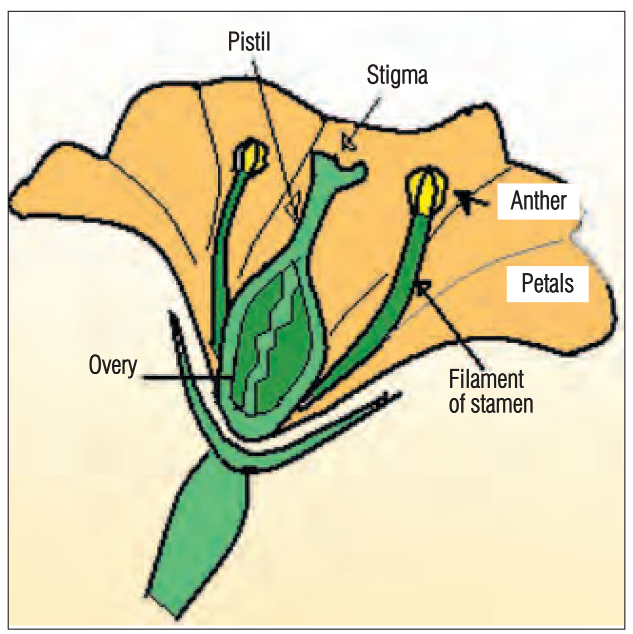
Electric charge in the food chain

THE FORAGING ADVANTAGE OF HONEYBEES HAS ITS DOWNSIDE, SAYS S ANANTHANARAYANAN



Flowers and pollinators have co-evolved. Flowers form carefully matched colours and scents to advertise their store of nectar to draw honeybees, the principal pollinator. And the bees come to feed and help carry pollen from the stamen of one flower to the pistil of another to set off the reproductive process of plants.

Pollen is also nutritious for the bee and she has evolved specialised pollen-gathering and pollen-carrying structures that help her to efficiently perform the function for which flowers keep these good things for her. To do a great job, in fact, the honeybee uses electric charges on her body to pick up the pollen from the flower, like a magnet can pick up iron filings. But biologists at the University of California at Berkley have found that the wily spider has evolved its web to make use of the electric charge to trap the bee!

Pollen is a fine, sometimes rough powder, of particles that are the precursor of *sperm cells* of the plant. This is produced in the flower in the *stamen*, which consists of a stalk and a head called the *anther*. Pollen that is released from the anther forms lumps that can attach to birds or insects, or pollen grains can be spread by the wind or water. When the pollen lands on the *pistil* of a flower, it germinates and transfers sperm cells to the *ovule*, the source of egg cells.

Bees are the main agents of pollen transference from plant to plant and they are clearly adapted for this role. Apart from pollination that takes place while gathering nectar, they also gather pollen to use as food for themselves and their young. The pollen gathering activity is the more efficient in pollination. For pollen gathering, bees are fuzzy and have dense, long, often branched hair covering their hind legs and on the lower abdomen, with a cavity, fringed with hairs, in the hind legs. But the most remarkable adaptation is that bees generate an electrostatic charge that helps attract and retain pollen grains.

Electric charge

Electrostatic charge, like electricity, consists of electrons that detach from atoms of materials. Unlike electricity, which flows in conductors, static charge collects on insulators after being transferred from other material during contact. We may have experienced the effect with plastic wrapping material that sticks to our hands. Rubbing silk in the dark can cause flashes of light when the silk gets charged and discharges. This is also the effect that makes a plastic comb pick up bits of paper after the comb has been run through the hair. In practice, the effect is used in the photocopier – the image to be printed is transferred to the paper as an electric charge to make the ink stick to the paper.


Robert Dudley


Ortega-Jiminez

The honeybee, by rapid movement of its wings, generates a sizeable electric charge, a positive one, on its body and scopa. The comb that attracts bits of paper is able to do this because the charge on the comb affects the charges on the paper; it pushes like charges away and attracts unlike charges.

The like charges then crowd in the part nearer the comb and there is a net attraction. In the same way, the charge on the honeybee attracts the unattached pollen grains on the anthers and petals, even before it actually comes into contact. And then the pollen sticks to the scopa and is not easily shaken off.

