Title
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Domoic Acid in Marine Diatoms: Biochemical Pathways and Environmental Regulation

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Background

The coastal United States has more toxic algal species, more algal toxins and more toxic algal blooms than ever before. The apparent spread of harmful agal blooms not only poses a human health threat but also has significant economic consequences for the seafood industry.

While declining water quality may be one reason for many of the observed increases in toxic blooms, the mechanisms through which man-made pollutants contribute to algal blooms is not well understood. Some of the “new” harmful algal blooms, for instance, have occurred in relatively pristine waters off the coast of Alaska and may be an artifact of better environmental testing. In the case of domoic acid, one of the more recently discovered toxins on the West Coast, sediment cores suggest the diatoms that synthesize the toxin have lived in coastal waters for more than a thousand years and are ubiquitous in coastal waters.

The Project

The purpose of this project was to identify environmental cues that can trigger toxic *Pseudo-nitzschia* blooms by examining the biochemical pathways of domoic acid (DA) production in these diatoms. Diatoms within the genus *Pseudo-nitzschia* produce DA.

More specifically, the focus of the study, led by Dr. G. Jason Smith of Moss Landing Marine Laboratory, was to investigate the hypothesis that DA is produced in *Pseudo-nitzschia* in response to stress. This hypothesis is motivated, in part, by the striking structural similarity between domoic acid and proline, an amino acid produced by many marine organisms in response to stress.

The Method

To examine the effects of environmental stress on diatoms, Dr. Smith exposed diatoms to varying levels of copper, urea, nitrate and silicate. Copper is an essential nutrient that becomes toxic at high levels. Nitrate and urea both contain nitrogen, which is required for reproduction and cell growth. For this reason, plankton blooms cannot occur without a minimal amount of nitrogen. Silicate is another essential nutrient, used by diatoms to construct their frustules, or shells.

After exposing diatoms to nutrients, Dr. Smith measured levels of three key amino acids—DA, proline, and taurine. Taurine may reduce the toxicity of DA.

The Findings

The findings from this project support the theory that stress can trigger DA production.

Dr. Jason Smith found that:

Photomicrograph of a dense bloom of diatoms from Monterey Bay, September 2000. The dominant needle-like cell chains are *Pseudo-nitzschia australis*. Photo: G. Jason Smith ©2000.

Photomicrograph of the toxic diatom *Pseudo-nitzschia australis*, isolated from a net tow during a bloom in Monterey Bay in September 2000. Note: the middle cell is alive while the two flanking cells are in states of senescence. Photo: G. Jason Smith ©2000.

- as silicate levels were lowered, DA production increased as much as a hundredfold;
- cells producing high levels of DA had relatively low levels of proline and relatively high levels of taurine; and,
- DA levels were higher when copper concentrations were higher and lower when copper levels were lower.

He also observed that nitrogen in urea and nitrate had no effect on DA production, beyond its known role in regulating cell growth.

Dr. Smith recently received funding from the National Science Foundation to isolate genetic markers that can be used to monitor DA production in diatoms from Monterey Bay.

Applications

This project helps answer basic genetic and biochemical questions about how and why cells produce DA. This information potentially can be used to help develop treatments for shellfish poisoning, and it has direct relevance for improving monitoring of coastal waters. At present, the state tests waters for the presence of *Pseudo-nitzschia* diatoms but does not have the ability to tell whether these diatoms are actively producing DA. Dr. Smith said that his work lays the foundation for genetic fingerprinting that can discriminate between DA-producing and non-producing diatoms.

Cooperating Organizations

Merck & Company, Inc.
Monterey Bay Aquarium Research Institute
Provasoli Guilliard National Center for the Culture of Marine Phytoplankton
University of California, Santa Cruz—Marine Sciences Institute

Presentations

Ladizinsky, N.L., G.J. Smith, and K.H. Coale, 2000. Intracellular accumulation of domoic acid by *Pseudo-nitzschia* multiseries in response to increasing total copper levels. Sanctuary Currents 2000. Monterey Bay National Marine Sanctuary Symposium: Causes of Ecosystem Change: Natural or Human?, Santa Cruz, California.

Ladizinsky, N.L. and G.J. Smith, 2000. Accumulation of domoic acid by the coastal diatom *Pseudo-nitzschia* multiseries: A possible copper complexation strategy. PSA Annual Meeting, San Diego. Student Bold Award Presentation runner-up.

Smith, G.J. 1999. HAB or HAB NOT Workshop: Evaluation of the relationship between domoic acid and proline metabolism in *Pseudo-nitzschia* spp. from Monterey Bay, California. Invited instructor for an online, interactive presentation sponsored by the College of CoExploration and USC Sea Grant. Conference website: http://www.coexploration.org/hab. Presentation website: http://members.aol.com/symbios222GJSHAB99.html.

Awards

The Fred and Ethel Meyers Marine Biology Trust Award
Sigma Xi Grant in Aid of Research

Graduate Trainee and Thesis

Ladizinsky, Nicolas L., M.S. in Chemical Oceanography, California State University, Monterey Bay, anticipated June, 2002, "Accumulation of Domoic Acid by Diatoms in the genus *Pseudo-nitzschia* in Response to Increasing Cupric Ion Activity: A Possible Complexation Strategy."

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