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# News

**Using shark scales to design better drones, planes, and wind turbines**

A team of evolutionary biologists and engineers at Harvard University, in collaboration with colleagues from the University of South Carolina, have shed light on a decades-old mystery about sharkskin and, in the process, demonstrated a new, bioinspired structure that could improve the aerodynamic performance of planes, wind turbines, drones and cars. The research is published in the *Journal of the Royal Society Interface.*

Sharks and aeroplanes are both designed to efficiently move through fluid (water and air), using the shape of their bodies to generate lift and decrease drag. The difference is, sharks have about a 400 million-year head start on the design process.

The skin of sharks is covered by thousands and thousands of small scales, or denticles, which vary in shape and size around the body, according to George Lauder, the Henry Bryant Bigelow Professor of Ichthyology and Professor of Biology in the Department of Organismic and Evolutionary Biology, and co-author of the research. A lot is known about the structure of these denticles, but their function is still under debate.

Most research has focused on the drag reducing properties of denticles, but Lauder and his team wondered if the denticles were actually better suited for increasing lift.

To help test that hypothesis, the researchers collaborated with a team of engineers from the Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS). For inspiration, they turned to the shortfin mako, the fastest shark in the world. The mako's denticles have three raised ridges, like a trident. Using micro-CT scanning, the team imaged and modelled the denticles in three dimensions. Next, they 3-D printed the shapes on the surface of a wing with a curved aerodynamic cross-section, known as an aerofoil.

The researchers tested 20 different configurations of denticle sizes, rows and row positions on aerofoils inside a water flow tank. They found that in addition to reducing drag, the denticle-shaped structures significantly increased lift, acting as high-powered, low-profile vortex generators. These are small, passive devices designed to alter the air flow over the surface of a moving object to make it more aerodynamic. Most vortex generators in the field today have a simple, blade-like design.

This research not only outlines a novel shape for vortex generators but also provides insight into the role of complex and potentially multifunctional shark denticles.

*Source: Harvard John A. Paulson School of Engineering and Applied Sciences*

**Substances used in household goods affect the immune system of a coastal mussel**

Perfluoalkyl substances (PFAS) is shorthand for a group of fluorinated compounds that have been used extensively in household products such as non-stick cookware, stain-resistant carpeting and upholstery. They can also be found in things from clothing to adhesives, and even in some cosmetics. PFAS use is being phased out because they have been shown to target the immune system in humans and rodents. However, PFAS substances have found their way into the environment and stay there because they are not biodegradable. The effects of PFAS on marine organisms are still not clearly understood.

In a study recently published in *Environmental Toxicology and Chemistry*, Changhui Liu and Karina Yew-Hoong Gin of the National University of Singapore further investigated the toxicity of PFAS to marine organisms by studying their effects on the immune systems of green mussels. They found that PFAS can inhibit a mussel's immune system and they were also able to identify how it does so through its modes of action.

However, the research also showed that the modes of action are reversible, and that the concentrations of PFAS that contributed to the adverse effects in this study are much higher than those typically observed in the environment. Mussels, and other invertebrates, play an essential role in their ecosystem, and the ocean is the final sink for many pollutants like PFAS, so it is important to monitor regions that may have higher environmental concentrations due to unregulated discharges of these substances.

*Source: Society of Environmental Toxicology and Chemistry*

**Plastics linked to disease in coral**

Contact with plastic waste massively increases the chance of disease in corals according to an international team led by a James Cooke University (JCU) scientist Dr Joleah Lamb from the ARC Centre of Excellence for Coral Reef Studies based at JCU. The study is reported in the journal *Science*.

More than 120,000 corals were examined by the team in both plastic-free and with plastic present conditions, on 159 reefs from Indonesia, Australia, Myanmar and Thailand. The researchers found that the chance of disease increased from 4% to 89% when corals are in contact with plastic.

Dr. Lamb said that very few studies have examined the role plastics could play in promoting disease in the marine environment. The exact mechanisms are unknown, but plastics make ideal vessels for colonizing microscopic organisms that could trigger disease if they come into contact with corals. For example, plastic items such as those commonly made of polypropylene, like bottle caps and toothbrushes, have been shown to become heavily inhabited by bacteria that are associated with a globally devastating group of coral diseases known as white syndromes. Lamb also stated that the problem of plastic waste looks to be getting worse.

*Source: ARC Centre of Excellence in Coral Reef Studies*

**Land-based pollution with microplastics**

It is now widely accepted that microplastics contaminate oceans and

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are harmful to coastal and marine habitats. But tiny plastic particles have also been found to present a threat to creatures on land and may have damaging effects similar or even more problematic than in the oceans. Researchers from the Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB) in partnership with Freie Universität Berlin warn that the impact of microplastics in soils, sediments and the freshwaters could have a long-term negative effect on terrestrial ecosystems throughout the world.

Over 400 million tons of plastic are produced globally each year. It is estimated that one third of all plastic waste ends up in soils or freshwaters. Most of this plastic disintegrates into particles smaller than five millimetres, referred to as microplastics, and breaks down further into nanoparticles, which are less than 0.1 micrometre in size. In fact, terrestrial microplastic pollution is much higher than marine microplastic pollution, an estimate of four to 23 times more, depending on the environment.

Sewage, for example, is an important factor in the distribution of microplastics. In fact, 80 - 90 % of the particles contained in sewage, such as from garment fibres, persist in the sludge. Sewage sludge is then often applied to fields as fertilizer, meaning that several thousand tons of microplastics end up in soils each year.

