**////Title: Energy: A Clue to the Origins of Life**

**////Standfirst:**

Energy is vital for life. It allows important functions to occur in living systems, from the molecular level to the scale of the whole organism. Dr Helen Greenwood Hansma, from the University of California in Santa Barbara, believes that the types of energy used in living cells can provide clues to help us understand the origins of life. In her recent research, she explores how mechanical energy could have driven the processes that gave rise to early life in the absence of chemical energy.

**////Main text:**

When we think of energy, we may imagine the electrical energy that powers so much of our modern lives. But energy exists in many different forms aside from electricity. Light is a type of energy – the only kind of energy we can see. Heat, sound, and gravity are also types of energy. Chemical energy – held within the bonds in molecules and released during chemical reactions – is used within living systems to drive processes essential to life.

Also prominent within living organisms is mechanical energy, which describes the energy of motion – or ‘work’. In living systems, chemical energy is sometimes converted to mechanical energy before it is used.

Mechanical energy is more readily available in the non-living environment than any of the various kinds of chemical energy used by living organisms. Clues like these, from living organisms and non-living systems that exist today, help scientists such as Dr Hansma piece together one of the most fascinating events that occurred in the entirety of our planet’s history: the origins of life.

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Before the first living organisms were brought into being, before the existence of ‘biochemical energy’ (the chemical energy stored within living matter), and before enzymes were available to facilitate chemical reactions, molecules were still moving and changing. Many forces, including light and heat from the sun, were available to provide the energy needed to drive chemical reactions at the point of life’s emergence.

Dr Hansma suggests that the prevalence of mechanical forces and mechanical energy in living systems today could be the ghost of life’s ancient past – a remnant of the mechanical energy that drove early life before chemical energy became readily available.

Scientific methods that use mechanical energy to drive chemical reactions in the laboratory are a useful tool to understand how mechanical energy at life’s origins would behave. For example, these methods have been used to produce both small and larger molecules associated with life. While some molecules necessary for life would have already been present on early Earth, including amino acids, others, such as the building blocks of DNA and RNA, must have been created with the types of energy and chemical reactions available within the environment.

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Previous studies have demonstrated that using alternating cycles of dry and wet conditions in conjunction with the correct materials, such as certain types of clay, can produce the larger molecules essential for life. Cycles of wetting and drying occur on land in hot puddles where volcanoes form, such as the Kamchatka [kam-chat-kah] peninsula in Russia, or in active geothermal fields, such as The Geysers in California.

These wet-dry cycles have the advantage of concentrating any pre-life molecules during the drying phase, bringing them into closer contact with one another – and increasing the likelihood of them interacting with one another to facilitate the formation of early life.

This wet and dry cycling occurs on mineral and rock surfaces – such as on a clay-like mineral called mica [mike-ah]. In everyday life, mica can most commonly be found in cosmetics, paints, and electronics – but it is equally ubiquitous in the environment, being found as shiny deposits in many types of rock.

Mica is remarkable because it forms extremely thin sheets of tightly stacked crystals. These sheets are held together by positively charged potassium ions. Mostly, these sheets remain tightly packed and impenetrable, but over repeated cycles of wetting and drying, water can seep between the edges of the sheets, providing a stable, protective, and wet environment – perfect for new life to emerge.

As the mica sheets move, opening and shutting in response to the water flow, a source of mechanical energy is provided. Dr Hansma suggests that this energy could have powered the many types of chemical reactions that occurred as life was coming into being.

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Dr Hansma’s research has revealed other compelling evidence supporting mica as the site of the origin of life. All types of living cells have high internal concentrations of potassium. The origin of this cellular potassium is still a mystery. The simplest hypothesis is that life emerged in an environment that was high in potassium: just like the spaces between sheets of mica.

Additionally, both the surface of mica and structures within DNA possess a negative charge, which means that they are easily held together by positive charges in between them, because positive and negative charges stick together. In practical terms, this means that longer strands of DNA stick to mica surfaces better than shorter strands of DNA. And this, in turn, provides a longer period for the DNA to grow large enough to store the coding information vital to life.

Finally, scientists have not reached a consensus about when and how fat molecules called lipids became incorporated into living systems. Lipids are a key component of cell membranes, but it is not yet clear whether lipids were needed when life first emerged.

Some studies have shown that lipids could have facilitated the production of pre-life molecules in hot, wet environments. However, the versatile surface of mica is also compatible with lipids. Therefore, mica could have provided the site for life’s emergence, whether lipids were present from the beginning or not.

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Understanding where and how life on this planet emerged is one of the most enduring scientific pursuits. Dr Hansma’s research demonstrating mechanisms for the provision of mechanical energy could help us build a full picture of how early life sprang forth from non-living groups of molecules.

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This SciPod is a summary of the paper ‘Mechanical Energy before Chemical Energy at the Origins of Life?’, in *Sci*. <https://doi.org/10.3390/sci2040088>

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