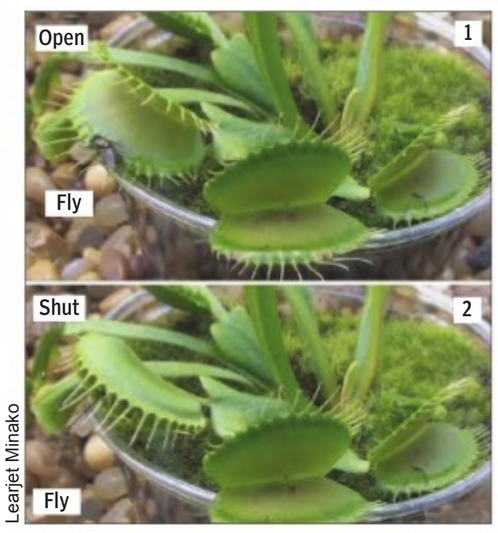
Drumbeat of the flytrap

THERE IS CLOCKWORK THAT DRIVES THE ACTION OF INSECT-EATING PLANTS, WRITES **S ANANTHANARAYANAN**

The Venus Flytrap, or *Dionea Muscipula*, left Charles Darwin spellbound by its ability to sense, capture and digest small creatures to supplement the nutrients it received from its depleted habitat. That a plant that is usually lower in the food chain can turn carnivorous was, indeed, testimony to the potency of evolution.

The Venus Flytrap is native to South and North Carolina in the USA and is usually found in swamps and bogs, areas that are typically poor in nitrogen and phosphorus. Nitrogen is vital for plant growth, particularly for the synthesis of chlorophyll, and hence the need for a plant that cannot fond nitrogen in the soil to look for other sources. A team of researchers from institutes in Germany and also Australia, Madrid and Riyadh report in the journal *Current Biology* their study of the mechanism and sequence of events in the remarkable adaptation of the Venus Flytrap in providing for metabolic nitrogen by the digestion of animal tissue.


Noah Elhardt



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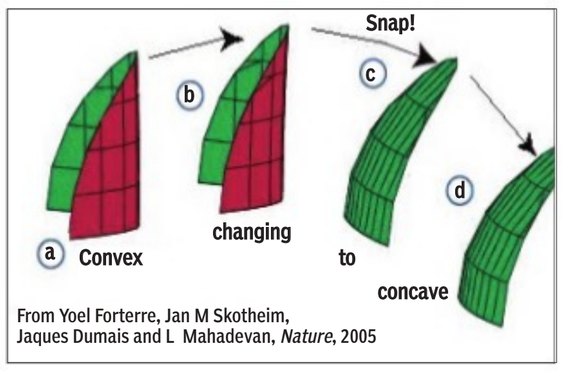

From Yoel Forterre, Jan M Skotheim, Jaques Dumais and L Mahadevan, *Nature*, 2005

It is a small plant that consists of four to seven leaves that branch out from a short stem, almost at the root. The leaves start out as a heart-shaped, base portion that receives sunlight and carries out photosynthesis, but the true leaf is a pair of lobes that are joined in the midrib. The inner surface of the lobes is covered with a gluey substance called mucilage, which has a fruity odour, and attracts small insects. The surface also contains fine, hinged sensors that are the trigger-hairs that cause the two lobes to snap shut, to trap the insect when one touches them. The action is that light movement of the sensors sets off an electrical *Action Potential*, a short electrical burst of electricity discharge by the movement of charged ions within cells at the base of the hairs.

The effect is similar to the passing of signals by nerve cells that cause the flexing of muscle tissue in animals. The result is that the two lobes snap shut within a fraction of a second and capture the insect.

This snapping shut of the lobes is one of the fastest movements in the plant kingdom. How this comes about has long remained a mystery and explanations of Action Potential-induced loss of fluid pressure, etc, have been unsatisfactory. But high-speed photography studies of the closing lobes have shown that it comes about by the relaxing of elastic tension of a concave surface that has been stretched into a convex shape, as suggested in the picture. The edges of the lobes also have larger hairs that act as a barrier to prevent the escape of larger prey. The idea, however, as we shall soon see, is that smaller prey should get away.

