Prehistoric Gold Rush

The first human immigration to the Americas has been found to be earlier than thought so far, says s ananthanarayanan

THE origin of *homo sapiens*, the modern human, is taken as 100,000-50,000 years ago, in Africa, and the migration to other parts. It is possible that humans evolved in different parts of the world from the populations of *homo erectus*, which had moved out of Africa some 2.5 million years ago. But there is genetic and archaeological evidence that the earliest migrants out of Africa, who have living descendants, were of some 60,000 years ago. There is also evidence of these early humans having spread in Southeast Asia as a result of continental drift, when the land masses of Australia, India and South America split out of Gondwanaland. But there has been great interest in how the populations of the indigenous people of Central and North America arose.

The established theory is that the human population in the Americas came from north-eastern Asia, when humans crossed over from Siberia to Alaska over the *Bering land bridge*. During the last great Ice Age, which lasted till 14,000 years ago, much seawater was locked as ice and sea levels were low. The land beneath the present day Bering Straits was thus above water and permitted human migration. This area, dubbed *Beringia*, remained ice-free but cut off from Asia during heavy glaciation, which supports the finding that the indigenous Americans evolved from a single-source ancestral population.

As the Ice Age retreated, these people migrated south, through an ice-free corridor east of the Rockies in western Canada. This theory of migration, called *Clovis First*, is supported by archaeological discoveries at *Clovis*, New Mexico. The discovery, in 1927, of human bones at Folsom in New Mexico was the first evidence of human habitation of prehistoric America. Further excavations revealed distinct stone tools at Clovis, which have been dated between 13,500-13,000 years ago. Tools that seem to derive from the Clovis pattern, particularly the fluted projectile points known as *Clovis Points* have since been discovered at many sites in western and central North America, Mexico and even northern South America and it is considered that Clovis represents the earliest presence of humans in the Americas.

The theory has been variously contested, with instances of apparent earlier presence. But the objections have been consistently set aside for one or another reason, either difficulty in the proposed passage to the south, the likelihood of earlier migrants having perished at the height of glaciation or reasons of the archaeological evidence presented not being beyond question.

Thus, for the reason that there is no established evidence of earlier presence, Clovis First has reigned as the correct understanding of humans in the Americas.

A line of attack on the theory has been that the widespread use of tools of the Clovis pattern could have arisen by adoption of the design by communities that had existed from before Clovis. While recent radiocarbon dating of Clovis artifacts refines their antiquity to 12,750-14,290 years ago, Clovis-like culture has been discovered at Monte Verde in Chile, dated at 13,500 years ago, and at the Channel Islands, California, at 12,500 years ago. There has been similar and much older evidence from *Perda Furada* in Brazil and *Topper* in South Carolina, but there are questions about their archaeological reliability.

Did a relatively small number of people who trecked across the Bering Strait Land Bridge give rise to the people of North and South America?

Dr Dennis Jenkins shows one of his trademark grins from the mouth of a cave at Paisley Caves. A senior archaeologist with the University of Oregon's Museum of Natural and Cultural History, he recently garnered international headlines for finding the New World's oldest human DNA (dating back 14,300 years) in coprolites—dried human faeces — in caves near Paisley, in central Oregon.

The most serious challenge to Clovis First was posed by the discovery at *Paisley Caves*, a system of four caves in the state of Oregon on the west coast of North America. There is geological evidence that the Pacific coastal route down to North America was open after 15,000 years ago. Excavations in the Oregon area were carried out to test the theory that pre-Clovis immigrants may have travelled down the Pacific coast, passing through the area surrounding Oregon. The Paisley Caves site, upriver from the Pacific Ocean, could hold evidence of occupation by these travellers.

A Clovis projectile point.

Artifacts and samples of human excreta, known as *coprolites*, discovered by a team from the University of Oregon at Paisely and other neighbouring sites, were, in fact, carbon-dated at some 1,000 years earlier than the Clovis discoveries.

