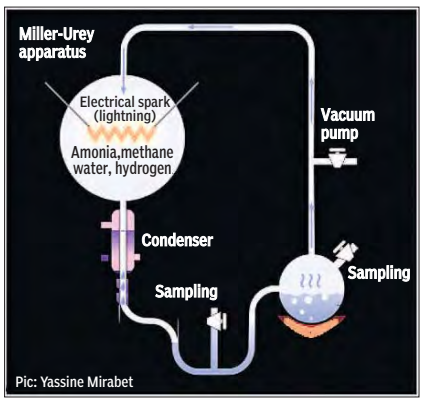
Seeds of life in comet impact

ANOTHER ROUTE TO GENERATING COMPONENTS OF LIFE HAS BEEN DISCOVERED, SAYS
S ANANTHANARAYAN

The Stanley Miller-Harold Urey experiment of 1953 had shown that *amino acids*, of which proteins are made up, are generated when a mixture of gases, like what may have existed in the primitive earth, is exposed to an electric discharge to simulate lightning. Other experiments have shown that these components could later assemble to form cell-like and primitive forms of self-replicating structures.

Zita Martins, Mark C Price, Nir Goldman, Mark A Sephton and Mark J Burchell from London, Canterbury and California, report in the journal *Nature* that the impact of rocky bodies into the icy surfaces of comets could also generate complex organic molecules, like amino acids. The discovery is significant in the context of the National Aeronautics and Space Administration's *Stardust* spacecraft having found the simple amino acid, *glycine*, in the gas surrounding the comet *81P/Wild 2*.

The Miller-Urey experiment demonstrated how organic molecules could arise from inorganic components. Water vapour, ammonia, methane and hydrogen were cycled through a flask in which electric sparks were fired. After passing through the flask where the mixture was sparked, the vapour was condensed, to be collected and heated again, and so on. Within a day, the mixture had turned pink in colour, and at the end of two weeks 10-15 per cent of the carbon in the system had turned to organic compounds. Two per cent of the carbon had formed amino acids, with glycine as the most abundant. Eighteen per cent of the methane-molecules became bio-molecules. The rest turned into hydrocarbons like bitumen. In an interview, Miller said, "Just turning on the spark in a basic prebiotic experiment will yield 11 out of 20 amino acids."



Pic: Yassine Mirabet

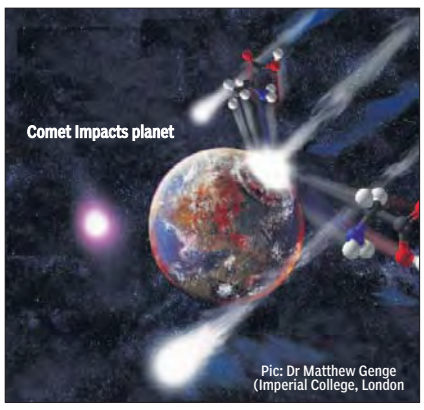
The experiment verified an earlier hypothesis, of Alexander Oparin and JBS Haldane, that the oxygen-free conditions of the very early earth would have favoured synthesis of organic molecules, using the energy of sunlight or lightning flashes. There are then different mechanisms suggested for explaining the appearance of the complexity of life, from high temperatures and a reducing (as opposed to oxidising) environment to freezing conditions. In extreme cold, water freezes, leaving dissolved components of organic molecules in higher concentration and under pressure. Freezing conditions thus favour the formation of two of the four bases of the DNA molecule, while the other two need boiling conditions.

At the time of the Miller-Urey experiment, there was consensus that early earth had a strongly reducing or hydrogen-rich and oxygen-free environment. The evidence hence appeared to be that the origin of life on earth was by synthesis driven by impacts, sunlight or electrical discharge. But there is now ground to hold that the early atmosphere on earth was either weakly reducing or neutral. Such conditions affect the extent and composition of amino acids that could be synthesised and suggest looking for other mechanism for the appearance of life.