A special feature of the snap-shut reaction of the lobes is that it does not occur at the first touch of the trigger hairs — it happens at the second, if the second touch comes within 15-20 seconds. The reason is one of economy, to be sure that any action taken would be purposeful; one contact with a trigger hair can happen without an insect being there — it could be a dewdrop, for instance — it does not make sense to activate an energy-expensive arrangemen where there may be no reward. But if the same hair is touched twice, or another hair is disturbed within a short time, then there is no sense in waiting and the trap snaps shut.

This is for activating the snapping shut. The next action is both to tighten the hold and secrete a mix of juices to break down the tissues of the insect that has been caught and to extract the nutrients. While the body of the lobes is provided with ample glands to secrete digestive enzymes, it takes resources to generate these substances and it does not make sense to use them unless the kill has been a worthwhile one. The Flytrap, hence, waits for a third contact with a trigger hair, which there would be if it was really an insect and a reasonably large one, before the secretion of juices is started. If there is no third touch, either because it was not really an insect or it was a small one that died or crawled away, then the lobes slowly open out after a few hours.

The *Current Biology* researchers made actual measurements of electrical impulses arising from the touch of the trigger hairs by attaching a light silver contact to the outer surface of the Flytrap lobe. When experimental six-12 mm crickets were exposed to the trap, it was seen that the lobes snapped shut at the second electrical pulse and then the pulses continued over 60 times after that as the insect struggled.

Apart from the electrical activity, the effects of mechanical force or stimulus on plants are well known. Root cells, for instance, grow around obstacles and the tendrils of climbing plants are able to sense shape and fashion growth to gain support. These responses are the result of the synthesis of a substance called *jasmonic acid* (JA) as soon as there is the touch of a category of cells. As there have also been studies that show that there is an increase in JA-derived substances soon after prey capture by the Venus Flytrap, the *Current Biology* group simulated prey capture by mechanical stimulation of trigger hairs and monitored the levels of JA derivatives and also the tissue-decomposing and nutrient-transporting enzymes and agents in the "green stomach" created by the Flytrap.

The group observed that the level of activity, which amounts to nutrient-gathering investment by the plant, increases according to the drumbeats of trigger hair stimulation by the struggling insect. While there is no secretion of digestive fluids till the third AP, continued stimulation increases the closing of the lobes till the cavity is sealed airtight. And as the insect keeps struggling, the quantity of juices secreted, including agents to transport nutrients, increases to deal with the larger prey.

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PLUS POINTS

Ancient prosthetics

About 1,500 years ago, there lived a man in Europe without a left foot. Instead, he wore a wooden prosthetic limb. Archaeologists digging in southern Austria's Hemmaberg found the man's grave in 2013 but only recently revealed details about the prosthetic. The findings will be published in the *International Journal of Paleopathology*.

"This represents one of the oldest examples of prosthetic limb replacement associated with the skeleton of its wearer in Europe to date," the study authors write. The middle-aged man's left foot was missing and in its place was an iron ring and pieces of wood, according to the researchers. They used radiography and CT-scanning to determine that the man had a lesion that had healed. "He appears to have got over the loss of his foot and lived for two more years at least with this implant walking pretty well," Sabine Ladstätter of the Austrian Archaeological Institute, told the *AFP*. This wouldn't be the oldest use of a prosthetic device though as it's believed they were used in ancient Egypt and the Greco-Roman world. But "archaeological evidence for the practice prior to the second millennium AD is very scant," the study says.

THE WASHINGTON POST

Brightest imaginable

Astronomers have detected the brightest known exploding star in the Universe in a galaxy about 3.8 billion light years away. It is about 570 billion times brighter than the Sun and 20 times brighter than all 100 billion stars in the Milky Way galaxy put together. So much energy has been emitted from the supernova, known as ASASSN-15lh that scientists are mystified about what could be responsible, although they suspect it may have come from a type of rapidly-spinning neutron star, called magnetars, which are the leftover, hyper-compressed cores of massive, exploded stars.

