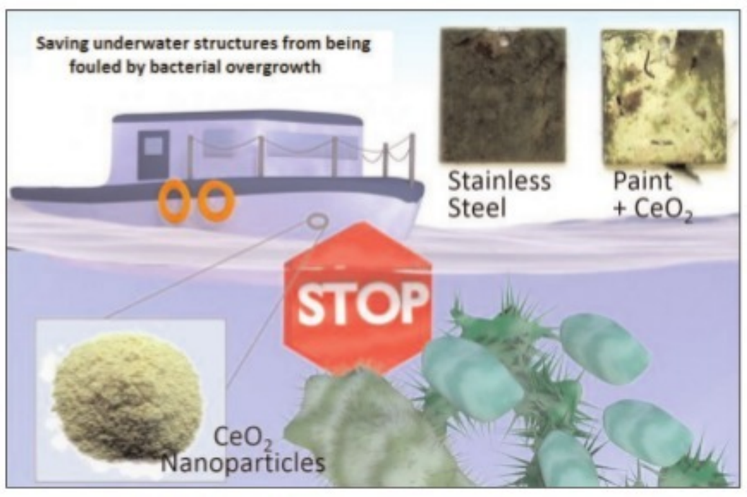
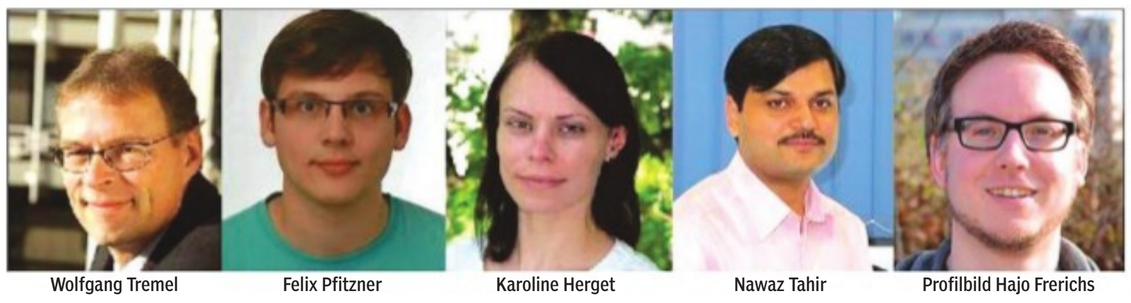
Taking a leaf out of Nature's book





Wolfgang Tremel | Felix Pfitzner | Karoline Herget | Nawaz Tahir | Profilbild Hajo Frerichs

THE DEFENCE OF SEAWEEDS AGAINST PARASITES COULD HELP OCEAN LINERS PRESERVE THEIR STEEL BODY AND FREE SURGICAL INSTRUMENTS FROM INFECTION, WRITES **S ANANTHANARAYANAN**

Seawater, like the rest of the environment, is teeming with bacteria and other miniature life forms. Stationary structures like buoys, off-shore platforms or aquaculture nets get quickly covered by colonies of barnacles, bacteria and algae. The hulls of ships are known to get overgrown with organisms within a few months of an overhaul. The higher drag that ships experience has been reported to increase fuel costs by 28 per cent.

Most things we handle like packaging material, door handles, keyboards, pipes that bring us water, also get covered with bacteria, which lead to the spread of infection. It is the same in medical practice and patients in treatment run serious risks of contracting bacteria from devices like catheters or tubes that deliver blood, saline or drugs.

The scale of the problem led Karoline Herget, Patrick Hubach, Stefan Pusch, Peter Deglmann, Hermann Götz, Tatiana E Gorelik, Il'ya A Gural'skiy, Felix Pfitzner, Thorben Link, Stephan Schenk, Martin Panthöfer, Vadim Ksenofontov, Ute Kolb, Till Opatz, Rute André and Wolfgang Tremel, of the Johannes Gutenberg University, Mainz, the Taras Shevchenko National University of Kyiv, Ukraine and at the laboratories of the giant chemical company, BASF, at Ludwigshafen, to seek a solution in the way seaweeds, which spend their lives in sea water, remain free of bacterial fouling. The team reports in the journal, *Advanced Materials* of the development. It is building on earlier work by Tremel and colleagues, of a material that simulates the working of natural enzymes to inhibit the build-up of algae and bacteria on plant surfaces.

Conventional protection of surfaces is with paint or covering, which contain substances to deal with different fouling agents. Many of these are metal compounds, a common one being CuO_2, cuprous oxide, a powerful biocide. The problem, however, is firstly environmental pollution, as the substances are toxic, and then that organisms react by developing resistance. Less toxic alternatives have been found but those need the surface to be moving rapidly.