But the findings were questioned, even by the Oregon University team, as the excavation technique was not foolproof — the coprolite could have washed in from other sources and the DNA in the coprolite had not been clearly established as human. Also, no Clovis-age tools had been found along with the coprolites.

Rigorous testing

A team of researchers, including Dr Dennis Jenkins and Dr Loren Davis from the University of Oregon, Dr Paula Campos, Professor Eske Willerslev and Dr Thomas Stafford, Jr, from the Centre for GeoGenetics at the University of Copenhagen, Denmark, undertook a renewed study with the most rigorous controls. The methods used were to specifically test each of the shortcomings of previous studies so that conclusions could be relied upon. Dr Campos, a former post-doc at Professor's Willerslev's lab in Copenhagen, elaborates, "When we published the first DNA results from the Paisley Caves four years ago it caused an outcry. Many archaeologists felt that our results must be wrong. They considered it an established fact that Clovis were the first Americans. People would come up with any number of alternative explanations to our data in order to repudiate our interpretation."

But Tom Stafford clarifies about the present study, reported in the journal, *Science*, "No other archaeological site in the US has been as thoroughly and exhaustively dated as the Paisley Caves. We've completed more than 141 new radiocarbon measurements on materials ranging from coprolites to wood and plant artefacts, fossil plants and mummified animals, to unique, water soluble chemical fractions from sediments and the coprolites themselves. We have used Carbon 14 dating to physically and temporally dissect the Paisley Caves strata at the millimetre l level. At present, we see no evidence that geologically younger, water-borne molecules — DNA in particular — have moved downward and contaminated deeper, older coprolites. The DNA and 14C data are iterative and corroborate each other. Our conclusion is that humans were present in North America at least 1,000 years before Clovis and that these earlier peoples probably had no technological or genetic similarity to the iconic Clovis Culture. The Clovis First debate has ended. The theory is now dead and buried."

Professor Willerslev says of the new results, "Our investigations constitute the final blow to the Clovis First theory. Culturally, biologically and chronologically the theory is no longer viable. The dissimilar stone artefacts, as well as the DNA-profiling of the human excrement show that humans were present before Clovis and that another culture in North America was at least as old as the Clovis Culture itself. Or to put it differently, either America was populated several thousand years before Clovis by people who created 'mother' technologies to the two very different styles of Clovis tools and Western Stemmed Tradition tools; or else there must have been two earlier migrations into North America of which one must have predated the Clovis immigration by at least 1,000 years. Both assumptions would explain our findings, but trying to distinguish which is more likely is very premature."

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Jellyfish the size of a football field

According to a British satellite expert and government adviser, the outlandish alien imaginings of Hollywood may not be quite alien enough, writes rob williams

FROM little green men to the crustacean-like "prawns" of *District 9* and HR Giger's nightmarish creation in the "Alien" films — our appetite for imagining how visitors from another planet might look shows no sign of diminishing. Dr Maggie Aderin-Pocock, a leading scientist at European space company Astrium – apart from being a British satellite expert and government adviser — has suggested that, far from being little green men, aliens could actually look like giant jellyfish.

The bizarre creatures she has dreamt up are, she says, an example of life "not as we know it".
The aliens she imagines are the product of what evolution might create on a world such as Saturn's moon Titan. She imagines aliens that drift through methane clouds scooping up chemical nutrients into their mouths. The creatures could also be able to live off light taken in through their skin, she says.

The alien jellyfish — which Dr Aderin-Pocock (right) imagines could be the size of a football field and have an orange underbelly — would be generated from silicon as opposed to carbon, which is the basis of all life as we know it.

The alien jellyfish — which Dr Aderin-Pocock imagines could be the size of a football field and have an orange underbelly — would be generated from silicon as opposed to carbon, which is the basis of all life as we know it. The orange underbelly could act as a camouflage, allowing them to evade would-be predators. The aliens are kept afloat by onion-shaped buoyancy bags that dangle from their body, taking in or letting out gas in order to gain or lose altitude. She also suggests they could communicate using pulses of light.