Another theory is that the explosion, first detected by telescopes in Chile in June 2015, might have been triggered by the demise of incredibly massive stars that are even bigger than the biggest one imaginable to astronomers.

"ASASSN-15lh is the most powerful supernova discovered in human history. The explosion's mechanism and power source remain shrouded in mystery because all known theories meet serious challenges in explaining the immense amount of energy it has radiated," said Professor Subo Dong of the Kavli Institute for Astronomy and Astrophysics at Peking University in Beijing who is also the lead author of the study published in the journal *Science*.

STEVE CONNOR/THE INDEPENDENT

Lychees can kill

Researchers confirmed that a toxic chemical in the fruit of the Asian lychee tree (*Litchi chinensis*) is responsible for outbreaks of a fatal brain sickness in children in Bihar, where the fruit is commercially grown. Methylene Cyclopropyl-Glycine has been detected in lychee fruit by a team of virologists led by T Jacob John at the Christian Medical College, Vellore in India. The findings were published in *Current Science* on 25 December 2015. The chemical is akin to another toxin found in ackee (*Blighia sapida*), a West Indian fruit. Both lychee and ackee come from the *Sapindaceae* (soapberry) family of plants.

Methylene Cyclopropyl-Glycine is known to cause hypoglycaemic encephalopathy, a metabolic illness that affects the brain when body sugar levels are low due to fasting or undernourishment. Earlier, viral encephalitis was suspected to be causing the deaths. "When no virus was detected, researchers suspected a toxin from pesticides or from the fruit itself," says John.

Methylene Cyclopropyl-Glycine forms compounds with carnitine and coenzyme A, making them less available for important metabolic reactions in the body. When a person is fasting, stored glycogen is released initially for energy production. Later, body fat is mobilised and this requires a breakdown of fatty acids aided by carnitine and coenzyme. "When this metabolism is impaired, hypoglycaemia develops," said Maya Thomas, a paediatric neurologist at CMC, Vellore.

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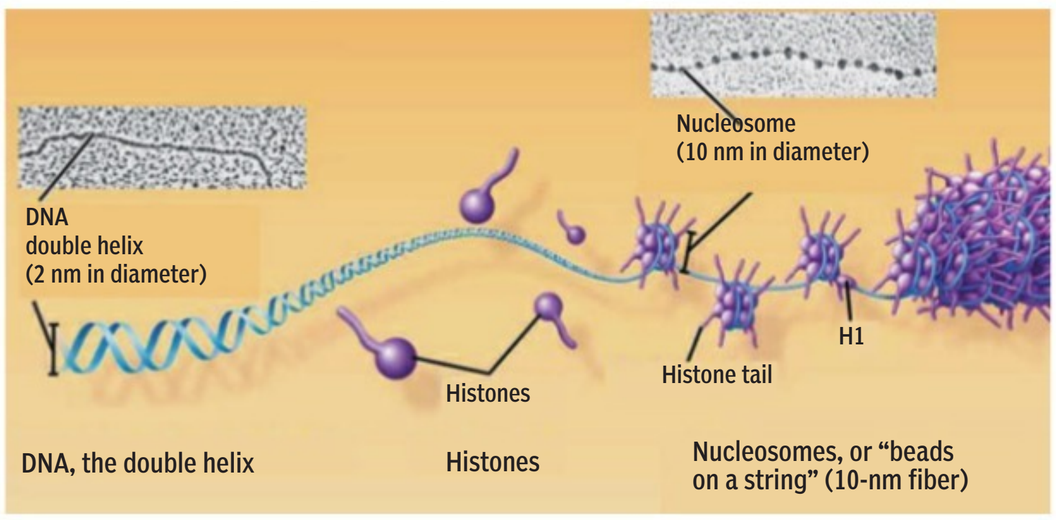
DNA PACKAGING

TAPAN KUMAR MAITRA EXPLAINS THE MECHANISMS BY WHICH PROKARYOTIC AND EUKARYOTIC CELLS PRODUCE CHROMOSOMES

The amount of DNA a cell must accommodate is huge even for organisms with genomes of modest sizes. For example, the typical *E coli* cell measures about 1 μm in diameter and 2 μm in length, yet it must accommodate a (circular) DNA molecule with a length of about 1,600 μm — enough to encircle it more than 400 times.