Microplastics can interact with soil fauna, affecting their health and soil functions. Earthworms, for example, make their burrows differently when microplastics are present in the soil, affecting the earthworm's fitness and the soil condition.

Humans also ingest microplastics via food. They have already been detected not only in fish and seafood, but also in salt, sugar and beer. It could be that the accumulation of plastics in terrestrial organisms is already common everywhere, the researchers speculate, even among those that do not "ingest" their food. For example, tiny fragments of plastic can be accumulated in yeasts and filamentous fungi.

The intake and uptake of small microplastics could turn out to be the new long-term stress factor for the environment, but there is a lack of standardized methods for determining microplastics in terrestrial ecosystems in order to produce an accurate assessment of the situation.

*Source: Forschungsverbund Berlin*

**New alien species invasions still rising globally**

Up to 16% of all species on Earth could qualify as potential alien species and if they invade new regions, impacts will be difficult to predict, according to new research involving University College London (UCL). The study shows that the number of newly emerging alien species, those never before encountered as aliens, continues to rise, posing a significant challenge to biosecurity interventions worldwide.

Approaches to tackle the growing issue largely rely on knowledge of species' invasion history elsewhere, giving new previously unrecorded alien species a higher chance of slipping through border controls and eluding early response management.

The new study, published in the *Proceedings of the National Academy of Sciences* (*PNAS)* and led by scientists at Senckenberg Biodiversity and Climate Research Centre (BiK-F), the University of Vienna and UCL, analysed a global database of 45,984 records detailing the first invasions of 16,019 established alien species from 1500 until 2005 to investigate the dynamics of how alien species spread worldwide. Between the years 2000 and 2005, one quarter of records are of species that had not previously been found anywhere as an alien, which is a worryingly high proportion.

For plants, mammals, and fish, the proportion of newly emerging alien species has remained constant during the last 150 years, but the total number of alien species has increased. Insects, molluscs and other invertebrates have the highest proportion of emerging alien species.

Previously, growth in alien species numbers has been largely attributed to increases in import volumes, human mobility and land-degradation. However, statistical models in this study suggest that the high proportion of emerging alien species cannot be solely explained by these drivers and is actually likely to be due to the incorporation of new regions as a source of potential alien species. The team estimated that there are therefore many potential alien species yet to emerge.

These findings will be helpful for horizon scanning studies that aim to identify species not yet recorded as an alien species but are suspected of presenting a high risk of arrival and detrimental impacts.

*Source: University College London*

**Treatment of nitrogen-polluted sediment using marine bacteria**

Working on a way to alleviate eutrophication in coastal waters, a research collaboration between Kumamoto University in Japan and the Virginia Institute of Marine Science (VIMS) in the US have found a combination of bacteria with the potential to lighten the impact of excess nitrogen found in many coastal water systems.

Water enrichment through excessive amounts of nutrients in coastal environments (eutrophication), is a major issue for many coastal areas around the world. As eutrophication increases in coastal areas around the world, methods of counteracting its consequences are highly sought after.

Researchers have had limited success with different nitrogen removal techniques. Flushing is often ineffective at removing contaminants because it does not reach sources deep in sediment. Relocation can produce new environmental risks when sediment is transferred away from the area. And recirculation with denitrification can have low contaminant removal efficiency.

However, anaerobic ammonium oxidation (anammox) with bacteria is thought to be a cost-effective alternative that could be performed "on-site", but its effectiveness and interaction with other microbes was unclear.

The researchers used sediment from a shrimp pond in southern Japan and compared the nitrogen removal between an unmodified sample (SB-C) and one with an increased amount of indigenous marine anammox bacteria (MAB) (SB-AMX). The sediment samples went through four different phases over 285 days. By the end of the experiments, the researchers found that a bicarbonate supplement and high nitrogen content was necessary for anammox bacteria to thrive.

The researchers also assessed the makeup of other microbial colonies in the sediment samples to reveal any symbiotic or disadvantageous relationships. They discovered that the microbial communities between the two samples were very different. A relatively large amount of sulphur-oxidizing bacteria (SOB) was found at the bottom of SB-C, and higher amounts of sulphate-reducing bacteria (SRB) were found in SB-AMX. As compounds produced by SRB are toxic to anammox bacteria, it is thought that SRB is the cause for the low nitrogen reduction performance of both samples at various times in the experiment. SOB, on the other hand, is beneficial because it removes the sulphur compounds that are toxic to anammox bacteria. Furthermore, other researchers have noted that SOB can be stimulated by the addition of bicarbonates.

*Source: Kumamoto University*

**Polar bears finding it harder to catch enough seals to meet energy demands**

A new study finds polar bears in the wild have higher metabolic rates than previously thought, and as climate change alters their environment a growing number of bears are unable to catch enough prey to meet their energy needs. The study, recently published in *Science*, reveals the physiological mechanisms behind observed declines in polar bear populations according to first author Anthony Pagano, of University of California (UC) Santa Cruz.

He and his colleagues have been documenting declines in polar bear survival rates, body condition, and population numbers over the past decade. This new study identifies the mechanisms that are driving those declines by looking at the actual energy needs of polar bears and how often they are able to catch seals. Pagano, who is also a wildlife biologist with the U.S. Geological Survey (USGS), conducted the study at UC Santa Cruz, where he has been working with co-authors Terrie Williams and Daniel Costa.

The researchers monitored the behaviour, hunting success, and metabolic rates of adult female polar bears without cubs as they hunted for prey on the sea ice of the Beaufort Sea in the spring. High-tech