Dr Aderin-Pocock, who was describing her alien as part of Science Month on TV channel Eden, says much of her inspiration comes from the bizarre life-forms discovered deep beneath the ocean. She says, "Our imaginations are naturally constrained by what we see around us and the conventional wisdom has been that life needs water and is carbon-based. But some researchers are doing exciting work, playing with ideas such as silicon-based life forms evolving on other planets in environments very different to our own.

"My vision of aliens is an inhuman, silicon-based life form that looks much more like a jellyfish than sci-fi's little green men. Silicon is just below carbon in the periodic table, has some chemical similarities and is widely available in the universe. So perhaps we could imagine similar instructions to DNA but with silicon. Maybe life doesn't have to resemble anything like DNA at all."

Based on the latest discoveries of star-orbiting planets, Dr Aderin-Pocock believes there could be as many as four intelligent alien civilisations in existence in our galaxy. But due to the distances involved, she believes we are unlikely to ever encounter them. "The *Voyager 1* spacecraft, which is carrying a recording of greetings from earth in different languages, has been travelling through the Solar System since the 1970s and has only just made it into deep space," she says. "To get to our nearest neighbouring star, Proxima Centauri, would take it 76,000 years."

Her imagined extra-terrestrials would also not be able to survive if they visited earth — finding the damp oxygenated atmosphere lethal.

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Life as we know it

In the absence of catalysts, most of the chemical reactions that must take place in cells would occur much too slowly. Hence the need for enzymes that can speed up reactions by many orders of magnitude, writes tapan kumar maitra

BROADLY speaking, every cell has four essential needs: molecular building blocks, chemical catalysts called enzymes, information to guide all its activities and energy to drive the various reactions and processes that are essential to life and biological function. The various molecules that cells need include amino acids, nucleotides, sugars and lipids. To these we can add other essential molecules and ions, such as water, inorganic salts, metal ions, oxygen and carbon dioxide. Some of these materials are produced by cells while others must be obtained from the environment.

In the absence of catalysts, most of the chemical reactions that must take place in cells would occur much too slowly to maintain life as we know it. Hence, there is a requirement for enzymes, which can speed up reactions by many orders of magnitude.

The third general requirement of cells is for information to guide and direct their activities. Information is encoded within the nucleotide sequences of DNA and RNA and expressed in the synthesis of specific proteins. The genetic information that is stored, transmitted and expressed as DNA, RNA and proteins determines what kinds of chemical reactions a cell can carry out, what kinds of structures it can form and what kinds of functions it can achieve.

In addition to molecules, enzymes and information, cells also require energy. This is needed to drive the chemical reactions involved in the formation of cellular components and to power the many activities that these components carry out. The capacity to obtain, store and use energy is, in fact, one of the obvious features of most living things.

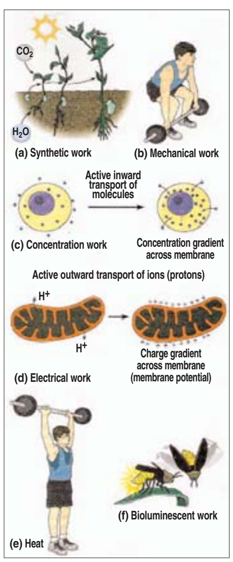
Usually, energy is defined as the capacity to do work. But that turns out to be a somewhat circular definition because work is frequently dependent on energy changes. A more useful definition is that energy is the ability to cause specific changes and since life is characterised first and foremost by change, this definition underscores the total dependence of all forms of life on the continuous availability of energy.
We also recognise that asking about cellular needs for energy really means inquiring into the kinds of changes cells must effect — that is, the activities that give rise to change. Six categories of change come to mind, which in turn define six kinds of work — synthetic, mechanical, concentration and electrical work, as well as the generation of heat and light.