Extra-terrestrial

The alternate mechanism is that the precursors of life originated in outer space and were brought to earth through comets or meteorites or were acquired through gravitation. The discovery of *glycine* in the clouds that surround *81P/Wild 2* strongly suggested that this was in fact the route that was followed.

In 1999, Nasa sent out a 300-kg robotic space probe, *Stardust*, with the primary mission of collecting dust samples from the coma or atmosphere of comet *Wild 2* (pronounced "Vilt 2"). *Stardust* flew through the dense gas and dust close to the icy comet in January 2004. A special grid, filled with a sponge-like "aerogel" material collected gas and dust and was stored in a capsule, to be parachuted down to earth when the craft returned in 2006. Since then, the samples of comet dust in the aerogel, and also on the aluminium foil used in the grid, have been analysed with better and better equipment to deal with the exceedingly sparse sample material.



Pic: Dr Matthew Genge (Imperial College, London

The first analyses showed traces of glycine both in the aerogel and on the foil. But as glycine is used by life forms on the earth, it was possible that this was just contamination. To check on this possibility, an isotope analysis of the carbon atoms in the glycine was carried out. The carbon atom can be of two kinds, the regular kind, with 12 particles in the nucleus, or the radioactive kind, which has 13. The processes that give rise to molecules, including glycine, on earth have reached a balance with a certain proportion of C_{12} to C_{13}. But samples of glycine that have come from space would have a slightly higher C_{13} content. Analysis has shown that the glycine in the *Stardust* capsule had the higher percentage, which indicates that it did come from the gas cloud around the comet.

Finding amino acids out in space puts a whole new spin on the question of where the molecules of life on earth came from. "If you're seeing amino acids in comets, then that really gives credence to the idea that the basic components of life are going to be widespread throughout the universe," planetary biologist Max Bernstein of the Nasa Astrobiology Institute said.

How did they get there?

The sources of complex organic molecules in space are considered to be impacts of icy bodies, like comets, on rocky surfaces or the impact of hard projectiles on icy surfaces, like the satellites of Jupiter or Saturn. There is ample evidence that these satellites contain ammonia, carbon dioxide and methane. As there are so many Solar System objects that have the necessary starting components, the authors of the paper published in *Nature* undertook to test whether impacts on icy objects could create organic molecules.

The main target samples were ice formed of ammonia dissolved in water, carbon dioxide and methanol, in the ratio 9.1:8:1, frozen to -160? Celsius. The targets were divided into two samples, one was impacted and the other was placed below the first so that it experienced the same conditions but was not impacted. The impact was by high-speed steel projectiles, impelled to about seven kilometres a second by a gas gun especially designed with a light gas, like helium or hydrogen. After impacting, the samples were heated to over 90? Celsius so that the ice mixtures evaporated and left a residue, which was examined for traces of organic molecules using chemical and spectroscopic methods.

Analysis showed that the high-speed impact of typical comet ice mixtures resulted in a number or amino acids. All containers and implements had been sterilised by baking at 500? Celsius for six hours. The methods of analyses were the same as used with the samples that had come from space. The control, unimpacted, ice as well as the containers and implements were also analysed to be sure that what was detected was from impacting ice. The experiment thus shows that impaction is a reliable mechanism to account for extraterrestrial amino acids and an analysis of the results of different speeds of impacts has yielded some ideas about the pathway of synthesis.

"These results present a significant step forward in our understanding of the origin of the building blocks of life," say the authors in the paper. The results will guide the selection of instruments to accompany future life-detection missions that are planned to the icy moons of Jupiter and Saturn.

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ACTIN-BASED CELL MOVEMENT

MYOSINS, SAYS **TAPAN KUMAR MAITRA**, HAVE DIVERSE ROLES IN CELL MOTILITY

The movements of molecules and other cellular components also occur along another major filament system in the cell, the actin cytoskeleton. As with microtubules, mechanoenzymes act as ATP-dependent motors that exert force on actin microfilaments within cells. These mechanoenzymes are all members of a large super-family of proteins known as myosins.

