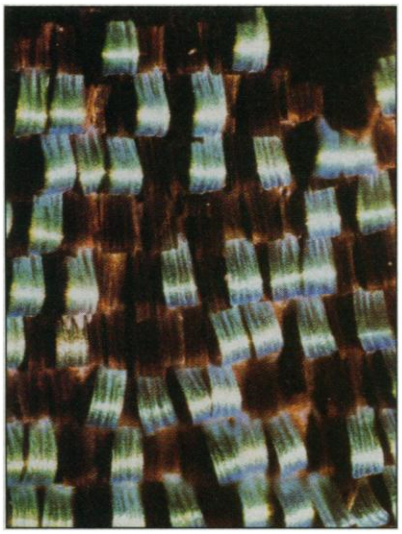
BUTTERFLY BIOMECHANICS

Wing Scales May Help Beat the Heat

Like a Day-Glo mohawk, the iridescent blue-green colors adorning the wings of some butterflies and moths get a lot of notice. And that's just how entomologists have viewed them: as eye-catching patterns designed to attract a mate or warn off a predator. But it's possible the jewellike scales that form these patterns may serve another, more mundane, function as well: Measurements by engineers at Tufts University in Medford, Massachusetts, suggest that the scales can reflect or absorb sunlight to regulate the cold-blooded insects' body temperatures.



GEORGE ELLMORE

Hot patterns. The optics of iridescent scales on the wings of the butterfly *Urania fulgans*, magnified 125 times, may help the insect regulate body heat.

The scales are made of stacked layers of a shell-like material, and the Tufts researchers—in work to be reported at a meeting in November—have shown that tiny changes in the thickness of these stacks can have large effects on the amount of absorbed solar energy. Although scientists have not tested these effects in living insects, specialists are intrigued. Joel Kingsolver, a zoologist at the University of Washington, Seattle, who has found that pigments in butterfly wings play an important heat-gathering role, says the changes "appear to affect absorptivities in such a big way that they could have important thermoregulatory consequences."

The project took off, not on a wing, but a chip. In 1991, Ioannis Miaoulis, dean of the school of engineering at Tufts, and engineering graduate students Peter Wong and Bradley Heilman were trying to understand defects in computer chips made of silicon films. Computer models indicated that tiny variations in film thickness could magnify the amount of heat the chips absorb during manufacturing, sometimes to the point of ruining them. Miaoulis, who also directs Tufts's Comparative Biomechanics Laboratory, wondered whether certain insects, whose scales are constructed in layers roughly analogous to the films, had evolved a way to control radiation absorption.

A literature search led the researchers to iridescent butterfly scales. Electron-microscope images of the scales (taken in the early 1970s by Helen Ghiradella, a biologist at the State University of New York) showed that the scales' alternating layers of air and chitin—the shell material—are close in thickness to the silicon films the Tufts group had simulated.

The Tufts team took a closer look at the scales' optics. In experiments to be reported at the annual meeting of the American Society of Mechanical Engineers in San Francisco in November, they showed that scales from one iridescent species, *Papilio palinurus*, absorbed significantly more light than did scales from another iridescent butterfly, *Urania fulgans*—although the chitin layers in *P. palinurus* are only 1/100th of a micron thinner. The reason: Chitin layers in *P. palinurus* are close to one quarter of the length of a typical light wave, says Wong. So waves reflected off the top and bottom of the layer will be half a wavelength out of phase (the peak of one will meet the trough of the other), cancel one another out, and dissipate their energy within the layer. A slightly thicker layer will move such waves back into phase, and they will reflect away from the scale. Over the whole range of wavelengths in sunlight, such differences add up, with cancellation winning out over reflection more consistently in *P. palinurus* than in *U. fulgans*.

The idea that iridescence has a thermoregulatory effect "shouldn't be in the least bit controversial," says Michael Locke, a biologist at the University of Western Ontario in London who has studied the development of insect cuticles. "Everybody accepts the notion that wing colors are important for thermoregulation in butterflies," he says. The novel feature of the Tufts work, he points out, is the suggestion that the effect is caused by optical interference rather than pigmentation.

Other scientists, however, note that no one has yet shown that the amount of heat absorbed through the scales makes an appreciable difference. "Just because a feature would seem to serve a given function well doesn't mean it's something that matters to the organism," cautions Thomas Schultz, a behavioral ecologist at Denison University in Granville, Ohio. Schultz has conducted absorption experiments—with negative results—on iridescent tiger beetles.

The next step will be to conduct such heat tests on butterflies. Biophysical ecologist Warren Porter of the University of Wisconsin says he is interested in performing them. If they pan out, says Kingsolver, it would be interesting to survey iridescent scales in wing regions that affect body temperature on butterflies from colder environments, to see whether they are of different thicknesses and have greater absorption than those on butterflies from warmer climes. Tiny variance in the chitin could, Kingsolver says, turn out to be a way that butterflies adapt to different latitudes.

–Wade Roush

CANCER BIOLOGY

Another Blow Weakens EMF-Cancer Link

Perhaps the most plausible piece of laboratory evidence linking electromagnetic field (EMF) exposure to cancers has just become much less plausible. This area is rife with tenuous connections, but work suggesting that low-level EMF exposure can dramatically affect the workings of the *Myc* gene, an oncogene implicated in a host of human cancers, has stood out as stronger than most. Now, however, two elaborate attempts to replicate the findings have failed completely.

The two papers, both to be published in the October issue of the *Journal of Radiation Research*, rebut the decade-long work, begun in 1982, of Columbia University cell biologist Reba Goodman and Hunter College molecular biologist Ann Henderson. The two had reported that the *Myc* gene in immature human blood cells had a two- to threefold increase in expressed RNA when the cells were exposed to low-level EMF. These large effects impressed Jeff Saffer, an author of one of the new papers and head of the department of biology and chemistry at the Pacific Northwest Laboratories (PNL). But when he completed his own study, he says, he was less than overwhelmed: "There was no observable effect."

Saffer's study, which was conducted with his colleague Sarah Thurston, was funded by a program run jointly by the Department of Energy (DOE) and the National Institute of Environmental Health Sciences (NIEHS). The program's goal "is to try to take the most important and most relevant findings, those driving the science in the EMF controversy, and try to validate and replicate them under very, very carefully controlled conditions," says Gary Boorman, who runs the NIEHS side of the effort.

In the United Kingdom, the National Grid PLC, a major power distribution com-