CAPSULE

As oceans give way
The ocean's uptake of anthropogenic CO_2 during 1994-2007 showed clear regional deviations from the usual according to a study in *Science*. The ocean absorbs nearly 30% of human emissions. This casts a doubt, whether we can depend on this effect for the future.

Precise estimate
The distance from the Large Magellanic Cloud is an important factor in calculating the Hubble constant. The current best values estimate this distance to an accuracy of about 2%. But an article in *Nature* has found a way to calculate this distance to an accuracy of 0.8%, bettering estimates of the constant.

DNA therapy for vision
Gene therapy was seen to restore sight in mice. Researchers at the University of California, Berkeley. inserted a gene for a green light receptor into the eyes of blind mice using viruses. A month later they were able to see motion, large brightness changes and fine detail enough to distinguish letters.

An example of symbiosis
Brazilian scientists have discovered that the strong odour released by some amphibian species is produced by bacteria and that one of its purposes is to help in attracting a mate. The bacteria in question are a noteworthy example of symbiosis as they assist in the animal's mating process. A paper which recounts the discovery of this role of microorganisms isolated from the skin of frogs has been published in the journal *Proceedings of the National Academy of Sciences* (PNAS).

Treating Alzheimer's
MIT researchers have found that cognitive and memory impairments like those seen in Alzheimer's patients can be treated with a combination of light and sound. Using such a combination, they induced brain waves known as gamma waves in mice with Alzheimer's disease, which reduced amyloid plaques in their brains.

A gel to selectively remove oil or water

IIT Guwahati's material can switch from being water-repelling to oil-repelling and vice versa

R. PRASAD

A natural biopolymer, chitosan (a kind of polysaccharide obtained from a chitin shell such as the shrimp's), which is water-soluble, has been chemically modified by researchers at the Indian Institute of Technology (IIT) Guwahati to selectively remove either an oil or water phase from an oil-water mixture. This becomes possible by making the chitosan-based material, also biodegradeable, to exhibit either an extremely water-repelling property in air (like the lotus leaf) or an extremely oil-repelling property under water (like a fish scale).

In a breakthrough, the researchers have also made it possible to switch the chitosan-based material's property – from being extremely water-repelling to extremely oil-repelling and vice-versa – by treating it with certain chemicals. It is also possible to repeatedly switch from one property to another.

Fabrication
To prepare the water or oil repelling chitosan, a team led by Dr. Uttam Manna from the institute's Department of Chemistry and Centre for Nanotechnology first converted the material into nanoparticles and then to a stable gel material by treating it with a chemical (5Acl). This gel was found to have chemically active residues (amines and acrylate), which when treated with a small amine resulted in optimisation of the two very different properties in the same material.

Says Nirban Jana from the institute's Department of Chemistry and first author of a paper published in the journal *Chemistry of Materials*, "This is the first time that the liquid repellency property of the material is made switchable, from superhydrophobic to superoleophobic under water and back to superhydrophobic by treating the material at low pH and ethanol, respectively."

The chitosan – which is converted into a stable gel – allows the researchers to selectively remove the oil or water phase from an oil-water mixture by making the material either superhydrophobic or superoleophobic, respectively. For example, if the oil spill (in water) is less, the material can be made water-repelling to remove or collect the oil. In case the spill is huge and the water phase relatively less, the material can be made extremely oil-repelling to collect or remove water.

Property switch
By treating the material with acid (pH 1) for about 15 minutes, the team (led by Dr. Uttam Manna from the institute's Department of Chemistry) was able to completely switch the property of the material – from being extremely water-repelling to becoming extremely oil-repelling under water.

Similarly, by treating the biopolymer with ethanol for 10 minutes followed by air drying, the team was able to switch the property from being oil-repelling to becoming water-repelling.

Says Dr. Manna, "The water contact angle of the superhydrophobic biopolymer is over 152° and the oil contact angle under water is nearly 159°." The higher the contact angle the greater is the liquid repellency of the material.

Superior performance
The researchers tested the ability of the biopolymer to separate oils – kerosene, motor oil, olive oil and even crude oil – of different densities from water. Says Dr. Manna, "Under water, we were able to completely remove even crude oil from the water phase. The selective separation efficiency for both oil and water phases was above 95% immaterial of the viscosity of the oil."