In fact, flowers have also adapted to make the best use of electrostatic charges — they have a slight negative charge. The charge on the flowers also seems to lead the bees to them. In an experiment, half a collection of uncharged, artificial flowers was sweetened with sugar water, while the other half had quinine, which bees find distasteful. When the flowers were uncharged, the bees landed randomly on the flowers, the ones that found sugar staying to sip while the others beat a hasty retreat. But when the sweetened flowers were lightly charged, the bees went to them in preference. This shows that the bees can sense the charge that flowers carry.

Spider's web

The spider's web is a marvel of biotechnology, engineering and material science. Spider silk is spun from protein-rich material in complex silk-spinning organs called *spinnerets*, located on the abdomen of the arachnid. These spinnerets create the orientation of molecules to give the material its phenomenal strength. There could be just one spinneret or two, four or eight, working independently or in concert, to create patterns that combine strength and economy. The result is the cobweb (so called from the word *coppe*, which means spider), which has been around for over 100 million years. There are different kinds of webs — spiral, tangle, funnel or tubular — and the sticky strands help trap prey without the need to run them down. But spinning the protein-rich web is energetically expensive and the material loses its texture. Spiders, hence, eat part of their web every day to recycle the protein. The construction of the strand is so efficient that weight for weight, a spider's web is many times stronger than steel. But the icing on the cake is the discovery that Ortega-Jimenez, a post-doctoral fellow at the University of Carilfornia at Berkley, and Robert Dudley, professor of integrative biology, report their findings in *Scientific*

Reports, and online facility of the publishers of the journal, *Nature*. The team reports thinner strands of spider web are electrically attracted by the positive charge on the bodies of insects that fly past. In an experiment, dead insects that were charged with the charge they usually carried were dropped on to cobwebs to see, with high-speed cameras, if the charge affected the strands. It was seen that the falling insects deformed the webs, which reached out to touch the insects before they reached the web.

"You would expect that if the web is charged negatively, the attraction would increase," says Ortega-Jimenez. The research is to be continued to determine how much this effect helped spiders in the wild, and whether charged webs attracted dirt and pollen enough to need daily renewal. It would also be interesting to see if the electric charge affected the adhesion of the sticky web material, which is known to have its own surface structure.

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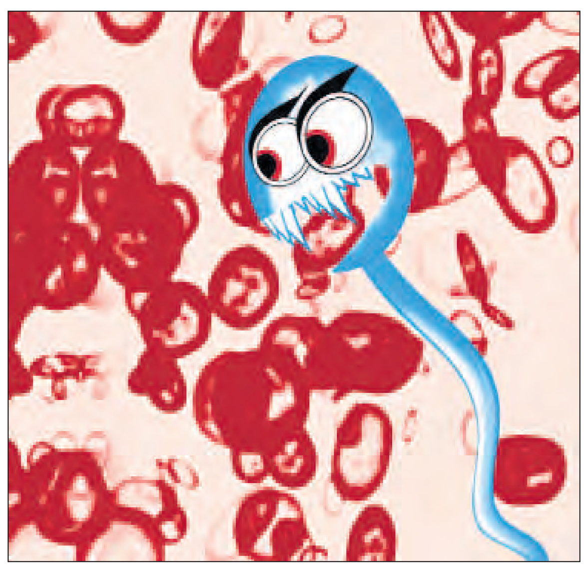
PLUS POINTS

Quick trick

Candida fungus shares a love-hate relationship with humans. It forms an integral part of the gut and skin flora, but the friendly fungus can turn foe if it overgrows or appears in other parts of the body – and then it can cause health problems, like fatigue, headache, weight gain, oral and genital candidiasis and, worst of all, a blood infection called candidemia. This infection has a 40



per cent mortality rate, mainly attributed to the long time required for a diagnostic test. But the situation might change with a new test that can detect the fungus in less than three hours.