Currently, there are at least 18 known classes of myosins and all have at least one polypeptide chain called the heavy chain, with a globular head group at one end attached to a tail of varying length. The globular head binds to actin and uses the energy of ATP hydrolysis to move along an actin filament. The structure of the tail region varies among the different kinds of myosins, giving their molecules the ability to bind to a variety of different molecules or cell structures. The tail structure also determines the ability of myosins to bind to other identical myosins to form *dimers* or large arrays.

Myosins typically contain small polypeptides bound to the globular head group. These polypeptides, referred to as the light chains, often play a role in regulating the activity of the myosin ATPase. Some are unusual in that they have a binding site for actin in their tail region, as well as in the head. In addition, some myosins, such as myosin I and myosin V, appear to bind to membranes, suggesting that these forms of myosin play a role in the movement of the plasma membrane or in transporting membrane-enclosed organelles inside the cell.

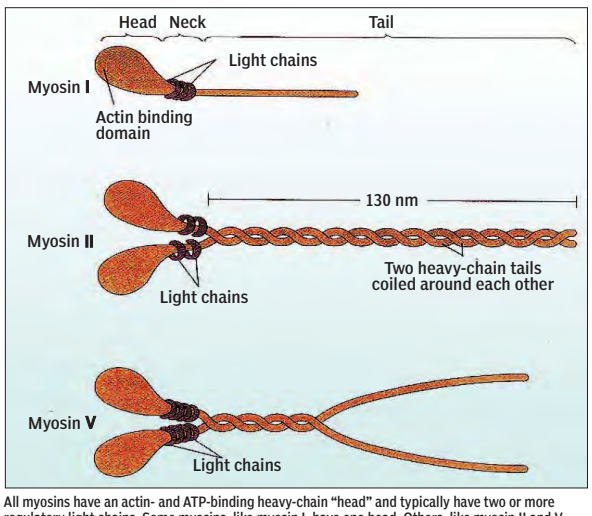
Several myosins have been shown to have specific functions in events as wide-ranging as muscle contraction, cell movement and phagocytosis. For example, mutations in a indicate that a myosin V is required for the transfer of pigment granules from melanocytes (cells that produce pigment) to keratinocytes (cells in the hair shaft that normally take up the pigment). A myosin V also appears to be required for normal positioning of the smooth endoplasmic reticulum in nerve cells, suggesting that it functions in vesicle transport or other membrane-associated events. A human disorder called Griscelli's disease, which involves partial albinism and neurological defects, has recently been shown to result from a mutation in the same class of myosin. One unexpected function for myosins from several classes is in the maintenance of structures required for hearing in humans.

The best-understood myosins are type II. They are composed of two heavy chains, each featuring a globular head, a hinge region, a long rod-like tail and four light chains. These myosins are found in skeletal, cardiac (heart), and smooth muscle cells as well as in non-muscle cells. Type II myosins are distinctive in that they can assemble into long filaments such as the thick filaments of muscle cells. The basic function of myosin II in all cell types is to convert the energy of ATP to a mechanical force that can cause actin filaments to slide past the myosin molecule, typically resulting in the contraction of a cell.

For example, in Drosophila embryos, a non-muscle type II myosin is found at the free edges of a sheet of epithelial cells that closes rather like a purse string. Analysis of mutants in which this myosin is missing or defective indicates that it is required for the closure of the sheet. The myosin II may allow the free edge of the sheet to contract by the sliding of actin microfilaments at its free edge. There is some evidence from slime mold cells grown in suspension that non-muscle type II myosins are also involved in the constriction of the contractile ring during cytokinesis.

Like kinesins, myosins have been studied at the level of single molecules. Several techniques have been used to analyse how myosin heads move along actin filaments and how much force a single myosin head can generate. All rely on the observation that myosins will move along actin filaments *in vitro* in the presence of ATP. These techniques have shown that the force individual myosin heads exert on actin is similar to that measured for kinesin. The average distance that a myosin II can slide an actin filament is about 12-15 nanometres. Like kinesin, myosin II is an efficient motor; when myosins must pull against moderate loads, they are about 50 per cent efficient.