The biopolymer's superhydrophobic property remained intact under diverse chemical conditions such as extreme pH (pH 1 and pH 13), sea and river water for seven days, and high (100° C) and low (10° C) temperatures.

The material was found to retain both hydrophobicity and oleophobicity even when the top surface of the biopolymeric material was physically abraded using sand paper. Despite the abraded surface being cleaved through manual peeling using an adhesive, the liquid repellence property remained intact. No change in this was seen after the mechanically damaged material was subjected to even a continuous stream of sand grains. Exposure to UV light for a month too did not destroy this repellence property.

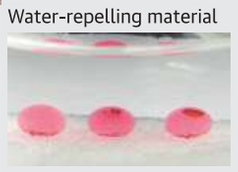
Selectively repellant

Researchers from IIT Guwahati have been able to change the property of a biopolymer to repel oil or water

- Using certain chemicals, the polymer can also be made to switch from water-repelling to oil-repelling and vice-versa
- One of the many possible applications is during oil spills in water. The material can be made to remove oil if the spill is less and water if oil spill is more
- The gel can separate kerosene, motor oil, olive oil and even crude oil from water
- The selective separation efficiency for both oil and water phases was above 95%
- The gel-based material is mechanically robust and chemically stable

Nirban Jana (left) and Uttam Manna at work

Water-repelling material



Oil-repelling material

Topical gel protects farmers from pesticides

Found to cleave pesticides, reducing pesticide-induced enzyme inhibition

ASWATHI PACHA

Using easily available, inexpensive natural polymers, researchers in Bengaluru have developed a gel for the skin to protect agricultural workers from harmful pesticide sprays. The gel does not just act as a simple physical barrier; it chemically deactivates pesticides.

Ripple effect
Organophosphate pesticides bring about the inhibition of important enzymes (AChE) of the body, which can, in turn, affect the functioning of nervous system, heart, immunity, and even the reproductive system.

Explains Ketan Thorat, a doctoral scholar at the Institute for Stem Cell Science and Regenerative Medicine (inStem), Bengaluru, "The base of the gel is chitosan, a natural substance extracted from the waste shells of crabs and shrimps, to which we added a nucleophile and few aqua reagents to get the consistency and desired pH."

Dr. Thorat, who is also the first author of a paper on the subject published in *Science Advances*, adds, "The gel looks and feels like a cold cream and we can add suitable fragrance too."

Since pesticides can inhibit enzymes in blood, different experiments were carried out using rat blood to see if the gel could prevent this. The gel was found to cleave a wide range of commercially available pesticides before they enter the bloodstream, thus reducing the pesticide-induced enzyme inhibition.

In-vivo studies were carried out using rat models. Even 96 hours after pesticide exposure, the gel-applied rats did not show any reduction in enzyme activity. The control animals (without gel) exposed to pesticides lost about 20% of their body weight by four days, whereas the protected rats had normal weight.

To understand pesticide-induced mortality, the researchers sprayed a higher concentration of pesticide on the rats for four consecutive days and monitored them. The rats without the gel showed signs of pesticide poisoning such as diarrhoea, trouble in breathing, tremors and died after five days. All the rats in the protected group survived and showed no signs of toxicity even after 30 days.

Post-mortem studies showed that the rats had decreased levels of the important enzyme in their system.

Mode of action: The gel does not just act as a simple physical barrier; it can also chemically deactivate a range of pesticides. ▪ SPECIAL ARRANGEMENT

> **The gel looks and feels like a cold cream and we can add suitable fragrance too.**
> KETAN THORAT, inStem, Bengaluru

Safe to use
Explains Dr. Praveen K. Vemula, from inStem, and corresponding author of the paper, "We carried out pre-clinical toxicology studies and the gel was found to be safe for repeated applications. It had no side-effects even if inhaled, swallowed or if it comes in contact with the eye." According to Dr. Vemula, when produced in bulk, the gel may cost less than ₹1,000 for an entire month.

Too much vitamin D may cloud benefits

ASIAN NEWS INTERNATIONAL

According to a recent study, in the U.S., obese older women, who take more than three times the recommended daily dose of vitamin D showed improvements in memory and learning but also had slower reaction times. The researchers hypothesised that slower reaction times may increase the risk of falling among older people.

The results of the study were published in *Journals of Gerontology: Series A*. The researchers used computers to assess the impact of vitamin D on cognitive function. They evaluated three groups of women between 50 and 70 years in a randomised controlled trial. One group took the recommended daily dose of 15 mcg of vitamin D each day for a year. Another group took more than three times and the third took nearly seven times.

