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Insect Biomimetics

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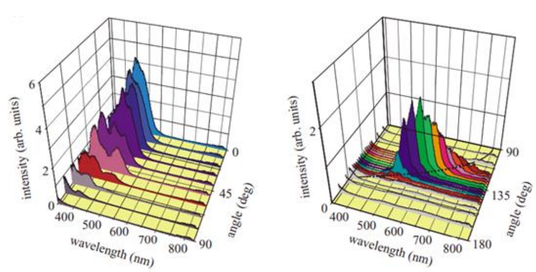
Biomimetics also known as Biomimicry, is the study and use of structural and functional aspects of living organisms as templates to create materials, substances or products by reverse engineering techniques. Insects have the required potential to act as models owing to their diversity and unique adaptations. There are many practical examples of insect biomimicry around us used in our everyday life without even being noticed. Honey comb design is used to make clothes more flexible. The stable tripod stands were inspired by the structure and position of legs. The principle of pterostigma in the insect wings helped the aeroplane manufacturers to reduce the fluttering of the plane wings and make the flight more stable. The concise folding of earwig (*Forficula auricularia*) hindwings inspired engineers to make foldable solar plates and other electronic devices which occupy large space. Termite's humongous mounds helped us to understand and improve the natural ventilation system of huge skyscrapers. Butterfly wing structure when studied closely at nano structure level unraveled its self-cleansing property which have been pragmatically applied in manufacturing of self-cleaning window glass. Migros chain of supermarket in Switzerland uses ant inspired software to decide each day the order and route with which their trucks will deliver goods to the network of retail stores in order to shorten the route lengths by up to 20% thereby reducing carbon dioxide emissions and cutting cost.

Figure 1: A Robobee Prototype (Wood *et al.*, 2013)

Harvard's Robobee project (Wood *et al.*, 2013) ended up as the smallest ever man-made device (Fig. 1) based on an insect that have managed to achieve flight. In spite of being in a prototype phase, its latest versions are not just capable of flying but stick to surfaces, swim in water and even move in and out of water. In future it could be used for search and rescue operations, survey and surveillance and even as artificial pollinators.

A team of designers from Fraunhofer has come up with a camera based upon the compound eyes of insect that can reduce the size of the camera lens to just 2 mm compared to a normal one of 5 mm. They have been calling it as facet VISION, made up of 135 tiny lenses which captures individual images and later combine them together to create the final picture. This mechanism is present in compound eyes of most insects and such inspirations will bring down the bulk of micro-electronics dimensions and size with better contrast and higher resolution images. Another break-through in the tyre industry, that is Honeycomb tyres have imparted resilience to military vehicles for travelling in some of the nasty uneven terrains. They don't need to be filled with air, can support large weight and are puncture free but most importantly they are bullet & bomb proof. The only disadvantage of this technology is that the ride offered by them is uncomfortable. People may tolerate the bumpers of honeycomb tyres but the aichmophobia of people who are scared of sharp objects like needles is on another level. But even if they aren't phobic, injecting a needle can be a horrible experience at times. This may be due to the procedure followed but also because of the size of needles. To tackle this, researchers from Japan have taken inspiration from the mosquito's highly serrated proboscis used in piercing and injecting saliva as well as sucking blood. The piercing is with such precision along with such small proboscis that it doesn't even comes in contact with the nerves at times and hence we sometimes don't even feel the blood sucking by mosquitoes. Even if they come in contact, it only incites a sub-threshold stimulus which is incapable of producing any nerve impulse due to lack of depolarisation. So, the bite remains relatively pain-free. Japanese engineers have used this knowledge to manufacture just 1 mm long needles with a diameter of 0.1 mm, which is only a fraction of the regular needle size typically used for treatments and thus capable of delivering pain-free injection.

Figure 2: The structural blue colours of the Blue Morpho Butterfly, *Morpho peleides* (Source: laughingsquid.com)



(a) (b)

Figure 3: Single-scale angle- and wavelength-resolved experiment on a scale of *Morpho sulkowskyi* under normal incidence (0°) in (a) reflection and (b) transmission directions. (Kinoshita *et al.*, 2002).

The fascinating colours of some butterfly wings (e.g., Morpho butterfly, *Morpho* sp.) are not due to any pigment but as a result of prism like nanoscale structure of the scales present on the wings and are called structural colours (Fig. 2) produced as a result of a phenomenon called optical interference which causes an iridescence (Kinoshita *et al.*, 2002). This splits the white light into its various colours depending on the angle at which the light is incidence on the wing surface so the actual colour may vary with viewing angle (Fig. 3). Mirasol screens and IMod displays of Qualcomm company are inspired by the butterfly wing structure to produce an “always on” effect without draining energy for backlighting (Rai and Mishra, 2021). Since it uses sunlight rather than screen brightness, colours intensify outdoors unlike old screens that are washed away in daylight. And reduces the colour automatically in dark to act as night mode which doesn’t stress out user’s eyes. Mirasol technology also uses 10 times less energy since it doesn’t use much backlight to operate and hence increase the battery efficiency. Although, spiders are totally different from insects, they too can be useful for inspiring us. UV-reflecting strands of spider-webs inspired us to make UV light reflecting glass for installing in humongous glass skyscrapers. This saves the bees, birds and other insects which can detect UV light reflection, from crashing into the glass buildings.

Figure 4: The Namib Desert beetle collecting water droplets from the air (Source: namibdesrtbeetle.weebly.com)

The Dew Bank designed by Kitae Pak, which collects and stores condensation was inspired by the Namib Desert Darkling Beetle, *Onymacris unguicularis* (Tenebrionidae: Coleoptera) who’s hydrophobic (repels water) body is covered with hydrophilic bumps (about twice the thickness of a human hair). The fog/water droplets stick to these water loving bumps when the beetle raises its abdomen tip on the slope of a sand-dune (desert) facing the incoming cloud of fog. The water droplet due to the sloped posture, run down his back and into his mouth (Fig. 4). The Dew Bank is made up of stainless steel to avoid rusting and its beetle-back-shaped dome collects condensed fog and runs it into a circular reservoir (Seth, 2010) for later consumption (Fig. 5). This could provide an estimated one glass water per day for survival of Namib Desert (Southern Africa) people (Stewart, 2010). The Australian scientists has succeeded in manufacturing a near perfect rubber with 98% level of resiliency by studying resilin, an elastic protein found in joints of fleas which can jump 100 times their body length and other insects at various places including wings. This rubber could be used to improve everything from the efficiency of heart valves to the fragility of sports shoes. Hence, there are more learnings than you think in the world of insects. We should see the world from their perspectives and problems to find out the unique and effective solutions which they use to survive this cruel dynamic world.

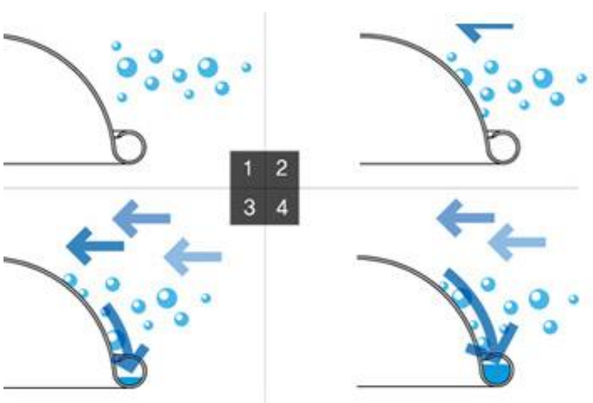


Figure 5: Mechanism employed by the Dew Bank Bottle inspired by the Namib Desert beetle (Seth, 2010).

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