Lipids in Freshwater Ecosystems

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Foreword by Robert G. Wetzel

With 63 Illustrations

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Cover illustration: Schematic representation of the deposition pattern of lipid droplets (triacylglycerols) in a well-fed freshwater calanoid copepod.

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Foreword

Although limnology is a young discipline, it has, over the past century, experienced marked growth. Its early descriptive period was a long one, given the enormous diversity of biota and environments in freshwater ecosystems. With the development of quantitative techniques came the ability to measure production rates and other parameters and to demonstrate the effects of nutrient limitation and predation on productivity and energy flow. As understanding of these phenomena grew, so too did our appreciation of the many complex chemical interactions among the biotic and habitat components of freshwater ecosystems.

A recent, exciting phase of limnology, which may be called *biochemical limnology,* is evolving rapidly. One of its many facets is the study of population and community dynamics at basic physiological levels. Examples are many. The integration of recent studies of food biochemistry with traditional studies of food quantity has begun to reveal the striking importance of food quality to reproduction and to the growth dynamics of many aquatic animals. Positive as well as negative alleleochemical interactions, already known in terrestrial ecosystems, are emerging as a major factor of many competitive interactions in fresh waters.

The role of dissolved organic matter, particularly humic and fulvic compounds of plant origin, in the aquatic ecosystem is complex. Not only do these compounds function as large stores of carbon and energy, but they are also metabolically interactive. For example, humic substances can complex with enzymes and other metabolic macromolecules and become stored in inactivated states for various periods of time. These complexes can then be displaced to other parts of the ecosystem, potentially to be reactivated at a later time. Thus, chemical communication among biotic components is certainly as prevalent in freshwater ecosystems as it is in the complex metabolic biochemistry of metazoans. If we are to manage freshwater ecosystems effectively, we must discover more about such interactive control mechanisms. Those controls are chemical; therefore, understanding the biology requires an understanding of the biochemistry.

This collection of work on lipids represents a synthesis of existing information on a diverse group of hydrophobic organic compounds of biological origin in freshwater ecosystems: their origins, functional couplings among biotic and abiotic processes, and fates. Syntheses serve many functions. If done well, as this one

is, they collect and integrate information from studies scattered in diverse journals, a pragmatic service in our era of burgeoning data and reports. More important perhaps, they provide critical evaluations and interpretations of existing data and explore interrelationships among biotic components of the ecosystem as a whole. Such analyses produce new insights that instill vigor and new directions into a discipline.

This text begins with summaries of some of the prevalent lipid compounds in freshwater ecosystems, produced within the aquatic systems and imported from the catchment areas. It then presents selected methodology for differentiation of lipid classes and fatty acids. Certain fatty acids have sufficient source specificity that they can be utilized as biochemical and trophic markers. With careful interpretation, such markers can provide qualitative insights into trophic relationships at higher levels in the food web.

Examination of environmental factors controlling synthesis of lipids in algae provides insights into their usefulness as indicators of the physiological status of the algae. Because zooplankton and probably most consumer organisms are capable of little de novo synthesis, lipids are primarily dietary in origin. Fluctuations in lipid content and quality in food sources, as well as feeding behaviors, are thus critically important to subsequent development, growth, and reproductive success of higher aquatic organisms. Differences in lipid requirements, utilization, and storage strategies among biota, particularly invertebrates and fish, can potentially influence evolutionary pathways, competitive interactions, and biodiversity.

The impacts of human activities on freshwater ecosystems are now so pervasive that they influence most biogeochemical cycling. Many nonpolar organic contaminants bioaccumulate in lipid compounds. Understanding of biochemical and environmental factors regulating bioaccumulation and cycling is therefore essential to freshwater management and remediation. Finally, hydrophobicity of lipids results in an accumulation of natural and anthropogenic compounds into lipid-rich tissues of organisms, water-surface microlayers, and foams. Numerous microbes and higher organisms have life stages that, during particular periods, inhabit the surface regions and thus are exposed to potentially elevated concentrations of lipid-associated contaminants. Study of this complex community is still in its infancy.

This book is a comprehensive summary of the status of our knowledge of the multifarious roles of lipids in freshwater ecosystems. Although gaps in our understanding still remain, the authors raise questions that will give impetus to accelerated experimental research in this exciting and essential area of inquiry.

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