The researchers found that memory and learning improved in the second group but not in the group that took the higher dosage. Meanwhile, the women's reaction time showed a trend to be slower as dosage increased. "The slower reaction time may have other negative outcomes such as potentially increasing the risk of falling and fractures," said senior study author Sue Shapses.

Solar tsunami can trigger the sunspot cycle

According to the model, the next sunspot cycle can be expected to begin in 2020

SHUBASHREE DESIKAN

It is believed that the "solar dynamo" – a naturally occurring generator which produces electric and magnetic fields in the sun – is linked to the production of sunspots. What kick-starts the 11-year sunspot cycle is not known. Now, a group of solar physicists suggests that a "solar tsunami" is at work that triggers the new sunspot cycle, after the old one ends.

The extreme temperature and pressure conditions that prevail some 20,000 km below the sun's surface cause its material to form a plasma consisting primarily of hydrogen and helium in a highly ionised state. The plasma is confined with huge magnetic fields inside the sun. Explains Dr. Dipankar Banerjee from the Indian Institute of Astrophysics, Bengaluru, and one of the authors of the paper published in *Scientific Reports*, "The [sun's] toroidal magnetic field, from which sunspots get generated, wraps around the sun in the east-west direction."

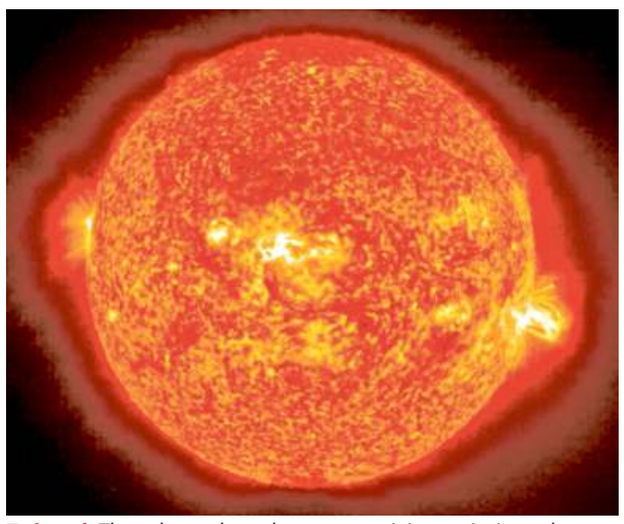
Celestial rubber bands
These magnetic fields behave like rubber bands on a polished sphere. They tend to slip towards the poles. Holding these fields in their place requires that there is extra mass (plasma mass) pushing at the bands from higher latitudes. Thus, a magnetic dam is formed which is storing a big mass of plasma. At the end of a solar cycle, this magnetic dam can break, releasing huge amounts of plasma cascading like a tsunami towards the poles.

These tsunami waves travel at high speeds of about 1,000 km per hour carrying excess plasma to the mid-latitudes. There they give rise to magnetic flux eruptions. These are seen as the bright patches that signal the start of the next cycle of sunspots. The tsunami waves can traverse the required distance in a few weeks, unlike in earlier models.

Humongous calculation
To arrive at this simulation, the group used data from the Kodaikanal observatory of sunspots recorded over 100 years and the Cheyenne supercomputer belonging to National Center for Atmospheric Research (NCAR), Boulder, U.S. Mausumi Dikpati of NCAR and first author of the paper said in an email to *The Hindu*, "Cheyenne has 1,45,000 processors, and is a 4.5 petaflop machine. Each of these processors can perform 184 million arithmetic operations per second," says Mausumi Dikpati of NCAR, the first author of the paper."

She adds "We used about 100,000 processor cores of the supercomputer to perform about 100 simulations to conclude our results. This means in each of these hundred simulations, we performed about 66,000 trillion arithmetic operations per hour."

Adds Dr. Banerjee, "The solar cycle and sunspot activity are intimately connected with space weather. The model provides a sound physical mechanism supporting why we should expect the next sunspot cycle 25 to begin in the year 2020, followed by a strong increase in space weather shortly after the trigger of a series of new sunspots in that year."