Known as T2 Candida, the test uses magnetic resonance to detect the presence of Candida's DNA in a blood sample. Developed by researchers from T2 Biosystems, a firm involved in the production of diagnostic test kits, this test is the first single-step blood assay for detection of the fungus. The findings were published in *Science Translational Medicine* on 24 April.

The researchers say the test is far more sensitive, precise and accurate than the standard Candida test that employs blood culture and takes two to five days to produce a result. For their study, the scientists collected blood samples from 24 patients and developed blood compatible nanoparticles. Magnetic resonance technology was then used to detect Candida DNA from the blood-nanoparticle mixture. The scientists were able to correctly identify eight candidemic patients out of the 24 samples, without any false-positive readouts.

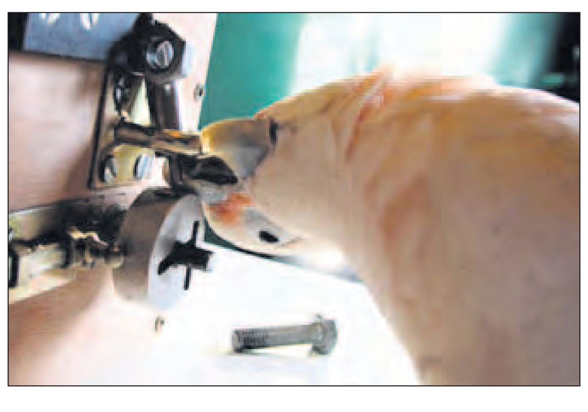
"The technology is no doubt exciting but it is too early to say whether this could be useful for quick diagnosis of blood infection in all cases," says Thangam Menon, head of the microbiology department at the University of Madras. "Candida is one of the easiest fungi to grow in the lab and presents little diagnostic challenge."

India has a fair number of candidemia cases and the disease also ails people in developed countries like the USA. The Postgraduate Institute of Medical Education and Research in Chandigarh carried out a six-month surveillance study from April-September 2011 to determine Candida distribution in hospitals. Incidence of Candidemia in intensive care units was found to be seven per 1,000 ICU admissions. The scientists also found a connection between Candidemia and gastrointestinal surgery. "In contrast to other studies, mortality rate was higher (greater than 50 per cent) in patients with Candidemia caused by two Candida species: *C guilliermondii* and *C parapsilosis*," the study states.

INDU MATHY S/CSE-DOWN TO EARTH FEATURE SERVICE

Nuts & bolts

Cockatoos can crack tough puzzles and even unpick locks to reach a reward, scientists have found. Researchers presented 10 birds with a box containing a cashew nut, which they could reach by removing five different interlocking devices. One of the not-so-bird-brained cockatoos solved the complex mechanical puzzle within two hours to get at the goodies.



The research, carried out by scientists from the University of Oxford, the University of Vienna and the Max Planck Institute in Germany, also found that other birds mastered the task after observing their peers. To reach the nut, the Goffin's cockatoos had to remove a pin, followed by a screw and then a bolt, and then turn a wheel and move a latch sideways.

In most cases, the results showed once a bird had mastered how to remove a lock it could do it again without error.

THE INDEPENDENT

INNOVATION OVER CONVENTION

KAUSHIK DEY EXPLAINS WHY BIOCERAMICS MAKE FOR AFFORDABLE HEALTH CARE


Abhijit Chakraborty


Rupnarayan Bhattacharya

To maintain a quality of life as they age, millions of people around the world go in for implants but what is of importance here is the need for materials with appropriate properties that will survive for as long as a patient using these.

Materials employed for the repair and reconstruction of diseased or damaged parts of the musculo-skeletal system are commonly known as bioceramics and have several properties that are superior to those of conventional implants primarily made of metals like stainless steel, cobalt chromium, titanium, etc.

Bioceramic applications include replacement for hips, knees, teeth, tendons ligaments, repairs for periodontics disease, maxillofacial reconstruction, augmentation and stabilisation of the jaw bone, including placement of implants, bone repair after tumor surgery, etc.

