What Color is Your Carapace?

by Cindy Weiss

Red and blue do not only define election issues and states, they are hue variations on the mottled brown we're used to seeing in lobsters. A UConn professor and his colleague have discovered how the color variations work.

A University of Connecticut chemistry professor and his colleagues have obtained experimental results that help answer the mystery of why most lobsters have a mottled brown shell, or carapace (before cooking) and why the rare specimen is blue.

Professor Harry A. Frank said experiments by his research group, led by doctoral student Robielyn P. Ilagan, support the theory that carotenoid molecules, or pigments, in the lobster's shell interact with each other when bound in a protein. The resulting pigment-protein complex produces the shell color.

In most cases, the combination of the red carotenoid molecules with the blue pigment-protein complex produces a shell that is mottled brown. In rare cases, the blue color of the protein predominates.

"It's a mystery why these rare lobsters are blue and why brownish lobsters have the color they do. Our data explain that," said Frank.

When a lobster is cooked, whether it is brown or blue in its live state, its shell turns red because the binding of the carotenoid pigment, astaxanthin, to the protein is broken, freeing the carotenoid to display its normal red color.

Frank, who has studied the structure and function of carotenoids since 1980, funded by a National Institutes of Health (NIH) grant, said the experiments on the lobster protein began last year when his research group, along with collaborator Ronald L. Christensen of Bowdoin College, studied a molecule called astaxanthin using a high-speed laser.

The laser, which has a flash duration of 100 femtoseconds (a femtosecond is one-quadrillionth of a second). The laser pulse is so rapid that the scientists could could watch the astaxanthin molecule change under the light into its "excited" or high energy state, and then relax back to its normal, ground, state. The observations enabled them to collect information about how the astaxanthin molecule interacts with its surroundings and with other molecules. Astaxanthin,

In Living Color:
The rare bright blue lobster occurs when the animal "over-expresses" a protein that binds the pigment astaxanthin in a complex structure.

recently named "Molecule of the Week" by the American Chemical Society (ACS), is "part of a nutritious diet" for lobsters and shrimp, giving crustaceans their bright red color when cooked.

How this happens was the subject of the Frank group's research. Lobsters accumulate astaxanthin in their shells and bind it, with other astaxanthin molecules in a protein called crustacyanin, Frank said. The binding together of pairs of astaxanthin with the protein molecule changes the normally red astaxanthin molecule to blue. The brownish-blue color of the native lobster arises from a combination of protein-bound and free astaxanthin in its shell.

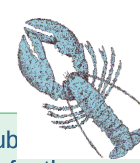
When a lobster is cooked, astaxanthin is released from the protein, but it stays in the shell and returns to its red color. It's the association of the molecule with the crustacyanin protein that shifts its light absorption spectrum and controls its color, Frank said.

In rare cases, a lobster "over-expresses" the crustacyanin protein, or has more than its normal share. The crustacyanin protein in its pure form is very blue, a rare color in nature.

The structure of the astaxanthin molecule bound in a smaller variant of the protein crustacyanin, was solved in 2003 by John Helliwell, a scientist at the University of Manchester. This was a major breakthrough in understanding lobster coloration, Frank said, but it didn't tell researchers the entire story of why the color changes when the lobster is boiled or why the rare lobster is blue.

The quest for the answer to the lobster's shell color is akin to asking, "why is does grass have the different green hues that it does?" or "why do autumn leaves have the colors they do?" Frank said.

"All of these biological coloration problems can be very complex."



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