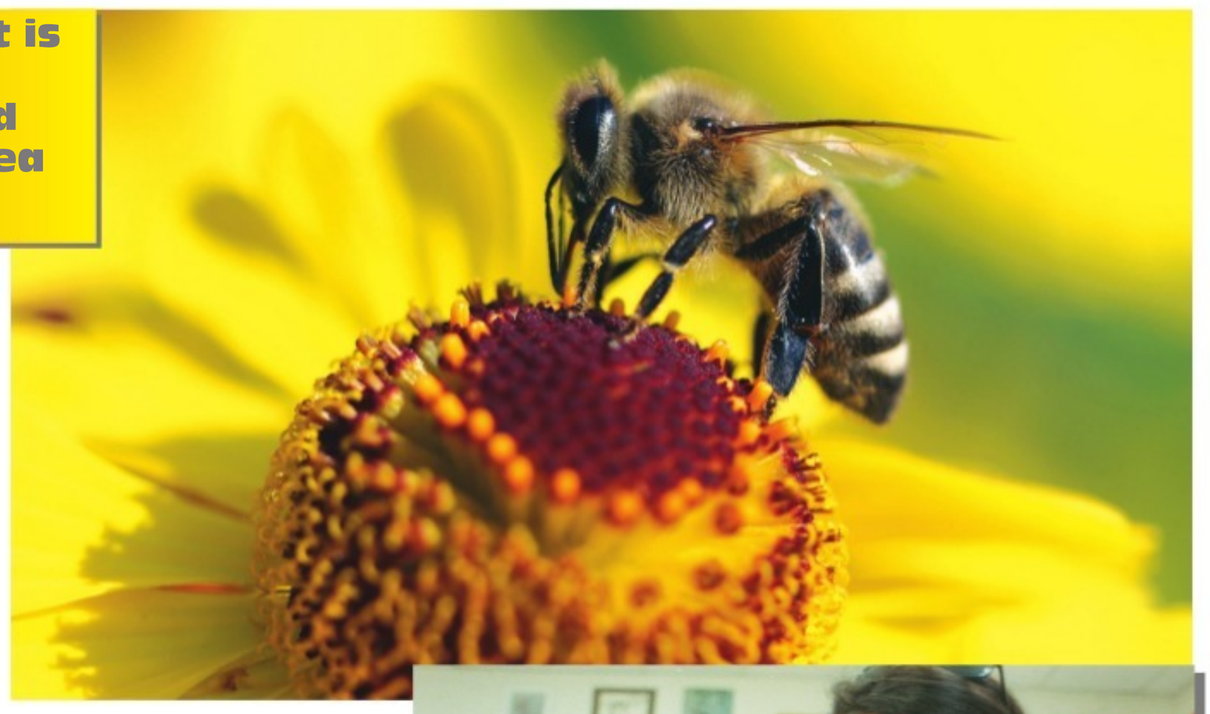
Bees count down to zero

The honey bee, it is found, can make out numbers, and even gets the idea of 'zero'



S ANANTHANARAYANAN

There is evidence that animals and birds can count up to small numbers and make out the difference between large and small collections of things. One celebrated parrot is credited with the recognition of "zero", or nothing, as a separate quantity, but numeracy in insects has not been widely studied.

Scarlett R Howard, Aurore Avarguès-Weber, Jair E Garcia, Andrew D Greentree and Adrian G Dyer, from the National Centre for Nuclear Science, Toulouse and the Royal Melbourne Institute of Technology and Monash Universities, Australia, report in the journal *Science*, a trial where honey bees could tell apart different numbers of objects shown including "no objects".

Understanding the concept of zero has been regarded as an important intellectual advance of humans and generally unique to us, the paper says. Although there is evidence that some animals have a grasp of "nothing" as being distinct, finding this ability in the distantly related species of the honey bee suggests that it is a widespread evolutionary response to the complexity of surroundings, the paper says.