Ceramics for biomedical applications are made of different types of material and shape and size differ, depending on the applications. Hip joint heads are made of alumina ceramic whereas synthetic bone grafts available both in granules and pre-forms are made of calcium phosphates and derivatives thereof. The advantages of bioceramics over conventional implants were recognised in the developed countries, as much because of the greater awareness there than in developing countries. Then again, bioceramic products were beyond the reach of common people because of the exorbitant prices of the materials imported and made available. Awareness about bioceramic products is also limited to a select few medical professionals who have had exposure in developed countries.

In India, the Council of Scientific and Industrial Research's constituent laboratory, Central Glass & Ceramic Research Institute, first recognised the importance of bioceramic products back in the early '90s. The Bioceramic and Coating Division was set up by the CGCRI under the leadership of the late Dr Debabrata Basu, considered to be a pioneer both in India and abroad in the development of such products. He was also instrumental in developing know-how for for manufacture of several products, some of these being (a) an alumina ceramic hip joint head; (b) a calcium phosphate (hydroxyapatite) orbital implant; (c) synthetic bone graft substitutes and bio glass; and (d) a bio active coating for metallic implants. Products developed and manufactured by the CGCRI are now available in the market at affordable prices. Dr Basu passed away in May 2012 and had been working on several projects, including a drug delivery system for the treatment of cancer, which are now being pursued by CGCRI scientists.

Over the years, the importance of bioceramics has also been recognised by several research organizations, such as the Sree Chitra Tirunal Research Institute for Medical Sciences and Technology, Trivandrum (Dr HK Varma), and the National Metallurgical Laboratory, Jamshedpur (Dr Arvind Sinha). These laboratories have also developed technologies to provide affordable health care products to the public at large. It is ironical that indigenously manufactured products that are used at several private multi-speciality hospitals find negligible usage in government and government-sponsored hospitals — despite government laboratories developing these after spending millions of rupees – where there are patients who need these most.

In government hospitals, modular hip joint prosthesis is still being used and this is said to have life span of seven to 10 years, whereas prosthesis with an alumina ceramic head is said to be trouble-free for more than 15-20 years. Similarly, patients undergoing surgery for the removal of a painful blind eye are either left without an implant in the empty socket or one made of glass or polymer. This leads to several complications that can easily be avoided with the use of a calcium phosphate (hydroxyapatite) orbital implant that is not only lightweight but is also integrated with the body with fibro-vascularisation, provides motility, extends permanent replacement and has several other advantages.

Imported comparables of indigenously developed orbital implants are priced at least four to six times more and, despite this, several government and government-sponsored hospitals use imported orbital implants. Again in government or government-sponsored hospitals, bone loss is still replaced by the patient's own bone, thereby causing further inconvenience. Ideally, synthetic bone grafts, which are available in abundance and also avoid the complications of transmitting disease, second surgery, etc, should be used.

Dr Abhijit Chakraborty, assistant professor, Department of Periodontics, Gurunanak Dental College, Sodepur, has been involved in the development of synthetic hydroxyapatite orbital implant of the CGCRI and has successfully implanted this product in more than 300 patients. Also involved in the development of calcium phosphate bone grafts by the CGCRI, he says products available in both granules and pre-forms are being used at his college regularly. According to the German journal *Ceramic Application* of April 2013, "Ceremtech announced a new record of producing over one million 'Biolox' ceramic components for hip replacement in 2012. Ceremtech has set the goal of producing nine million Biolox advanced ceramic components for hip replacement." This testifies to the superiority of and confidence in an alumina ceramic head over the conventional metal head.

According to Dr Rupnarayan Bhattacharya, orthopaedic surgeon of RG Kar Medical College and Hospital, the demand for synthetic bone graft is also increasing as the use of autograft (considered to be a gold standard) is reducing gradually. The same holds true for the use of allografts (human bone) and xenografts (bovine bone) because of the risk of disease transmission.

It stands to reason that awareness, use of and demand for bioceramics should increase exponentially in developing countries like India, not only because these are more advantageous than conventional implants but in long-term treatment the cost involved is substantially lower. This would a big boon to patients at large.

