The 7 Wonders of the World of Insects

Photonic insects - beauty, versatility, energy saving with little chemistry

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There are many species of insects that have colors and sculptures that make them similar to magnificent jewels. To go beyond the charm of these beings, you have to get into their genius who is also a great message for a better sustainability, energy efficiency and invention of new clean technologies.

What is behind the beauty of this weevil beetle from New Guinea?

What are hiding the fantastic reflexes of Neotropical Morpho Butterfly?

Why there are beetles that seem to be made of silver or gold?

Esapolis is one of the world largest insectarium located in Padova, Italy. Is known as the exploratory of the MicroMegaMondo of Butterfly Arc that includes also the historical Butterfly House of Montegrotto Terme. Esapolis displays, also from live, many beautiful small animals, mostly insects and their relatives, besides important museum collections, like the one on silkworms that includes an extraordinary library, a huge collection of silk cocoons, silk fibers of cultivated and wild silk moths and other invertebrates and other evidences from the silkworm industry of 19th and the early 20th century. Furthermore are presented educative, amusing and interactive exhibitions and activities. Now Esapolis has inaugurated a new section that takes into account the particular beauty of certain species of insects, in particular butterflies and beetles and the emotions generated by their particular jewel like shapes and colors.

Each of the presented species, some very rare from the museum's collections, represents those that in the exhibition are defined as the "7 Wonders of the Insect World." Of course it is very difficult to make a ranking of this kind, but all visitors agree that the species exhibited are very special and represent one of the aspects of nature that inspire more and more aesthetically beautiful. So much beauty is not devoid of important insights for science and technology. All colors of these wonderful specimens, are generated by different structures that reply on technologies of interference with the light, called "photonic crystals".

The armor of these insects, known to be made from chitin, a semitransparent substance, primarily a nitrogen-containing polysaccharide forming the principal component of arthropod exoskeletons, has produced nano-structures, such as ridges, pits, spheres, hexagons, plates, responsable, for the order in which they are arranged, for their optical properties. For their size, smaller than the wavelength of visible and ultraviolet light, they produce fantastic effects of interference and iridescence and

modulate them at will. **The reason?** Camouflage, send signals to conspecifics, reflect or capture the sun's heat, highlight special characters in males, scare predators, etc.

Photonic crystals are ranging from “simple” systems in nano-sheets (over 200) of different thickness and hydration, to striations and micro-reflective canyon, up to three-dimensional matrices of nanospheres, hexahedrons or lacunae arranged in para-crystalline structures similar to those of the opals. In insects have been identified many photonic systems and has been seen that in many cases are used more combined solutions.

What is proving the science on “the ecology” of these structures?

The scientists were looking for something that had the same properties of the crystals but less hard and more ductile, and perhaps, when we think of diamonds, less fragile than these, but with the same great refraction and maybe less expensive and reproducible with combinations of materials that formed lattices that were not on the molecular scale (order of a billionth of a millimeter,) but for example, about one forth of the length of visible light (from 380 to 760 nm, which is of the order of hundred thousandths of a millimeter.) This would means more efficient optical fibers, computers that base their operation on the light and not the electrons, with enormous savings in energy, space and speed increase (which becomes, in fact, photonics). Other applications are ranging from paints to the solar and photovoltaic panels that would take advantage of a sunlight concentration and a wider range of usable wavelengths.

But how old are insects photonic technologies?

From paleontology emerge surprising facts, one of these has been studied by Mary McNamara, of the School of Biological, Earth and Environmental Science, of the University College Cork North Mall, Ireland, who also realized beautiful images of fossils of still iridescent moths and beetles almost 50 million years old!

Scientists have speculated that the chitin of insects, in certain types of fossilization, could be last for 2 billion years! This is a prediction, as the oldest chitinous beings appeared on earth around 540 million years ago. Some of these, dated back to the beginnings of primary age, surprisingly still retain traces of chitinous armor. The “photonic insects” then, if properly stored as in the collections of museums, would last practically forever. We can therefore assume that the first iridescent colorations in insects are very old.

A great message to help to reduce environmental pollution

For many insects as well as for us, the colors are essential. Without them would disappear much of the vision of the world that we know. To produce man must use chemical processes and energy

demanding pollutants considered that each of these colors is the result of the interaction with the light of the different molecules that make up the pigments. For this reason, the insects, such as beetles, they had to “invent” the colors that were not pigments. If it is not the production of the colors would be limited to the resources available from the plants, from the time evolution of metabolic processes complex and very difficult to manage that imply long evolutionary times that may not be compatible with sudden changes in the environment. For example, two colors that are trivial for us, but that are essential to the life of insects, such as green for camouflage and white to reflect the sun's heat, are missing in the available palette of pigments of adult beetles and therefore are produced with photonic systems for interference with light.

What is the genius, the eco-logicity and therefore the usefulness for us?

The insects chitin armor, which is originally transparent and polarizing, by the way it is assembled, generates all the colors. The manipulation of the light produces polarized reflections, not only in a linear manner, but, in some cases, also helicoidal. In other cases, the superposition of transparent lenticular scales enhance the desired optical effect and, in others, adding pits or ridges on the surface of the armor the refractive brilliance is removed to generate more mimetics colors.

The helicoidal systems with polarized light were found in the armor of gold and silver beetles that live in the mountain cloudy pristine forests of Costa Rica. Their wonderful coats, that if settled in a collection make them look like jewels, in their natural environment function as the suit of invisibility of the famous alien of the movie Predator. The reflective structure, which at times resembles a fractured mirror, takes on the insect images and colors of the surrounding environment.

If we adopt the same technology of photonic insects we could, among other things, build colorful things with little or no pigments, where all the color we need may be produced by nano-manipulation of simple organic structures transparent and polarizing. This would result in a drastic reduction of pollution, the energy required to generate colors and clean them up, increasing their persistence over time and preserving their biodegradability.

To learn more about this subject and admire the jewel insects you have to visit the new exhibition of Esapolis “The 7 Wonders of the World of Insects.”

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