Twinned: The solar cycle and sunspot activity are intimately connected with space weather, says Dipankar Banerjee. ▪ AFP/NASA

In the case of the lizard, the regenerated tail is not identical to the lost one, but is an 'imperfect replicate'. ▪ SPECIAL ARRANGEMENT

The lost tail that wags research tales

How and why does a lizard regenerate its tail while a cat cannot?

SPEAKING OF SCIENCE

D. BALASUBRAMANIAN

A lizard, when attacked, loses its tail and runs for safety. Within 60 days, the tail is regrown. What is the biology behind this? This question was recently addressed by Dr. Kenro Kusumi and colleagues at Arizona State University in the U.S. (*PLOS ONE*, August 20, 2014). They found that a lizard turns on as many as 326 genes of its genome in specific regions of the regrowing tail to do so. It also turns on what are called "satellite cells" which can grow and develop into skeletal muscle and other tissues. One of the authors has suggested that since humans too have such satellite cells, maybe we too can regrow muscles and cartilage if we can harness them in us.

Lizards are a late entry into the world, having first arrived on earth around 310-320 million years (Myrs) ago. Preceding them are earthworms (518 Myrs) and flatworms (840 Myrs), which were called 'the intestines of the earth' by Aristotle and 'the earliest ploughers' by Darwin. In a recent paper (*Zattara et al. Proc. Royal Soc. B 286:20182524*), scientists studied the way how 35 different species of worms regenerate their body, after parts of their bodies were chopped off. At least four separate types of worms could regenerate their heads. Studying the biology of these organisms would be remarkably insightful, as has been attempted with lizards.

Up the evolutionary ladder
Why can worms even regenerate their heads, but the later-day arrivals, lizards, can only rebuild their tails, and 'higher animals' cannot even do that? There are two kinds of analytical arguments towards this. Professor Alexandra Bely, an expert in the area from the University of Maryland, U.S. has a review titled 'Evolutionary loss of animal regeneration: pattern and process' (doi:10.1093/icb/icq118), where she argues that while regeneration can produce cells, tissues and internal organs, the regeneration of structures such as limbs may be governed by age, sex, nutrition and other factors. Plus, is regeneration given up, or is selected against -- based on the energy and metabolism being invested more for growth rather than repair? We need to research into the energy cost-benefit analysis in order to understand the matter further.

A more recent analysis is by Dr. Jonathan Slack of the University of Bath, U.K. titled 'Animal regeneration: Ancestral character or evolutionary novelty?' which appears in *EMBO Reports 2017*. He points out using genetic analysis, that the ancestral character in all organisms is reflected by the expression of two major genes, conserved across all animals – lizard to human – namely Wnt and BMP. Wnt mediates the developmental pathway implicated in proliferation of cells and in self-renewal signals. BMP is another gene, seen again from fruit flies all the way up to us, and the BMP-mediated pathway too plays a key role in organ and body development. The fact that these genes are present in all cells of all animals would seem to make organ regeneration possible in principle.

But then, once the tail is lost, in say a rat or a cat, it does not regenerate. They just make do without the lost tail. Dr. Bely points out that the bio-energetic cost of regenerating the tail here does not appear worthwhile when the animal can make do without it. (Indeed, the lizard seems to need the tail as an important organ, in order to survive and flourish – it is what Slack might call as an evolutionary novelty; its predecessors did not 'invent' this important appendage.)

Come back to the lizard again. Actually the regenerated tail is not identical to the lost one, but an "imperfect replicate" as was shown by Lozito and Tuan (Dev. Biol.2015,399, 249). Instead of the original vertebral tail, the regrown one had no bones but a softer, more flexible cartilage. In other words it is what Dr. Sukla Ghosh of Kolkata had described as a 'compensatory growth' rather than true regeneration.

The promise of stem cells
While the Arizona group, working on the cell biology of the regenerated lizard tail, did not find any specific progenitor cells or stem cells of the tail tissues, the newly emerged stem cell technology is generating a lot of excitement in the field. Stem cells found, for example in the bone marrow, can be cultured in a laboratory to produce cells and tissues of a few other parts of the body. This has been done in generating a bladder and stitching it on to a youth who had a bladder injury. In recent times, any cell in the body can be "induced" to become a stem cell upon the introduction of four chosen genes. The so produced induced pluripotent stem cells (iPSCs) have been used in the laboratory to generate chosen tissues and even mini-organs called "organoids". While this field is still in its infancy, it promises to produce organs which, when needed, can be used for regeneration.

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