The method of seaweed and larger formations of algae, in contrast, is adapted to cause no environmental harm, allows the host to stay rooted at a spot and yet manages to block bacteria from getting their act going. The algae *Corallina officinalis* and *Deliseapulchra*, for instance, secrete a group of enzymes that comes in the way of collections of bacteria forming into films. This is hence a method that does not kill anything, for resistance to be formed, but keeps the host surface clean.

Bacteria are a basic life form that cannot be suspected of social organisation, but they still group themselves, like forming films, when they are present in numbers. The way they do this is by secreting substances that provoke more generation of the same substance when sensed by other bacteria. That can lead to a circle of communication within a group that has a threshold number, and is called quorum sensing.Algae that would like to keep bacteria from getting together in this way secrete enzymes that promote traces of bromine, chlorine or iodine, which are present in seawater, to react with hydrogen peroxide, and form a substance that interferes with the inter-bacterial signal.

These bacteria-suppressing enzymes in the algae are based on the element, vanadium. In the earlier work of Tremel's group, nanoparticles of an oxide of vanadium were embedded in the paint used on boat hulls. The nanoparticles, which have a very large surface area for their weight, were able bring about the reactions that generated the bacteria-suppressing substances. While this appeared to be a viable solution to the problem, it was not suited for large scale application as vanadium compounds cause genetic changes in organisms and can lead to cancers.

The current work, described in the paper, proposes a new material, cerium dioxide, which can bring about the same suppression of bacterial organisation when used in lesser concentration and significantly lower toxicity. This approach, "different from conventional anti-fouling agents — to target specific bacterial signalling and regulatory systems, represents a new strategy with the goal to emulate a natural defence system for preventing bacterial colonisation or bio-film development" and "would be a big step toward a sustainable anti-fouling solution," the authors of the paper say.

Cerium, a so-called "rare earth" element, is not particularly rare — it is as abundant as copper and only marginally more expensive. Its effectiveness in smaller quantities hence makes its use quite economical. CeO_2 is also insoluble in water, which renders it environmentally very safe. The discovery that cerium dioxide could be used for this purpose, Tremel says in a communication, was made during a classroom experiment to demonstrate a chemical process called oscillating reactions.

An oscillating reaction is one where the products or the properties of some components make the reaction start in the opposite direction soon after it has progressed in one direction. Progress in the reverse direction then gets the first reaction started afresh and the reaction changes direction again. The reaction thus acts like a pendulum and has given rise to the concept of the "chemical clock". While there are no practical uses for such behaviour, their nature does demonstrate concepts of the speed and direction of chemical reactions.

A classic example is the Belousov-Zhabotinsky reaction, where a mixture of potassium bromate, cerium sulphate, malonic acid, and citric acid in dilute acid oscillates in the concentration of the reagents, along with a spectacular and periodic change in their colour. While showing this reaction to a class of students, Tremel noted that a pair of charged states of cerium, present in the reaction, led to bromine ions getting added to malonic acid. As components of cerium dioxide switch between the same two charge states, the BZ reaction suggested that CeO_2 could be used to do the same thing with bromine and hydrogen peroxide in sea water.

The team hence synthesised nanorods, 20 to 100 millionths of a metre long and 10 millionths of a metre wide, and embedded the nanorods in paints to be used in panels immersed in marine water. "Steel panels with cerium oxide coatings can be exposed to seawater for weeks on end without becoming covered by bacteria, algae, molluscs, or barnacles. Reference samples with conventional water-based coatings develop massive fouling over the same time period," says a press release by the Johannes Gutenberg University.

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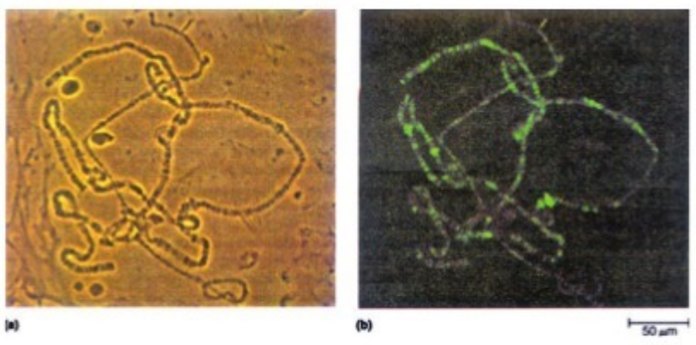
CHROMOSOME REPLICATION



