recent advances in phytochemistry

volume 30

Phytochemical Diversity and Redundancy in Ecological Interactions

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Cover photographs: Imago and larva of *Zygaena trifolii* which possesses a cyanogenic system similar to that of its host plant *Lotus*. It both accumulates linamarin and lotaustralin from the host and synthesizes the compounds *de novo*—redundancy?

Proceedings of the Thirty-Fifth Annual Meeting of the Phytochemical Society of North America on Phytochemical Diversity and Redundancy in Ecological Interactions, held August 12–16, 1995, in Sault Ste. Marie, Ontario, Canada

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PREFACE

Diversity within and among living organisms is both a biological imperative and a biological conundrum. Phenotypic and genotypic diversity is the critical currency of ecological interactions and the evolution of life. Thus, it is not unexpected to find vast phytochemical diversity among plants. However, among the most compelling questions which arise among those interested in ecological phytochemistry is the extent, nature, and reasons for the diversity of chemicals in plants.

The idea that natural products (secondary metabolites) are accidents of metabolism and have no biological function is an old one which has resurfaced recently under a new term "redundancy." Redundancy in the broader sense can be viewed as duplication of effort. The co-occurrence of several classes of phytochemicals in a given plant may be redundancy. Is there unnecessary duplication of chemical defense systems and if so, why? What selective forces have produced this result? On the other hand, why does the same compound often have multiple functions?

At a symposium of the Phytochemical Society of North America held in August 1995, in Sault Ste. Marie, Ontario, Canada, the topic "Phytochemical Redundancy in Ecological Interactions" was discussed. The chapters in this volume are based on that symposium. They both stimulate thought and provide some working hypotheses for future research. It is being increasingly recognized that functional diversity and multiplicity of function of natural products is the norm rather than the exception.

Berenbaum and Zangerl set the stage as they eloquently make the case that function in nature cannot be equated with biological kill in bioassays. With examples drawn from a single class of compounds, the furancoumarins, evidence for diverse functions, multiple functions, and the importance of synergism in mixtures is provided. Lindroth and Hwang, concentrating on a single genus of plants, the aspens, show how bioactivity of terpenoids and phenolics spans not only families, but kingdoms. Similar examples of multiplicity of function are provided by Renwick from *Pieris* butterfly/glucosinolate studies, and by Siegel and Bush from alkaloids in endophytic grasses.

Hammerschmidt and Schultz draw the parallel between insecticidal activity and defense against pathogens, emphasizing that different approaches to problems among plant/insect ecologists and plant pathologists have heretofore obscured the idea of the same or similar compounds having a range of biological function. Both groups may gain insight from studies of the other's discipline. Isman et al., in a discussion of compounds from the neem tree, emphasize the importance of nontoxic compounds which nonetheless can enhance toxicity. This is a relatively new concept which further complicates already complicated synergistic effects. It needs further attention. Cates' long-term study of the unique pine/sawfly interaction demonstrates convincingly that interactions mediated by chemicals are never simple, and that many relatively common natural products act in concert, possibly with common products of primary metabolism.

Nahrstedt's paper showing that an insect makes a toxic cyanogen which it can also accumulate from its host plant puts still a different twist on the debate. Is such duplication of effort redundancy in the narrow sense or an expanded functional role? In the same vein, the diversity of mechanisms which are responsible for systemic and non-systemic resistance to pathogens can be viewed as either "redundant" or adaptive to a variety of selective pressures. The papers by Constabel et al. and Uknes et al. are both enlightening and perplexing in this regard.

Finally, the ideas of complexity theory, made accessible in the paper by Jarvis and Miller, and the redundancy defense, here further refined by Firn and Jones, provoke a lively debate which ultimately may help ecologists and phytochemists alike refine their ideas about the ecological functions of natural products. While the papers in this volume go a long way towards solidifying the case for natural product functional diversity and multiplicity, they also emphasize a complexity of nature that is perhaps too convoluted and too varied to be explained by any single term, be it diversity, redundancy, or any new one on the horizon!

The senior editor expresses gratitude to Dawn McGowan for excellent technical expertise in the preparation of this volume. We have made an effort in all papers in this volume to emphasize the term "natural product" in lieu of the outdated term "secondary metabolite."

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CONTENTS