Chemistry

How antioxidants defend cells

Antioxidants in the body act as chemical scavengers, intercepting reactive molecules called free radicals before they have a chance to damage cells. Two recent studies shed some light on how such protective mechanisms work.

In one study, researchers examined how vitamin E, vitamin C, and carotenoids such as beta carotene collaborate to get rid of free radicals, whose harmful effects arise from their readiness to grab an electron from another molecule. The scheme the chemists propose works something like a bucket brigade, with the dangerous chemical property being passed from one molecule to the next.

First, vitamin E reacts with the free radicals, restoring them to their less harmful state. This reaction, however, turns vitamin E into a potentially damaging radical, which the carotenoids then inactivate. Finally, vitamin C repairs the resulting carotenoid radicals, and the water-soluble vitamin C radicals eventually wash out of the body.

The mechanism, says T. George Truscott of Keele University in England, may help explain the puzzling results of clinical studies showing that beta carotene supplements boost the incidence of cancer in smokers. The Beta Carotene and Retinol Efficacy Trial (CARET), funded by the National Institutes of Health, was halted early because of this finding (SN: 1/27/96, p. 55).

According to the researchers' proposed scheme, smokers tend to be low in vitamin C, so they don't have enough of the vitamin to scavenge carotenoid radicals. Giving smokers supplements of carotenoids only adds to the radicals in the body, he says.

"This [cascade] occurs in test tubes, but the proof will be in human trials" using combinations of antioxidants, Truscott says. He and his colleagues report their findings in the Jan. 22 Journal of the American Chemical Society.

Beta carotene, for example, seemed very promising in the laboratory, says Gilbert S. Omenn of the Fred Hutchinson Cancer Research Center in Seattle, but its effect was radically different in people. Truscott carried his study out in an organic solvent, so it's difficult to predict whether the mechanism would be the same in a physiological system.

Nevertheless, Omenn says, "I think it's terrific that trials have generated chemical research like this to try and explain the clinical results."

The second study addresses a very different kind of protection against free radicals—one built into proteins themselves. Rodney L. Levine, Earl R. Stadtman, and their colleagues at the National Heart, Lung, and Blood Institute in Bethesda, Md., propose that the amino acid methionine may function as a protein's last-chance defense against free radical damage. Their study appears in the Dec. 24, 1996 Proceedings of the National Academy of Sciences.

"It's just an initial concept, but we think it has good logic," Stadtman says. "Almost all [free radicals] we've studied have a preference for attacking methionine." Free radical attack turns the amino acid into methionine sulfoxide. That change didn't affect the structure or function of the particular protein they studied, however, suggesting that "perhaps methionine was put there to protect." The situation is similar in other proteins, he adds.

Moreover, earlier studies have shown that some enzymes can restore methionine sulfoxide to its original state, thereby setting up a cycle that allows its antioxidant activity to be renewed.

The group is now trying to create mutant strains of yeast that produce variable amounts of such enzymes. By looking at whether the yeast mutants are more or less sensitive to free radical damage, the researchers hope to lend further support to their theory. *— C.W.*

Earth Science

Gauging gas reserves

The first direct measurement of natural gas imprisoned in sediment beneath a portion of the ocean floor has added fuel to a debate about the magnitude of such gas reserves worldwide.

Scientists drilled hundreds of meters into the ocean bed in two spots on Blake Ridge, 3 kilometers below the ocean surface off the coast of North Carolina. Samples revealed an abundance of methane hydrate, a solid formed when high pressure and low temperature lock methane in ice (SN: 11/9/96, p. 298). The researchers also found free methane beneath that layer, in concentrations about 10 times previous estimates.

The study, published in the Jan. 30 Nature, indicates that a 25,000-square-km section of Blake Ridge holds methane equivalent to 35 billion tons of carbon—more than 100 times the U.S. natural gas consumption for 1996. An earlier study had concluded that only 40 billion tons of carbon are available over the entire 100,000 km^2 of the ridge.

The discrepancy between the old and new estimates may be due to different methods of measurement, says Charles K. Paull, a marine geologist at the University of North Carolina at Chapel Hill who participated in the new study.

"We actually measured," Paull says. "All other estimates have been based on inferences."

In their study, Paull and his colleagues trapped samples in a pressurized hollow drill bit, which kept the gases from escaping or decomposing as they were brought to the ocean surface.

The earlier study of the same region mapped gas reserves by bouncing sound waves off the ocean floor. The intensity of reflected sound waves and the time they took to bounce back gave scientists a picture of the composition of the ocean floor.

W. Steven Holbrook of the Woods Hole (Mass.) Oceanographic Institution participated in that earlier study, which appeared in the Sept. 27, 1996 Science. Holbrook calls the earlier estimates "conservative." Although he doesn't discount the larger concentrations of free gas found in the new study, he says the gas may not be distributed evenly across the bottom of the ocean, making it hard to estimate the total amount.

Despite the difference in the two estimates, Holbrook agrees there's a lot of free gas under the ocean floor trapped beneath layers of methane hydrates.

"We can't ignore the free gas zone anymore," he says. *— P.S.*

Ocean's impact on climate predictions

Forecasting the weather more than a few days in advance is no easier in Europe than it is anywhere else. A stabilizing effect of the North Atlantic, however, may enable scientists to predict climatic trends in the region for up to 10 years.

A new computer model developed by Stephen M. Griffies of the National Oceanic and Atmospheric Administration (NOAA) in Princeton, N.J., and Kirk Bryan of Princeton University indicates that ocean conditions like salinity and temperature—major factors affecting climate—change more slowly in the North Atlantic than in other locations. The North Atlantic has tremendous inertia, the researchers conclude in the Jan. 10 Science.

To take advantage of the new model's ability to improve climatic prediction, more measurements of temperatures, depth, and salinity throughout the North Atlantic are needed, Bryan says. Such data could be obtained from a system of climate-sensing buoys similar to one that NOAA installed recently in the western Pacific.

The computer model may be valuable because it accounts simultaneously for several factors influencing climate, says Peter Rhines, a University of Washington oceanographer. But its accuracy in portraying some of the factors, such as deep ocean convection, flows down steep seafloor boundaries, turbulent mixing, ice dynamics, and freshwater exchange with land and atmosphere, may require further refinement, he says. *— P.S.*