A CERTAIN DEGREE OF CHROMATIN DECONDENSATION APPEARS TO BE NECESSARY FOR THE EXPRESSION OF EUKARYOTIC GENES, WRITES **TAPAN KUMAR MAITRA**

Genome-level control is involved in making the eukaryotic genome — chromosomal DNA — accessible to the cell's transcription machinery. To initiate transcription, a eukaryotic RNA polymerase must interact with both DNA and a number of specific proteins (general transcription factors) in the promoter region of a gene. Except when a gene is being transcribed, its promoter region is embedded within a highly folded and ordered chromatin superstructure. Thus, some degree of chromatin decondensation (unfolding) appears to be necessary for the expression of eukaryotic genes.

The earliest evidence that chromatin decondensation is required for gene transcription came from direct microscopic visualisation of certain types of insect chromosomes caught in the act of transcription. Because the DNA of most eukaryotic cells is dispersed throughout the nucleus as a mass of intertwined chromatin fibres, it is usually difficult to observe the transcription of individual genes with a microscope.

But a way around this obstacle is provided by an unusual type of insect cell. In the fruit fly Drosophila melanogaster and related insects, metabolically active tissues (such as the salivary glands and intestines) grow by an increase in the size of, rather than the number of, their constituent cells. This process generates giant cells whose volumes are thousands of times greater than normal. The development of giant cells is accompanied by successive rounds of DNA replication but because this replication occurs in cells that are not dividing, the newly synthesised chromatids accumulate in each nucleus and line up in parallel to form multi-stranded structures called polytene chromosomes.

Each polytene chromosome contains the multiple chromatids generated during replication of both members of each homologous chromosome pair. The four giant polytene chromosomes found in the salivary glands of Drosophila larvae, for example, are generated by ten rounds of chromosome replication. Ten doublings of each chromatid produces 210 = 1024 chro-matids, so a polytene chromosome containing both members of a homologous chromosome pair would possess a total of 1024 + 1024 = 2048 chromatids aligned next to each other.

Polytene chromosomes are thus enormous structures measuring hundreds of micrometres in length and several micrometres in width -- roughly ten times longer and a hundred times wider than the metaphase chromosomes of typical eukaryotic cells. The micrograph shows several polytene chromosomes from the nucleus of a Drosophila salivary gland cell. Visible in each polytene chromosome is a characteristic pattern of dark bands. Each band represents a chromatin domain that is highly condensed compared with the chromatin in the "inter-band" regions between the bands. Activation of the genes of a given chromosome band causes the compacted chromatin strands to uncoil and expand outward, resulting in a chromosome puff. Such puffs consist of DNA loops that are less condensed than the DNA of bands elsewhere in the chromosome. Though puffs are not the only sites of gene transcription along the polytene chromosome, the extent of chromosome decondensation, correlates well with the enhancement of transcriptional activity at these sites.

As the Drosophila larva proceeds through development, each of the polytene chromosomes in salivary gland nuclei undergoes reproducible changes in puffing patterns, under the control of an insect steroid hormone called ecdysone. This hormone functions by binding to, and thus activating, a regulatory protein that stimulates the transcription of certain genes.

It appears, in other words, that the characteristic puffing patterns seen during the development of Drosophila larvae are direct visual manifestations of the selective decondensation and transcription of specific DNA segments according to a genetically determined developmental programme.

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Return of the Tasmanian tiger?

THE CARNIVORE HUNTED TO EXTINCTION BY EUROPEAN SETTLERS IN AUSTRALIA MAY HAVE SURVIVED IN AN ISOLATED WILDERNESS AREA IF SIGHTINGS BY A PARK RANGER AND TOUR GUIDE ARE GENUINE. **MATT BROOMFIELD** REPORTS

Apparent sightings of the Tasmanian tiger in northern Australia have sparked a search for the long-extinct carnivore.

The wolf-like predators were the largest known carnivorous marsupial to have existed alongside human society, but the last known specimen died in a zoo on the island of Tasmania itself in 1936.

However, based on eyewitness evidence provided by a tourism operator and a former park ranger, 50 camera traps will be set up across the Cape York Peninsula in the hope of finding a surviving population.

Professor Bill Laurance will be heading the survey, which will take place across remote locations in Australia's largest wilderness area. He told the *Daily Telegraph*, "All observations of putative thylacines to date have been at night, and in one case four animals were observed at close range, about 20 feet away, with a spotlight.

"We have cross-checked the descriptions we received of eye shine colour, body size and shape, animal behaviour, and other attributes, and these are inconsistent with known attributes of other large-bodied species in north Queensland such as dingoes, wild dogs or feral pigs."