Eukaryotic cells face an even greater challenge — a human cell contains enough DNA to wrap around it more than 15,000 times. Somehow all this DNA must be efficiently packaged yet still remain accessible to the cellular machinery for both DNA replication and the transcription of specific genes. Clearly, DNA packaging is a challenging problem for all forms of life. Let's look at how prokaryotes accomplish the task of organising their DNA and then consider how eukaryotes address the same problem.



In eukaryotes, DNA is complexed with histone proteins forming "beads" called nucleosomes, which appear as 10 nm chromatin during interphase.

The genome of prokaryotes such as *E coli* was once thought to be a "naked" DNA molecule lacking any elaborate organisation and with only trivial amounts of protein associated with it. We now know that the organisation of the bacterial genome is more like the chromosomes of eukaryotes than previously realised.

Bacterial geneticists therefore refer to the structure that contains the main bacterial genome as the bacterial chromosome. It is typically a circular DNA molecule, containing some bound protein, which is localised in a special region of the cell called the nucleoid. The DNA of the bacterial chromosome is negatively super-coiled and folded into an extensive series of loops averaging about 20,000 bp in length. Because the two ends of each loop are anchored to structural components found within the nucleoid, the super-coiling of individual loops can be altered without influencing that of adjacent ones.

In addition to its chromosome, a bacterial cell may contain one or more plasmids, which are relatively small, circular molecules of DNA that carry genes both for their own replication and, often, for one or more cellular functions (usually non-essential ones). Most plasmids are super-coiled, giving them a condensed form. Although plasmids replicate autonomously, the process is usually in sufficient synchrony with the replication of the bacterial chromosome to ensure a roughly comparable number of plasmids from one generation to the next. In *E coli* cells, three classes of plasmids are recognised. F (fertility) factors are involved in the process of conjugation while R (resistance) factors carry genes that confer drug resistance on the bacterial cell. And col (colicinogeni) factors allow the bacterium to secrete colicins, compounds that kill other bacteria lacking the same. In addition, some strains of *E coli* contain cryptic plasmids, which have no known function.

Coming to eukaryotic cells, DNA packaging becomes more complicated. First, substantially larger amounts are involved — each chromosome contains a single, linear DNA molecule of an enormous size. Second, greater structural complexity is introduced by the association of eukaryotic DNA with larger amounts and numbers of proteins. When bound to such proteins, the DNA is converted into chromatin fibres measuring 10 to 30 nm in diameter, which are normally dispersed throughout the nucleus. At the time of cell division (and in a few other special situations), such fibres condense and fold into much larger, compact structures that become recognisable as individual chromosomes.

The proteins with the most important role in chromatin structure are the histones, a group of relatively small proteins whose high content of the amino acids, lysine and arginine, gives them a strong positive charge. The binding of histones to DNA, which is negatively charged, is therefore stabilised by ionic bonds. In most cells, the mass of histones in chromatin is approximately equal to the mass of DNA. Histones are divided into five main types, designated HI, H2A, H2B, H3 and H4.

Chromatin contains roughly equal numbers of H2A, H2B, H3 and H4 molecules, and about half that number of HI molecules. These proportions are remarkably constant among different kinds of eukaryotic cells, regardless of the type of cell or its physiological state. In addition to histones, chromatin also contains a diverse group of non-histone proteins that play a variety of enzymatic, structural, and regulatory roles.

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History of everything

RATHER THAN BEING FEATURELESS BLOBS IN SPACE, A NEW THEORY SUGGESTS BLACK HOLES ARE FRINGED BY 'HAIRS' THAT COULD BE A RICH SOURCE OF INFORMATION, WRITES **DOUG BOLTON**

A new theory on black holes developed by famed physicist Stephen Hawking could provide a method to discovering the origins of the universe. The paper theorises that black holes, once thought to be huge, featureless blobs in spacetime, could have "hairs" that contain information about the holes' pasts, potentially solving the longstanding "information problem" of the fate of matter that falls into a black hole.

