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Colloquium Paper

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Chemical ecology

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Ours is a world of sights and sounds. We live by our eyes and ears and tend generally to be oblivious to the chemical happenings in our surrounds. Such happenings are ubiquitous. All organisms engender chemical signals, and all, in their respective ways, respond to the chemical emissions of others. The result is a vast communicative interplay, fundamental to the fabric of life. Organisms use chemicals to lure their mates, associate with symbionts, deter enemies, and fend off pathogens. Chemical ecology is the discipline that is opening our "eyes" to these interactions. It is a multifaceted discipline, intent on deciphering both the chemical structure and the information content of the mediating molecules. And it is a discipline in which discovery is still very much in order, for the interactions themselves remain in large measure to be uncovered.

Chemical ecology has made major progress in recent decades. This reflects, in part, the extraordinary technical innovation that has taken place in analytical chemistry. Highly improved procedures are now available for separating complex mixtures into their individual components, as well as for quantitating and chemically characterizing designated compounds. There has also been a vast increase in the sensitivity of the techniques. Where gram quantities were once needed for elucidation of chemical structure, milligram or even microgram quantities may now suffice. These refinements in sensitivity are of particular importance, given that organisms often produce their signal molecules in vanishingly small amounts.

Progress in chemical ecology has also been fostered by advances in biology itself. Chemical interactions in nature are often social, in the sense that they occur between conspecifics. Conceptual advances in behavioral biology, particularly sociobiology, have helped put new slants on inquiries into such social phenomena as mate attraction, sexual selection, parental investment, caste determination, and colony organization, all frequently mediated by chemicals. The questions themselves, answered at one level of organization, often lead to inquiries at another level. Studies of pheromones, for instance, first with insects and then with selected mammals, were doubtless influential in prompting the highly promising current inquiries into pheromonal communication in humans. Other biological disciplines are also proving relevant. Virtually every chemically mediated interspecific interaction, whether between predator and prey, herbivore and plant, or parasite and host, lends itself to interpretation in the broadest evolutionary, ecological, population-biological, and molecular-biological terms.

Molecular biology may, in fact, increasingly shape the questions that are asked in chemical ecology. How do given signal molecules arise in the course of evolution? How are they synthesized, and how is the rate and timing of their production controlled? How are they recognized at the level of the receptor? How do noxious chemical signals, designed to repel or poison, affect their intended targets? How is it that receiver organisms are sometimes able to circumvent, counteract, or even secondarily employ, such offensive chemicals? Molecules that transmit information between organisms are a fundamental part of the regulatory chemicals of nature. The rules that apply to intraorganismal chemical regulation apply in large measure to them as well.

Molecules that have signal value in nature sometimes prove to be of use to humans. One need only cite the example of medicinals to underscore the point. Major recent additions to our therapeutic arsenal include ivermectin, cyclosporin, FK-506, and taxol, compounds that can all be expected to have evolved as signaling agents. Many and varied benefits can be expected to be derived from an ongoing search for natural products. Chemical ecologists should become active participants in this search. They have the expertise, gained through laboratory and field experimentation and observation, to rate species by "chemical promise" and therefore to aid in the important task of selecting species for chemical screening. Chemical ecologists are also in a position to provide some assessment of the hidden value of nature. The search for natural products has essentially only begun. Most species, especially microbial forms and invertebrates, remain to be discovered, let alone to be screened for chemicals. What remains unknown is of immense potential value, and deserving of protection, lest we be forever impoverished by its loss. To help in the preservation effort, chemical ecologists will need to speak out as conservationists.

The essays that follow are synopses of lectures delivered at a colloquium on chemical ecology. Almost 150 participants attended the proceedings. The papers do not provide an overview of the discipline but rather give a glimpse into selected research areas that are contributing to advancement of the field. We are immensely grateful to our invited speakers, both for the quality of their communications and for the personal enthusiasm they brought to the meeting. Discussions were convivial and much enlivened by the youthfulness of most of the audience. Four participants, Ian T. Baldwin, Gunnar Bergström, Arnold Brossi, and Amos B. Smith III deserve special thanks, for presiding over the sessions and for leading the discussions. We are also grateful to Jack Halpern, Vice President of the Academy, for asking us to organize the colloquium, and to Bruce Alberts, President of the Academy, for providing introductory remarks at the meeting. For help in preparation of the colloquium we are indebted to Kenneth R. Fulton and Jean Marterre of the Academy and especially to our Cornell associates, Janis Strope and Johane Gervais.

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