Sightings of the 30 kilogram carnivore properly known as the thylacine are common, but are generally written off as cases of mistaken identity. Feral cats and dogs are the most common lookalikes.

But the two latest observations, whose exact location is being kept a secret by the researchers, are considered plausible. Patrick Shears, a qualified ranger, added that Aboriginal locals also reported sightings of the beast. "They call it the 'moonlight tiger'," he told the *Daily Telegraph*.

They're curious. If you're not moving and not making a noise they'll come within a reasonable range and check you out then just trot off."

The thylacine was not actually related to Western carnivorous dogs or cats, but evolved its teeth, claws and characteristic striped back in isolation. It is depicted in Aboriginal rock art from at least 3,000 years ago. However,

A tiger in captivity in a Hobart Zoo in 1936.

This grainy video grab shows a scrawny dog-like creature.

by the time Western explorers arrived in the Australian continent it was extinct on the mainland and increasingly rare in Tasmania itself, losing out in competition with dingos and human hunters.

Bounties worth £100 a head in today's money fuelled an intensive hunting drive, while diseases and dogs imported from Europe further contributed to its apparent obliteration from Tasmania.

Since the last captive thylacine died, there have been nearly 4,000 reported sightings on mainland Australian soil. Tasmanian tour operator Stuart Malcolm has offered $1.75 million reward for proof the thylacine has survived to the present day.

However, professor Laurance and his team are not expecting to claim any reward, emphasising that the chances of any tigers surviving on the Australian mainland remain very slim.

THE INDEPENDENT

PLUS POINTS

Reducing dengue cases

Mathematicians at the University of Strathclyde in the UK are modelling the impact of an innovative mosquito-trap that could reduce cases of dengue fever — potentially saving thousands of lives.

Cases of the mosquito-borne disease have grown dramatically around the world in recent decades as a result of population growth, unplanned urbanisation and climate change. Despite significant investment in traditional pesticides in affected countries, a life is lost to dengue every 25 minutes.

However, researchers believe adoption of the new kind of mosquito trap may offer a solution. The cost-effective technology works by attracting *Aedes* mosquitoes to a special solution, which prevents 100 per cent of their eggs from hatching in the mosquito traps, or when laid anywhere else. This provides an alternative to the traditional "seek and destroy" and pest-control method of spraying pesticides, which is labour-intensive, damaging to the environment, destroys biological predators and helps mosquitoes become more resistant.

The project is a collaborative effort between the University, the Institute for Medical Research, Kuala Lumpur, and a Kuala Lumpur-based enterprise, One Team Network Solutions, which designs practical and low-tech innovative solutions for pest control.

UK project leader David Greenhalgh of the University of Strathclyde's department of mathematics and statistics, said, "Dengue is a huge problem for populations living in tropical climates. It's dangerous and claims thousands of lives every year. Our research aims to create a strong case for the application of this trap not just in Malaysia, but across affected countries.

"By applying modelling to the application of the trap, we can accurately predict how effective the traps are in different scenarios, at a fraction of time and cost, compared to what it would take to do full field tests."

Researchers will develop models using existing data, which shows the positive impact of the trap on reducing dengue cases in the local vicinity, therefore enabling them to predict the required number and impact of traps over large areas.

Dengue fever is a viral, flu-like illness, which is spread by infected mosquitoes — most commonly the *Aedes aegypti* mosquito. It is estimated there are 390 million dengue infections each year, many of which occur in major urban centres with warm and humid climates. 2.5 per cent of the people affected die.

Shark diving tourism

Whether it is cage diving with white sharks in South Africa or shark feeding in the Bahamas, new research by scientists at the University of California Santa Barbara and Florida International University has found human interactions not to have any long-term behavioural impact on sharks.

The researchers went to Palmyra, an atoll in the central Pacific Ocean, where shark populations are healthy, fishing is not allowed and the majority of its near-pristine underwater world is rarely dived.

Researchers surveyed sharks by lowering cameras to the ocean floor. "After reviewing 80 hours of underwater footage taken from video surveys conducted in 2015 — 14 years after Palmyra was established as a wildlife refuge and scientific diving activities began — we found that shark abundance and shark behaviour were the same at sites with and without a long history of scuba diving," said co-author of the study Jennifer Caselle.

Lead author Darcy Bradley added that the results of the study are "good news". "It means that well-regulated shark diving tourism doesn't necessarily undermine shark-conservation goals," he said.

CAROLYN KHEW/THE STRAITS TIMES