It is useful to compare the two best-studied types of cytoskeletal motor proteins, "classic" kinesin and myosin II, because it is now possible to see how they function as biochemical motors at the level of single-molecules. Both have two heads that they use to "walk" along a protein filament, and both utilise ATP hydrolysis to change their shape. Despite these similarities, there are profound differences as well. Conventional kinesins operate alone or in small numbers to transport vesicles over large distances; a single kinesin can move hundreds of nanometers along a single microtubule. In contrast, a single myosin II molecule cannot move an actin filament as far as the next binding site on its own. Instead, myosin II molecules often operate in large arrays. In the case of myosin filaments in muscle, these arrays can contain billions of motors working together. The best-characterised conventional myosin that operates in such huge arrays was the first to be identified, myosin II involved in contrac-Bi of skeletal muscle.



All myosins have an actin- and ATP-binding heavy-chain "head" and typically have two or more regulatory light chains. Some myosins, like myosin I, have one head. Others, like myosin II and V, associate via their tails into two-headed proteins.

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A leap into the unknown

THE LEGENDARY CLONED EVENTING HORSE TAMARILLO IS ARGUABLY THE MOST STORIED ANIMAL OF ANY KIND TO BE REPLICATED TO DATE ~ BUT SOME EQUINE EXPERTS QUESTION THE PRACTICE, WRITES **ARCHIE BLAND**

To the layperson, Tamarillo probably looks like any other horse, but not to aficionados of eventing, the mixed equestrian discipline that requires competitors to show an extraordinary blend of courage, discipline and grace. To his owners, MW and Finn Guinness, Tamarillo has always been different. "I knew he was going to win everything from the beginning," said MW. "He was famous for this graceful movement. He had fans all over the world."

He stands out, the experts say, for his speed, his endurance, and his lightness in the dressage part of the sport. (That's the bit with the dancing horses, particularly popular during last summer's Olympics.) As much as anything else, Tamarillo was popular with fans for his personality and his charm. "He's exceptionally beautiful, and he has a real intelligence," says Lucy Higginson, editor of *Horse and Hound* magazine. "You needed an absolutely world-class rider to bring the best out of him – he was an exciting horse to watch because you never quite knew if he was going to bubble over. He was a complicated hero."

With just such a rider, William Fox-Pitt, Tamarillo had huge success, winning Badminton and Burghley horse trials, two of the biggest events in the sport. He had been in with a shout of an Olympic medal in Athens in 2004 when disaster struck — a chipped bone in one of his back legs as he completed a flawless cross-country round. Tamarillo is retired now, but that injury remains a source of regret to those who love him. Little wonder that they would like nothing better than to breed from the horse and see if an heir could match, or better, his achievements.

There's just one problem — Tamarillo can't breed. Like most stallions that take part in eventing, he was gelded — castrated — to avoid the kind of hormonal flightiness that can make for an uncontrollable competitor. When they saw how talented he was, the Guinnesses had hopes of breeding a sibling from his mother, Mellita.

"I adored her," says MW. "She was the best horse I ever rode." But then Mellita died. MW says she cried for a year. The hopes of another Tamarillo had gone. Or so you would think. In fact, there is a foal in New Jersey that proves this is not the case. He is said to move just like Tamarillo. He even shares a distinctive white "sock" on his left hind leg. And, although he is 21 years younger, he is the older horse's identical twin.

The foal — tentatively named Tomatillo, another variety of tomato — is a clone. Bred in secrecy, his existence was revealed recently by *Horse and Hound*. The similarities are said to be uncanny. "It's spooky how like Tam he is," William Fox-Pitt told the magazine. "You see this little boy darting around while all the other horses are standing still. He's a clown, just like Tam. He's still doing that at 21."

Although there are hundreds of cloned horses and other animals, Tomatillo is only the second eventing horse to be cloned from a British original; and Tamarillo is arguably the most storied horse of any kind to be replicated to date. Furthermore, the idea is gaining in currency. The International Federation for Equestrian Sports reversed their position and approved the right of clones to participate last year. In the USA, the governing body of quarter horse racing — sprinting contests over very short distances between small animals — lost a legal challenge to their ruling against clones, setting a legal precedent that could conceivably affect thoroughbred racing in the future.

