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# EDITORIAL

## Chemical Ecology

Plants and animals use special chemicals for purposes that include defense, aggression, communication, and reproduction. Perhaps 100,000 or more compounds are involved. Some taste bad. Others are extremely toxic. Some act as neurotoxins blocking ion channels. Others cross-link DNA. A few hundred molecules may elicit a response.

Organic chemists have tools that enable them to be essential partners in advancing chemical ecology. They have highly sensitive equipment and deep knowledge of substances and of synthetic pathways.

A sample of activities of chemical ecologists was provided in a colloquium held in Washington on 25 and 26 March and sponsored by the National Academy of Sciences. Organizers were Professors Thomas Eisner and Jerrold Meinwold of Cornell University. Speakers and participants included a distinguished national and international contingent. Material presented was exciting and inspiring. It is also likely to have medical and agricultural applications. Proceedings of the meeting will be published, probably later this year.

Topics of lectures included chemical defense mechanisms in plants and animals and their identification, use of substances for aggression, communication among ants involving both chemicals and movements, and the interplay of pheromones with nervous systems of both female and male insects.

In marine environments, many substances contain chlorine or other halogens. On land, almost all special chemicals contain only carbon, hydrogen, nitrogen, or oxygen. Many of the pheromones have long carbon chains. However, most of the special substances have ring structures that include oxygen or nitrogen. The alkaloids—which are numerous—contain nitrogen.

Starting materials for synthesis of the special chemicals are substances common to all life forms such as amino acids and lipids. A few steps convert phenylalanine into the bicyclic compound coumarin, a defensive constituent of many plants. More toxic modifications of the compound are found in different plant species. Enzymes act on oleic acid to introduce additional double bonds and to shorten length of the chain. Products are building blocks of cyclic compounds that include oxygen or nitrogen. Oleic acid is also a starting material for synthesis of straight chain pheromones that contain alcohol, aldehyde, or acetate groups. Once procured or synthesized, special chemicals are stored in glands where they are available when needed.

Most scientists are aware that female pheromones attract male insects. The detailed mechanisms involved are complex. For instance, the female corn borer moth does not emit chemicals until she is stimulated by substances emitted by the corn silk. The stimulus is followed by activity in her nervous system that leads to synthesis and to pulsed emission of pheromones. The attracted male or males have antennae with about 100,000 receptor cells. When these detect the pheromone they interact with the male nervous system. His flight upwind is erratic, and he responds only to the precise chemical formulation of the pulsed pheromone, which may have several components.

Corn borer moth larvae and larvae of other moths are subject to attack by tiny parasitic wasps. These insects deposit their eggs within the caterpillars, also stunning them. When the eggs hatch, they eat the insides of the caterpillar. The female wasps receive chemical signals that help them find the corn borer moth larvae. About 2 hours after the borer attacks, leaves of the plant emit terpenes. The terpenes attract the wasps. Experiments with laboratory-grown wasps indicate that they could be employed to diminish crop losses. However, for maximum effectiveness, the wasps must be "educated." They function best after they have had an opportunity to touch the regurgitates or feces of a corn borer caterpillar.

In some instances moths have developed systems that allow them to utilize plant chemicals that are toxic to other arthropods. In one example described at the colloquium, eggs are deposited on pods of a plant that contains a potent alkaloid. The larvae bore through the pods and partake of the seeds, which have a large content of the toxic substance. The alkaloid is sequestered. Later, moth females are selective in their mating. They choose males that have a large stored supply of the alkaloid, much of which is delivered to her during copulation. The alkaloid later appears in her eggs.

Countless inventions of special chemicals and behavioral patterns were made before humans appeared. We have only begun to grasp their subtlety.

**Philip H. Abelson**