A legendary story is about farmers who tested how far crows could count. A farmer walks up to a cornfield where crows are feeding, fires a gunshot in the air and goes into a cabin in the middle of the field. The crows scatter and do not return till they see the farmer walking out. The next time round, after the farmer fires the shot and enters the cabin, another farmer does the same. A little later, one of the farmers leaves, but the crows do not return, they wait till the second farmer has gone. It works the same way with three farmers and four farmers. But when there are five, the crows get uncertain when the fourth farmer left. Crows can hence count till four, but the number, five, seems to be out of their reach.

Number sense has been observed in many animals — primates, dogs, birds, rats, even fish. A prominent example is of Otto Koehler's work with a raven, Jacob, who was able to make out the numbers in collections of up to five objects. Another well known study is by Francis and Platt and Johnson, where rats learnt to press a lever between four and 16 times, as specified by the researchers, to obtain food. Work with primates has shown ability of animals to make simple additions and even to work with fractions.

A more recent study is by Pepperberg and Gordon of Brandeis University, where a grey parrot called Alex was able to differentiate numbers of different objects, up to six in number, and then articulate the number, or point to a lot with a particular number of objects when the number was spoken. He knew the numbers from one to six and could say how many green blocks there were in a mixed lot of blue, red and green, even when there were both blocks and balls of different colours.

The question could then be switched, asking Alex to identify, which was the group with four balls, for instance, from a collection of groups with different numbers. While Alex could tell the correct number 80 per cent of the time, he even responded with "none" when the answer was the absence of quantity. "Alex demonstrated numerical comprehension competence comparable to that of chimpanzees and very young children," Pepperberg and Gordon say.

This last aspect, of recognising "nothing" as a number, is of special interest. It is fairly recently, compared to the development of language and numeracy, that the concept of zero has appeared in human civilisation.

The first symbol to denote zero was used by the Babylonians in 300 BCE. The Babylonians used a number system based on a base of 60, as opposed to our own decimal system, based on the number, 10 and had complex mathematical ability. While they had a symbol for zero, they did not make full use of it — the symbol could appear within the number, to indicate the absence of quantity, like we may have in "204", but not at the end of a number, like "350" in our system.

It was only over the following millennium that the use of zero was developed, by mathematicians, Pingala to Aryabhatta, in India. That it was only in an advanced stage of civilisation that zero appeared in human computation makes it all the more remarkable that the concept exists in the animal world.

The work of the CNRS and Australian researchers is with the counting ability of the honey bee. The experimental set-up comprised a pair of panels, which displayed some numbers of dots. As bees were known to be able to count up to five, the panels had one to five dots, and each panel had a different number of dots. The game was for the bees to identify which panel had fewer dots. If they got it right, they were rewarded with sweetened water. If they got it wrong, they got a bitter, quinine solution.

The bees soon learnt the idea of "greater than" and "less than", and managed to get sweetened water most of the time. When the bees were trained, they were presented with a pair of panels where one was blank and the other had one or more dots. This time, the bees chose the blank panel — which indicates that they considered "no dots" to be less than one or more dots. This suggests that they identified "no dots" as signifying "zero" and assigned the number a lower value than the others.

A press release from CNRS notes that the bee brain has only a million neurons, which is a hundred thousand times less than what we have. The concept of zero is a pretty abstract one, which may be the reason that humans took many centuries to get to grips with it. Numbers themselves are understood as abstraction of the property that is shared by equal numbers of different objects. Zero would then be the number of objects when there are none, which is a degree of abstraction above that of other numbers.

When the bee sees "no dots" in the panel, what the brain receives is "no stimulus", as opposed to the stimuli from the dots. The brain often registers "no stimulus" when the eye sees a blank slate. But to translate this as "zero dots" in the context of counting is an act of some sophistication.

That the rudimentary brain of the honey bee should invest its resources in having this ability suggests that the concept of zero has another level where it plays a role in the survival of species.