Penetrating defences

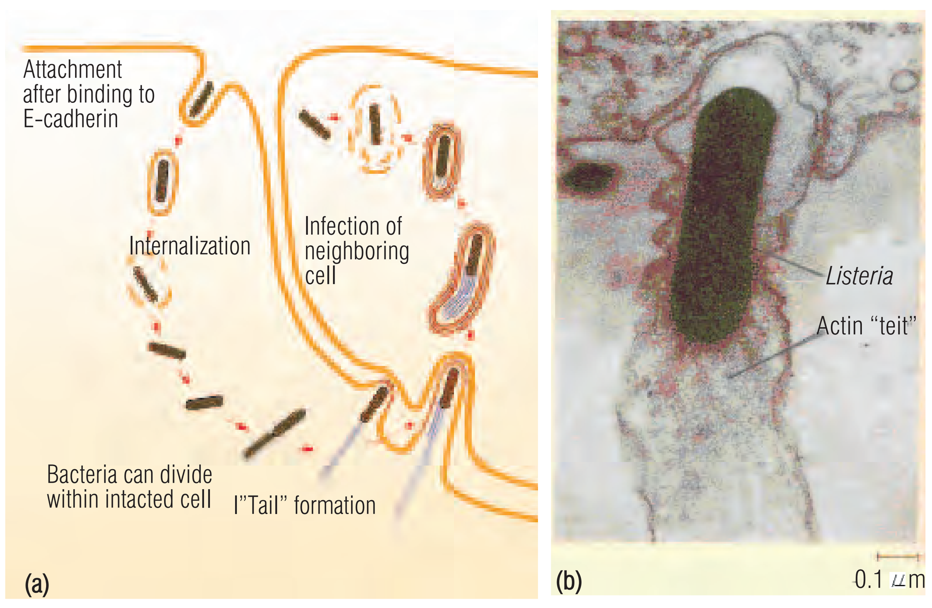
ADHESION INFECTIOUS MICRO-ORGANISMS CAN MOVE WITHIN CELLS USING ACTIN 'TAILS', WRITES TAPAN KUMAR MAITRA

One of the most remarkable findings of modern cell motility research is the discovery that disease-causing micro-organisms can co-opt the cell's normal cell adhesion and cell motility systems to penetrate its defences and enter the cell. The best-studied example of such motility is the gram-positive bacterium *Listeria monocytogenes*. One way in which Listeria attaches to the host's cells involves the binding of a Listeria protein known as *internalin A* to *E-cadherin* on the cell surface. Once bound, Listeria enter a cell, move through it at a rate of 11mm/minute, and progress to nearby uninfected cells, where they continue the cycle of infection.

Short actin filaments radiate away from the bacteria, forming "comet tails" of branched F-actin. By using fluorescently labelled actin, investigators have determined that the tails form by Arp 2/3-dependent polymerisation of actin, which is nucleated near the surface of the internalised bacterium. The protein on the surface of Listeria that promotes actin polymerisation is known as ActA. Because the microfilaments nucleated by ActA are strikingly similar to those found at the leading edge of migrating cells, the tails are probably formed using much of the same cellular machinery.

Other bacteria induce different sorts of actin "tails". Bacteria of the genus *Rickettsia* that cause spotted fevers induce long, unbranched actin filaments reminiscent of filopodia. Thus, different pathogens have devised various ways of recruiting the host cytoskeleton for propulsion.

Some pathogens bind to the cell surface, but are not internalised. For example, the enteropathogenic form of E. coli, which causes diarrhoea in infants by forming colonies on the surface of intestinal epithelial cells, attaches to the surface of intestinal cells, where it organises actin-rich "pedestals" that may function like the actin tails induced by Listeria.



Infection of a Macrophage by Listeria monocytogenes: (a) Life cycle of Listeria. A bacterium attaches to the surface of an uninfected cell. The bacterium then moves inside the cell, where it can divide to produce more bacteria in the infected cell, and then it spreads to a nearby cell by producing a "comet tail" of polymerised actin; (b) A transmission electron micrograph showing a Listeria within an infected macrophage and the "comet tail" of actin filaments that form behind the bacterium.

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