But some in the equestrian community are uneasy, and the Royal Society for the Prevention of Cruelty to Animals is against cloning. "There's huge potential for some of the animals involved to suffer unnecessary pain and distress," says Dr Nikki Osborne, senior scientific officer at the charity. The process to produce a viable foetus is known as somatic-cell nuclear transfer. Tissue is taken from the original horse's neck; the genetic material is injected into a donor mare's unfertilised egg. When that has developed into an embryo, it is inserted into a surrogate mare, which carries the foal to birth. Dr Osborne says the donor and surrogate mares can be caused to suffer by the process and adds that she is "quite categorical that the process cannot be justified".

THE INDEPENDENT

PLUS POINTS

Eye in the sky

As the earth turns and seasons change, millions of animals migrate from one part of the globe to another. Some travel thousands of miles every year in

search of food, water and amenable habitat. Human understanding of animal migratory behaviour has, up until now, been based more on conjecture than fact. But this might change soon. A study on zebra migration shows freely available satellite data can be used to gain insights into animal migration based on environmental cues.

Earlier research has proven that migratory behaviour increases extinction risk and that blocking a migratory route or loss of a preferred seasonal area for migration is often followed by a sharp decline in animal population. But this is the first time that remote sensing data has been used to monitor migration and travel speed in terrestrial mammals. The study, to be published in the *Journal of Geophysical Research: Biogeosciences*, used Nasa satellite data to document daily animal movements and map environmental conditions. It shows how zebras adjust their movement to changing environmental conditions during migration and are able to reverse migration to avoid adverse conditions or exploit renewed resource availability.

The research focused on the migration of zebras from the southeastern Okavango delta to the Makgadikgadi grasslands in Botswana. The route witnesses the second-longest zebra migration on earth. Between 1968 and 2004, animal migration on this route was blocked by a man-made fence erected to separate wildlife from domestic livestock. But within three years after the fence was removed, zebras again started taking this route to migrate at the start of the rainy season and return at the end of the rains. "The study shows how zebras can rediscover old migratory routes that have been blocked off by man-made barriers in a matter of years, once those barriers are lifted," says one of the authors, Pieter Beck, a research associate with Woods Hole Research Center in Massachusetts, USA. For the study, researchers used satellite data to monitor environmental factors, like rainfall, for investigating environmental influence on departure date and movement speed of migrating zebras in the delta.

Researchers suggest models that predict migratory movements can act as key conservation tools by evaluating vulnerability of migrating animals to population or environmental changes. They now plan to design models that can help game and conservation managers, farmers and tour operators predict animal migration. "In the future, this wealth of information has to be made more available, and presented in more meaningful ways to decision makers," says Beck. According to Stephen Harris, a professor at the School of Biological Sciences of University of Bristol, in the UK, this study "is a crucial step forward in helping us protect migration corridors as hitherto migration studies had little understanding of stimuli animals use to decide when to start migrating, how fast to migrate, and how to assess the chances of success."

SHUBHA KISHORE/CSE-DOWN TO EARTH FEATURE SERVICE

What the sun will look like when it dies

This picture gives us earthlings an idea of what the sun will look like in around five billion years, when it will effectively start coming to the end of its life. The image shows the star HD 184738, otherwise known as Campbell's hydrogen star. It is seen surrounded by a plume of reddish gas, including hydrogen and nitrogen.


The star HD 184738, also known as Campbell's hydrogen star, surrounded by plumes of reddish gas – the fiery red and orange hues are caused by glowing gases, including hydrogen and nitrogen.

Situated at the heart of a small planetary nebula (an interstellar cloud of dust and gas) HD 184738 is a sun-like star currently going through the process of ridding itself of its outer layers.

The sun will eventually go through a similar process, blowing off much of its material, which could reach as far as earth's orbit, leaving in its wake the remains of the planets in our solar system.

All that will likely remain of it is a small, dense core called a white dwarf.

NICK RENAUD-KOMIYA/THE INDEPENDENT