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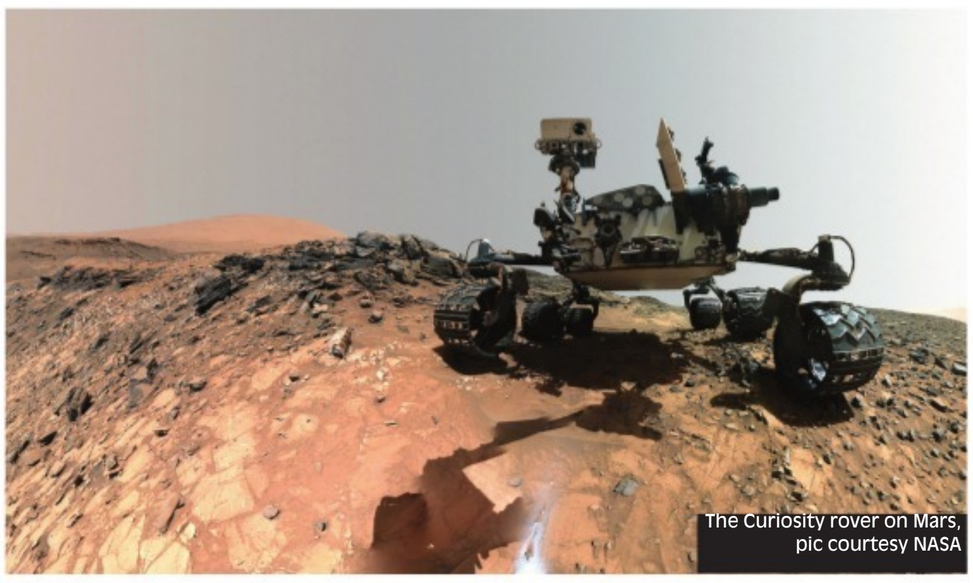
Wasn't always lifeless

Scientists say 'ingredients for life' on the Red Planet bring us closer than ever to finding extra-terrestrials



The Curiosity rover on Mars, pic courtesy NASA

JOSH GABBATISS

The latest discovery of organic matter on Mars is the closest researchers have come to finding extra-terrestrial life, according to scientists. Experts welcomed the new results from Nasa's Curiosity rover, which they say will be key in guiding future missions searching for aliens on the Red Planet.

While the results obtained are not direct evidence for life, the presence of ancient organic molecules preserved in the soil of a dried up lake have bolstered the case that Mars was not always the lifeless place seen today."To understand Mars was habitable and the conditions for life could have been there — part of the jigsaw was organics," John Bridges, head of the Mars Science Laboratory at the University of Leicester, told *The Independent*.

The case was further supported by the presence of fluctuating clouds of methane, which itself could be evidence of microbe activity on the planet surface. "We find remnants of organics in 3.2 to 3.8 billion year old rocks, and we find them in an environment we discovered was habitable around the same time," Inge Loes ten Kate, an astrobiologist at Utrecht University told *The Independent*, "That means there could have been life." As these kind of substances can serve as "starter materials", they are evidence that the arid planet could once have allowed life to flourish.

"This doesn't say anything about life actually being present, but there are ingredients for life," said ten Kate. However, as the organic materials and the methane could well be explained by geological processes, further exploration of the planet's surface will be crucial to confirm the presence of alien life in our solar system.

The launch of ExoMars, a joint European-Russian programme that will take another rover to the planet's surface, will take its cue from Curiosity's latest findings. "We are ramping up for ExoMars in 2020, and we will have a meeting in Leicester in November where we finally select the landing site," said Bridges, "Nasa's discovery will inform this decision."

Other targets in the search for aliens, such as the moons Enceladus and Europa, are "just as valid", according to r ten Kate. The oceans found underneath the surface of these astronomical bodies seem promising potential homes for alien microbes, but the current case is nowhere near as strong as Mars.

If life is ever found in other parts of our solar system, it will help scientists understand the origin of life on Earth as well. While Martians would support the idea of the first organisms emerging on the planet's surface, Europa and Enceladus would suggest a deep-sea origin.

