Zoology*, follows work at Princeton University, in the USA, which used a mathematical approach to discover that the ideal shell for self-righting would be a tall dome, rising to a peak and slightly flattened on one side. This shape is crucial to avoid ignominy, or worse, and many tortoise shells come very close to this ideal, although small imperfections can prompt frantic leg-waggling to help the tortoise to right itself.

Among the longest-living animals, tortoises are known for their calm determination and, it is to be hoped, an absolute lack of embarrassment about ending the wrong way up.

JAMIE MERRILL/THE INDEPENDENT