An important activity of virtually every cell at all times is the work of biosynthesis, which results in the formation of new bonds and the generation of new molecules. This activity is especially obvious in a population of growing cells, where it can be shown that additional molecules are being synthesised if the cells are increasing in size or number or both. But synthetic work is required to maintain structures just as surely as it is needed to generate them originally. Most existing structural components of a cell are in a state of constant turnover. The molecules that make up the structure are continuously being degraded and replaced.

In terms of the hierarchy of cellular structure, almost all of the energy cells require for biosynthetic work is used to make energy-rich organic molecules from simpler starting materials and to activate such organic molecules for incorporation into macro-molecules.
Mechanical work involves a physical change in the position or orientation of a cell or some part of it. An especially good example is the movement of a cell with respect to its environment. This movement requires the presence of some sort of motile appendage such as a *flagellum* or a *cilium*. Many prokaryotic cells propel themselves through the environment, as in the case of the flagellated bacterium.

The capacity to expend energy is one of the most obvious features of life at both the cellular and oreanismal levels.

Sometimes, however, the environment is moved past the cell, as when the ciliated cells that line your trachea beat upward to sweep inhaled particles back to the mouth or nose, thus protecting the lungs. Muscle contraction is another good example of mechanical work, involving not just a single cell but a large number of muscle cells Other examples of mechanical work that occur within a cell include the movement of chromosomes along the spindle fibers during *mitosis*, the streaming of cytoplasm and the movement of a ribosome along a strand of messenger RNA.



Several Kinds of Biological Work. The six major categories of biological work are shown here, (a) Synthetic work is illustrated by the process of photosynthesis, (b) mechanical work by the contraction of a weight lifter's muscles, and (c) concentration work by the uptake of molecules into a cell against a concentration gradient, (d) Electrical work is represented by the membrane potential of a mitochondrion (shown being generated by active proton transport), (e) heat production is illustrated by the sweat of the weight lifter, and (f) bioluminescence is depicted by the courtship of fireflies.

Less conspicuous than either of the previous two categories but every bit as important to the cell is the work of moving molecules or ions against a concentration gradient. The purpose of concentration work is either to accumulate substances within a cell or sub-cellular compartment or to remove byproducts of cellular activity that cannot be further utilised by a cell and, indeed, might be toxic if allowed to build up. Examples of concentration work include the active transport of sugar and amino acid molecules across the plasma membrane and the concentration of specific molecules within organelles.

Electrical work is often considered a specialised case of concentration work because it also involves movement across membranes. In this case, however, ions are transported and the result is not just a change in concentration but also the establishment of an electrical potential across the membrane. Every membrane has some characteristic potential that is generated in this way.

An electrochemical gradient of protons across the *mitochondrial* or *chloroplast* membrane is essential for the production of Adenosine triphosphate (ATP) in both respiration and photosynthesis. Electrical work is also important in the mechanism whereby impulses are conducted in nerve and muscle cells. An especially dramatic example of electrical work is found in *Electrophorus electricus*, the electric eel. Its electric organ consists of layers of cells called electroplates, each of which can generate a membrane potential of about 150 millivolts.

Because this organ contains thousands of such cells arranged in series, the eel can develop electric potentials of several hundred volts.

It is easy to forget about heat because living organisms do not use heat as a form of energy in the same way that a steam engine does. But heat is, in fact, a major use of energy in all *homeotherms* (animals that regulate their body temperature independent of the environment).

In fact, as you read these lines, about two-thirds of your metabolic energy is being used just to stay warm — that is, to maintain your body at 37° Celsius, the temperature at which it functions most effectively. The relationship between work and heat energy is demonstrated when you perspire while exercising or shiver when cold.

To be complete, we must also include the production of light, or *bioluminescence*, as yet another way in which energy is used by cells. The light produced by bioluminescent organisms is generated by the reaction of ATP with specific luminescent compounds and is usually pale blue in colour. This is a much more specialised kind of energy use than the other five categories, and for present purposes we can leave it to fireflies, luminous toadstools, *dinoflagellates*, deep-sea fish and other creatures that live in its strange, cold light.

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