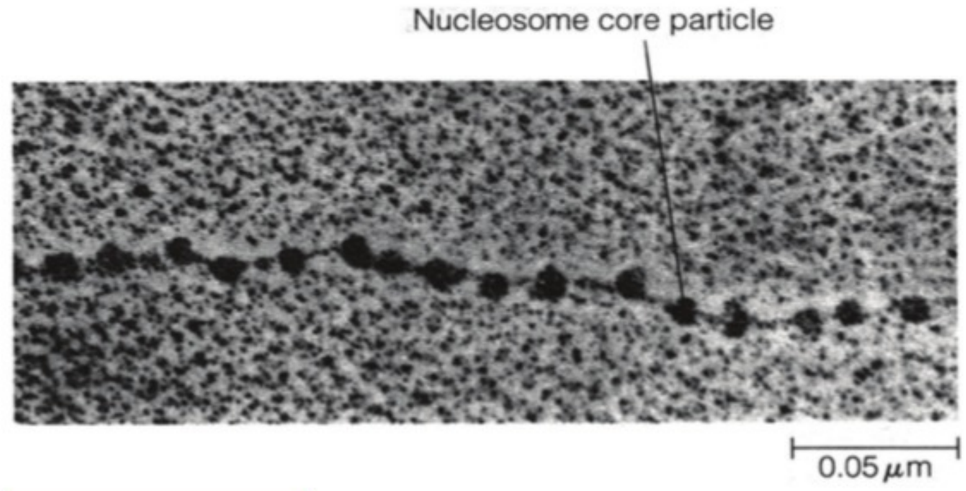
Finding organics on Mars is the culmination of years of frustration and false alarms, after the Viking programme failed to provide convincing evidence in the 1970s. According to Bridges, the latest news shows how far scientists' knowledge of the Red Planet has advanced in recent years. "If you look back before 2012, our view of Mars has really changed — we guessed there had been water and so on but we didn't have the hard evidence there had been long-standing lakes and river systems," he said.

"Now we know they are there — and now we know the mudstone in the lakes were organic-bearing. We're piecing it all together."

The independent

Repeating in intervals

Nucleosomes are the basic units of a chromatin structure



TAPAN KUMAR MAITRA

The DNA contained within a typical nucleus would measure a metre or more in length if it were completely extended, whereas the nucleus itself is usually no more than five to 10 μm in diameter. The folding of such an enormous length of DNA into a nucleus that is almost a million times smaller presents a significant topological problem.

One of the first insights into the folding process emerged in the late 1960s, when X-ray diffraction studies carried out by Maurice Wilkins revealed that purified chromatin fibres have a repeating structural subunit that is seen in neither DNA nor histones alone. Wilkins therefore concluded that histones impose a repeating structural organisation upon DNA.

A clue to the nature of this structure was provided in 1974, when Ada Olins and Donald Olins published electron micrographs of chromatin fibres isolated from cells in a way that avoided the harsh solvents used in earlier procedures for preparing chromatin for microscopic examination. Chromatin fibres viewed in this way appear as a series of tiny particles attached to one another by thin filaments.

This "beads-on-a-string" appearance led to the suggestion that the beads are made of proteins (presumably histones) and the thin filaments connecting the beads correspond to DNA. We now refer to each bead, along with its associated short stretch of DNA, as a nucleosome.

On the basis of electron microscopy alone, it would have been difficult to determine whether nucleosomes are a normal component of chromatin or an artifact generated during sample preparation. Fortunately, independent evidence for the existence of a repeating structure in chromatin was reported at about the same time by Dean Hewish and Leigh Burgoyne, who discovered that rat liver nuclei contain a nuclease that is capable of cleaving the DNA in chromatin fibres.

In one crucial set of experiments, these investigators exposed chromatin to this nuclease and then purified the partially degraded DNA to remove chromatin proteins. When they examined the purified DNA by gel electrophoresis, they found a distinctive pattern of fragments in which the smallest piece of DNA measured about 200 bp in length, and the remaining fragments were exact multiples of 200 bp.

Since nuclease digestion of protein-free DNA does not generate this fragment pattern, they concluded that first, chromatin proteins are clustered along the DNA molecule in a regular pattern that repeats at intervals of roughly 200 bp, and second, the DNA located between these protein clusters is susceptible to nuclease digestion, yielding fragments that are multiples of 200 bp in length.

