< Butterflies: Science On The Wing

Heard on All Things Considered

July 3, 2010 - GUY RAZ, host:

Butterflies get their colors in one of two ways: some of them, like monarchs, have pigments. But others, like the morpho butterfly, have microscopic geometric structures in their wings called gyroids. Those structures reflect certain colors of light much like a rainbow.

A new research from Yale University suggests these gyroids could help engineers figure out new ways of developing faster electronic and optical devices. The study was led by Richard Prum, an ornithologist at Yale.

Dr. RICHARD PRUM (Ornithologist, Yale University): A gyroid is a really fascinating and poorly understood shape. Actually, we're still trying to wrap our brains around gyroids and what they are. They were described by mathematicians only in the 1970s, and they have evolved in at least three lineages of butterflies independently.

RAZ: And it's a shape, basically, right?

Dr. PRUM: Yeah. It's a Swiss cheese with spiraling channels of air traveling through it that intersect one another. But those channels actually travel in three different directions through the cheese, right? And what you end up with is this very complicated form left behind, and that shape is a gyroid.

RAZ: So why are engineers, particularly electronic engineers, interested in your research?

Dr. PRUM: It turns out that all of the electronic gizmos in our lives function by controlling the flow of electricity with gated channels that allow certain frequencies through and not others. So controlling the flow of electrons is at the heart of a lot of technology.

A lot of the cutting edge of technology right now is the development of photonic devices. And these are objects that work in a similar way but by controlling the flow of light or photons. And so as a biologist, I look at these butterflies and I imagine or I see the white light transmitted through the air hitting the butterfly scale and then scattering back to our eyes as a beautiful green color.

What that means though to the engineer is that green light is prohibited or not allowed to transmit through that material. And so, the way in which these butterflies make their beautiful colors is by controlling the flow of light, and that's a fundamental property that is really at the cutting edge in engineering.

RAZ: Well, what are some of the possibilities?

Dr. PRUM: One of the fundamental ways in which these sorts of materials might work would be as the insulation around fiber optic fibers. So imagine if we were communicating in a fiber with pulses of green light. If we surrounded that fiber with material that had the same nanostructure as some of these green butterfly scales, any of the green light that tried to leak out of the fiber would go into a material which cannot transmit that green light. It would bounce it back into the fiber.

So it would act like a perfect insulation to that fiber. There's, of course, lots of engineering working precisely on this question: How do we control the leakage of light out of fiber optics?

RAZ: Which is a problem now?

Dr. PRUM: Which is a problem now, yeah. So we have to put stations between in the middle of the ocean to boost fiber optic signals so that they get all the way across the ocean or all the way across the country without loss.

RAZ: So right now, along the fiber optic cable, light leaks out, you need these boosters to make sure that the signal goes across the ocean. But in theory, if this technology is exploited, it could create insulation that would seal that light inside those cables?

Dr. PRUM: Yeah. And biological systems like butterflies self-assemble these nanostructures. And that's why they're interested in butterflies because, of course, you could machine these things at the nano scale, the side scale of light, in order to make an optical device. It would take a lot of effort. But if you could grow one at exactly the right scale, as butterflies do, you could make these things a lot easier.

RAZ: Absolutely fascinating. That's Richard Prum. He's an ornithologist at Yale University. He joined me from New Haven.

Richard Prum, thank you so much.

Dr. PRUM: Thank you very much.

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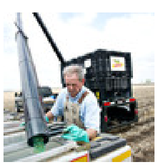

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Recent First

Penny Lane (crooowww) wrote:
Butterflies are just the coolest. The way they migrate thousands of miles, their colors, their contributions to flowers and plants. Beautiful flying flowers. Love'em.
Sun Jul 04 2010 11:36:25 GMT-0400 (Eastern Daylight Time)
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David Goff (MrFiber) wrote:
I certainly agree that this is very exciting work with lots of potential. However, the suggestion that this technology could make fiber optics better because it will "prevent light from leaking out" is complete nonsense. Light doesn't leak out of modern optical fibers. It is confined in the fiber core by a process known as Total Internal Reflection (TIR). As the terms implies, it is "Total Reflection." All of the light is reflected back into the core. You can't improve on 100.000%. Light does indeed attenuate over long distances of fiber, but not because of "light leakage." The predominant mechanisms that cause light loss are Rayleigh scattering and absorption by impurities.

Modern optical fibers have losses below 0.2dB per km allowing unrepeatered transmission of 100km or more.
Sun Jul 04 2010 09:24:51 GMT-0400 (Eastern Daylight Time)
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Mye Flatley (P_U_Wallpaper) wrote:
To GaryFromTexas: Agreed. But is the color in the insects from a diffraction grating effect (like a rainbow) or is it by interference effect (like a soap/oil film)?
Sun Jul 04 2010 02:02:07 GMT-0400 (Eastern Daylight Time)
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K T (gator2010) wrote:
This doesn't just apply to insects. Generally, blues and greens in bird feathers are "structural colors" as well.
Sat Jul 03 2010 21:55:08 GMT-0400 (Eastern Daylight Time)
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Uncertainty Principle (SchroedingersCat) wrote:
Gary T (GaryFromTexas) wrote:

Physics lesson: Rainbows and oil slicks produce colors by different mechanisms – refraction and interference.

Thanks gary, the guy's comparison of them confused me. I wonder which he meant? I can't really tell by the "swiss cheese" comment. Which is swiss cheese more like, an oil slick or a rainbow? Sounds like something straight out of "Through the looking glass!"
Sat Jul 03 2010 12:02:34 GMT-0400 (Eastern Daylight Time)
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larry fer (littlefer) wrote:
Wow. It just freaks me out how incredible the evolution of a butterflie wing is. And everything else for that matter.
Sat Jul 03 2010 11:42:57 GMT-0400 (Eastern Daylight Time)
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Gary T (GaryFromTexas) wrote:
Physics lesson: Rainbows and oil slicks produce colors by different mechanisms – refraction and interference.

A rainbow does it by refraction as light enters and exits rain drops. This is the same mechanism as a prism separates white light into colors. Sunlight is reflected internally by raindrops. The light is bent entering and exiting the rain drops. Each color of light bends a different amount. The resulting color seen is dependent on the angle of view. Viewers in different positions will see the same colors in different locations.

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Star Wars. Send us YOUR cultural blind

10 days ago

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An oil slick produces colors by interference in thin films. When light enters a thin layer of oil on the surface of water, some light is reflected by the top surface and some light passes through the top surface and then is reflected back by the bottom surface of the very thin layer of oil on water. If the bottom surface reflected wave is in phase with the wave reflected from the top surface, then that wave will be reinforced. If it is out of phase, it will be cancelled. Because the geometry depends on the length of the light wave to determine if it will be added (reinforced) or subtracted (cancelled) as the two reflected light beams combine and different wave lengths are perceived as different colors, the reflected color will vary with the thickness of the film. Therefore, variations in the thickness of an oil film will produce variations in the color of reflected light.
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