Black holes, as explained by Albert Einstein's theory of general relativity, are celestial bodies that are so dense that their strong gravitational pulls prevent anything, including light, from escaping them. For a long time, it was thought that black holes were essentially all identical apart from variations in their spin, angular momentum and mass. Any attempt to find out a black hole's origin would fail, since they contained no unique information.

In the 1970s, Hawking developed a theory that black holes, despite their huge mass, did "leak" particles over time — a phenomenon that was named Hawking radiation. Over the course of millions of years, leaking Hawking radiation causes black holes to "evaporate", leaving a vacuum. But since the original theories on black holes stated that they were all identical, these vacuums would be, too — meaning that they would hold no information about the hole's origin.

However, Hawking's new theory, developed with Cambridge University colleague Malcolm Perry and Harvard physicist Andrew Strominger, could throw that idea into doubt.

By introducting a photon with no light or energy — a "soft photon" — into one of these vacuums, you change its angular momentum, the theory claims. This would mean that rather than being identical, the vacuums left by evaporated black holes are unique, with their properties depending on their origins and history. It also suggests that black holes are fringed by "hairs" — strands of energy-free particles that can carry information.

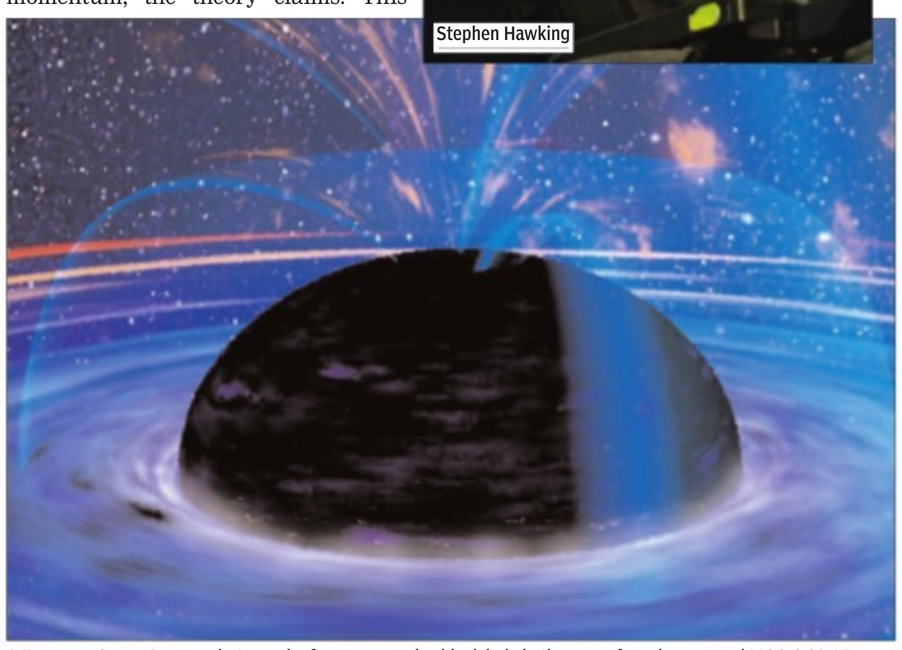
As Strominger explained to *Live Science*, "Far from being a simple, vanilla object, it's like a large hard drive that can store essentially an infinite amount of information in the form of these zero-energy photons and gravitons."

If true, this new theory means black holes could hold huge amounts of information about the universe's history. If we were somehow able to observe black holes accurately enough, we may be able to use these hairs to discover this information.

This theory could be step towards discovering what happens to information that falls into a black hole. Currently, the method for decoding the information theoretically held in black holes is unknown, but as physics progresses, we might get there one day.

THE INDEPENDENT


Stephen Hawking


A European Space Agency photograph of a supermassive black hole in the core of a galaxy named MCG-6-30-15.