The question arose whether the protein clusters postulated to occur at 200 bp intervals correspond to the spherical particles observed in electron micrographs of chromatin fibres. Answering this question required a combination of the nuclease digestion and electron microscopic approaches. Chromatin was briefly exposed to micrococcal nuclease, a bacterial enzyme that, like the rat liver nuclease, cleaves chromatin DNA at intervals of 200 bp.

The fragmented chromatin was then separated into fractions of varying sizes by centrifugation and examined by electron microscopy. The smallest fraction was found to contain single spherical particles, the next fraction contained clusters of two particles, the succeeding fraction contained clusters of three particles, and so forth.

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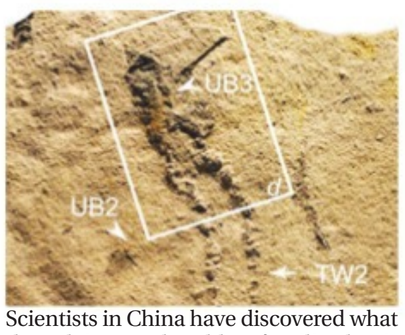
PLUS POINTS

Oldest footprints



Scientists in China have discovered what they claim are the oldest fossilised animal footprints ever found. The parallel tracks were formed in mud up to 551 million years ago in southern China's Yangtze Gorges.

They potentially date to 10 million years before the Cambrian Explosion, when arthropod and other animal life rapidly flourished, and when creatures with pairs of legs capable of leaving such footprints were thought to have arisen.

Scientists from the Chinese Academy of Sciences' Nanjing Institute of Geology and Palaeontology, along with colleagues from Virginia Tech in the US, studied the tracks and burrows found within part of the Denying Formation, a fossil-rich area near the Yangtze River.

Asked how the teams knew the impressions were footprints, Dr Shuhai Xiao of Virginia Tech told *The Independent*, "If an animal makes footprints, the footprints are depressions on the sediment surface, and the depressions are filled with sediments from the overlying layer. This style of preservation is distinct from other types of trace fossils, for example, tunnels or burrows, or body fossils.

"The footprints are organised in two parallel rows, as expected if they were made by animals with paired appendages. Also, they are organised in repeated groups, as expected if the animal had multiple paired appendages."

Previously, no evidence of limbed animals had been discovered that predated the Cambrian Explosion, the sudden surge in diversity that occurred on Earth around 510 to 540 million years ago.

Unusually, the footprints of the creature in question appear to be irregular and disorganised, suggesting it was somewhat clumsy. In the paper published on the findings, researchers said tracks bore a resemblance to fossil prints recorded in Dunure and Montrose in Scotland, thought to be between 419 and 358 million years old.

The new find does not however provide scientists with enough information to determine what kind of animal the footprints belonged to.

The independent

Drones to the rescue

A new report demonstrating how drones can come to the rescue in natural disasters, help starving people in conflict and provide emergency medicine has been published recently by one of the UK's leading robotics experts.

The report, unveiled by the Foundation for Responsible Robotics, which is led by Noel Sharkey from the University of Sheffield, outlines five key areas in which drones can be used to benefit humanity.

Aside from industrial uses, drones have gained a bad reputation as tools for violations of human rights, breaches of privacy and irresponsible and dangerous uses by hobbyists — particularly at airports. However, new uses of drones are emerging that could greatly benefit us all, according to the authors of the report.

The report highlights how, if used appropriately, drones can serve society in numerous ways:

- Humanitarian aid: assisting in the acquisition of data during humanitarian crises and delivering essential goods such as food and medical supplies;
- Environmental protection: helping scientists with observation of (often endangered) species as well as monitoring and wildlife protection;
- Emergency services: search and rescue, monitoring disasters and crises, inspecting critical infrastructure, and finding missing persons;
- Responsible journalism: reaching areas of international interest that might otherwise be inaccessible;
- Activism: helping activists collect information about societal injustices, such as pollution from industry, unjust livestock treatment, inadequate delivery of healthcare supplies, et al.

"The benefits of using drones in some circumstances can reap great benefits but we need to ensure that we don't overlook potential negative impacts on individuals, communities, and the environment that would undermine the benefits of the technology," emphasises Kristen Thomasen from the law faculty of Windsor University, Canada.