carbon dioxide concentrations are likely to have quite complex and far-reaching effects on ecosystems," Drake says.

L. Hartwell Allen, a crop physiologist with the U.S. Department of Agriculture in Gainesville, Fla., finds similar methane enhancements in studies of rice. Plots growing in double the current concentration of carbon dioxide emitted roughly twice as much methane as did those subjected to lower carbon dioxide amounts, he told SCIENCE NEWS.

Although they cover only a limited part of the globe, wetlands and rice paddies account for 30 to 40 percent of methane emissions into the atmosphere. By enhancing methane production in these environments, the buildup of carbon dioxide could significantly boost atmospheric concentrations of methane, Dacey says.

Indeed, methane amounts are rising, having more than doubled since preindustrial times. Researchers blame most of this increase on coal mining, use of natural gas, rice cultivation, raising of cattle and sheep, and burning of vegetation. But the new study suggests that the buildup of carbon dioxide may have caused roughly 15 percent of the methane increase by stimulating growth in wetlands and rice paddies, says Dacey.

Climate experts are concerned about methane because each molecule can trap about 20 times more heat than carbon dioxide can. —*R. Monastersky*

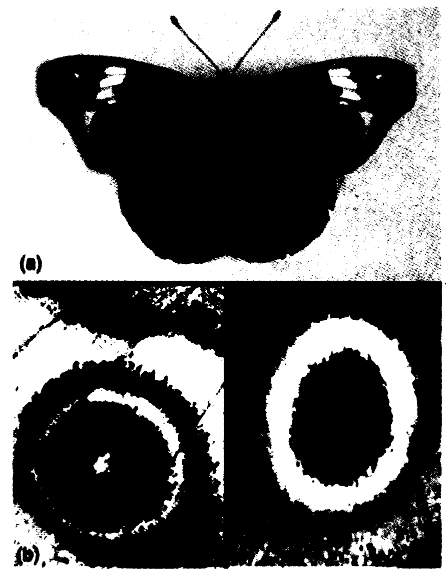
Gene patterns decorate butterflies' wings

Nature photographer Kjell B. Sandved made his reputation exploring the diversity of the world's approximately 200,000 moths and butterflies. Over the years he has found the alphabet, numbers, and many other human symbols inscribed in their wings (SN: 6/16/90, p.376).

But it took the plain fruit fly *(Drosophila melanogaster)* to help scientists understand how nature can be so creative.

In fruit flies, and presumably all insects, the activation, or expression, of certain genes in particular cells for short periods helps define body parts. Just before an insect larva changes into a flying adult, it develops white globs of cells called imaginal disks that later become its wings, explains Sean B. Carroll, a geneticist at the Howard Hughes Medical Institute at the University of Wisconsin-Madison.

Carroll's group used fruit fly genes to study these disks in the buckeye butterfly, *Precis coenia*, which is common throughout the United States. They found six genes very similar to the fruit fly's. In fruit flies, these genes specify the top and bottom, back and front, and inner and outer margins of the developing wings. The same holds for butterflies, the Wisconsin group now reports in the July 1 SCIENCE. For example, in butterflies, as in



Carroll and Stephen W. Paddock/HHMI-Univ. Wisconsin

Buckeye (a) eyespots (b, c) up close.

fruit flies, the cells that make up the top wing surface contain an activated apterous gene, while those destined to frame the wing perimeter express one called Distal-less. "The same genes are expressed in the same relative coordinates that we know operate in the fruit fly wing," says Carroll.

Fruit flies began evolving separately from butterflies about 200 million years ago. "So it looks like that program was very much conserved," he adds.

But then the butterfly goes one step further, reactivating those genes to generate colorful wing designs. "Distal-less is expressed in a new and unexpected pattern," comments H. Frederik Nijhout of Duke University in Durham, N.C.

Carroll and his colleagues observed that within each section of developing wing, a wedge of cells activates Distal-less genes. Over time, that wedge narrows and finally shrinks to a small spot, just as Nijhout had predicted years earlier when he was theorizing about how patterns should arise.

"It confirms that all butterfly color patterns are derived from a common ground plan," says Nijhout. On each wing, several small groups of cells act as organizing centers that guide the patterning of the entire wing. "Different parts of the color pattern are uncoupled. You can think of it as a mosaic system," he adds. This uncoupling leads to great variety.

Thus, while all wing sections can generate eyespots, only certain ones do. Carroll and Nijhout think the expression of other genes helps define other types of butterfly wing patterns and that natural selection guides the final outcome. For example, showy colors on the upper surface help attract mates, while duller bottom surfaces help the insect blend in with its background to avoid predators, they note. – *E. Pennisi*

Future for artificial photosynthesis shines

Is artificial photosynthesis possible? Might scientists someday mimic nature's sunlight-capturing molecular machinery in order to use solar energy for human purposes?

Based on recent work revealing the structure of key membrane proteins that enable plants and bacteria to harness the sun's energy, photosynthesis may become "the first complex biological system to have its structure, function, and regulation described in rigorous physical-chemical terms at the atomic level," say James Barber, a biochemist at the Imperial College of Science, Technology, and Medicine in London, and B. Andersson, a chemist at Stockholm University.

"Such knowledge could provide a blueprint for new technologies for the production of energy," they write in the July 7 NATURE.

Specifically, the scientists herald recent work showing the structure of a "light-harvesting pigment protein," an advance that they say could eventually make possible artificial photosynthesis. This light-harvesting pigment protein lets photosynthetic organisms take advantage of the entire solar spectrum and grow where little light shines. By means of a new technique called electron crystallography, scientists can view the structure of the light-harvesting chlorophyll a/b-protein complex, also known as LHCII.

The most abundant membrane protein in chloroplasts, where photosynthesis occurs, LHCII binds about half of all chlorophyll, the researchers say. Organisms able to harvest light in this way can survive continual and unpredictable fluctuations in sunlight. Within seconds of a slight shift in clouds, sunlight can vary by up to 100 times in intensity. Thus, chemical mechanisms are crucial in regulating light absorption and restoring interrupted photosynthesis.

In recent months, an artificial photochemical system has generated for the first time a "spin-polarized triplet state"—a charge-transfer reaction previously seen only in live photosynthetic organisms. In another key advance, a group has synthesized self-assembling proteins genetically engineered to incorporate specialized pigments.

The "secrets of the molecular electronics" of photosynthesis will soon become available for solar energy conversion, Barber and Andersson predict. "The challenge now is to devise an artificial system based on this knowledge."

—*R. Lipkin*