

THE BIOCHEMISTRY  
OF THE  
CAROTENOIDS

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Volume II Animals

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Volume II Animals

T. W. GOODWIN, C.B.E., F.R.S.  
*Johnston Professor of Biochemistry*  
*University of Liverpool*

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## PREFACE TO THE FIRST EDITION

The carotenoids are not only amongst the most widespread of the naturally occurring groups of pigments, but probably also have the most varied functions; witness their known roles in photokinetic responses of plants, in phototropic responses of fish and as vitamin A precursors in mammals and birds. Pigments with such wide distribution and such diverse functions are obviously of great interest to biological scientists with very different specializations, especially as it is unlikely that the study of the functions of carotenoids is anywhere near complete.

The primary aim of the present work is to discuss the distribution, biogenesis and function of the carotenoids throughout the plant and animal kingdoms in such a way that, because of, rather than in spite of its biochemical bias, it will be of value to workers interested in all the biological aspects of these pigments. The biochemical approach is considered the most effective because, generally speaking, most progress in the study of carotenoids in living material has been achieved using biochemical techniques, be they applied by zoologists, botanists, entomologists, microbiologists or other specialists; what is even more important is that a consideration of the present position makes it certain that further fundamental progress will also be made along biochemical lines.

Although many good accounts of the pure chemistry of the carotenoids are available, the most recent and comprehensive being Karrer and Jucker's *Carotinoide* (Birkhäuser, Basel, 1948), (now available in an English translation by E. A. Braude and published by Elsevier) sufficient descriptive chemistry has been included to make this book adequately self-contained and to allow the discussion to be followed without undue difficulty. The most up-to-date spectrographic data have also been included, because spectrophotometric techniques are of great importance in identifying carotenoids in biological systems.

The first comprehensive survey of the biochemistry of carotenoids was made in 1922 by the late L. S. Palmer (*Carotinoids and Related Pigments*, Chemical Catalog Co., New York); this was followed in 1934 by Zechmeister's *Carotinoide* (Springer, Berlin) and Lederer's *Les Caroténoïdes*

*des Plantes* (Hermann, Paris), and in 1935 by Lederer's *Les Caroténoïdes des Animaux* (Hermann, Paris). Since then a survey such as the present one has not appeared. In order to present a full picture, much of the pre-1934 work has been reconsidered and, as far as is known, every important contribution which has appeared since that date has been discussed. Two peripheral aspects of the subject have, however, been omitted, namely (a) the qualitative and quantitative changes which the carotenoids of plant materials undergo in storage or during processing into food and (b) the carotene (pro-vitamin A) requirements of different animal species; it was felt that the former, about which a great deal has been written, was too technological to be suitable for inclusion in the present volume, whilst the latter is more suitable for a monograph on vitamin A.

The very wide distribution of the carotenoids in Nature suggests that, in spite of the superficially diverse functions ascribed to them in different living tissues, there may be some factor or property through which all these functions will eventually be correlated; any suggestion as to the nature of this common property can perhaps come most readily from a comparative approach. Apart from critically surveying the literature this book has been constructed so as to focus attention on comparative data and their possible implications. If the comparative aspects do not always appear to have been given sufficient explicit consideration it is because essential data are still lacking; it may even be hoped that when research workers realize fully the lacunae, they will be stimulated to carry out investigations on comparative lines. If this does occur then the author will feel that the book has served one of its main purposes.

To many biochemists the word 'carotenoid' stimulates the mental response 'vitamin A precursor' and no more. There is a need, which it is hoped this book fulfils, to emphasize to all concerned, directly or indirectly, with carotenoid biochemistry that a much wider view must now be taken of these pigments and that in the course of elucidating their biogenesis, metabolism, and functions, very significant advances with wide implications for our understanding of living processes are to be expected.

My sincere thanks for considerable help during the writing of this book are due to many friends and colleagues; it should be emphasized however, that none of them can be considered in any way responsible for any peculiarities which may exist in the book. Professor R. T. Williams (St. Mary's Hospital Medical School) read and criticized the original typescript; Mr. D. A. Coult (Department of Botany, The University of Liverpool) read the section on plant carotenoids and corrected many errors of nomenclature; Dr. J. Glover (Department of Biochemistry, the University of Liverpool) devoted considerable time to correcting both the galley and the page proofs, and made many valuable suggestions. Miss B. M. Morris and Miss M. W. Boggiano between them produced an unblemished typescript from a far-from-perfect manuscript; the Staff of the Liverpool University Library (especially Miss E.

Whelan) went to considerable trouble to trace and obtain obscure journals and monographs.

My greatest debt of gratitude is, however, due to Professor R. A. Morton, F.R.S. His encouragement stimulated me to begin this book and his continued unstinting help during the writing of it has been invaluable.

Conditions in the British publishing world are today extremely difficult and the long delays in publishing Scientific Books, especially monographs, tend to make them out of date before they appear. My Publishers have been most tolerant in dealing with my attempts to reduce this delay to a minimum. It is entirely due to their wholehearted co-operation, that it has been possible eventually to include information available in this country up to the end of September 1951.

T.W.G.

## PREFACE TO THE SECOND EDITION

It is just over twenty-five years since the first edition of this book was published and, as in most fields of biochemistry, profound developments have occurred in carotenoid biochemistry in the intervening years. So great have these developments been that the original small book has developed into two large volumes. In the first edition, complete coverage of the literature was aimed at and probably to a great extent achieved; in the present edition I hope that the main developments have been fully covered and documented but in order to keep within a reasonable size, some selectivity has been observed.

The present volume (Volume II) deals with carotenoids in animals; higher plants and Protista have already been dealt with in Volume I, published in 1980. The basic chemistry and properties of carotenoids were discussed in Chapter 1 of Volume I so they are not covered again in this volume. However Chapter 1 is once more a general chapter dealing this time with carotenoproteins which are very characteristic carotenoid derivatives found in animals, particularly in invertebrates. In the chapters which follow, the nature of carotenoids and their distribution in the major animal divisions are described in detail although emphasis is put on the carotenoids recently completely characterized by modern biochemical and physico-organic methods. In particular the stereochemistry of these compounds, which is of great interest and often somewhat unexpected, is emphasized.

The central dogma of carotenoid biochemistry is that animals cannot synthesize the pigments *de novo* but they can only alter the molecules by oxidation, as in the conversion of  $\beta$ -carotene into astaxanthin or, if the structure is appropriate, by central fission to form vitamin A. The first premise of the dogma appears still to be true but within the last few years two new metabolic activities have been revealed: one, resulting in the conversion of  $\beta$ -rings into  $\epsilon$ -rings in birds for example (see Chapter 10), a reaction which appears not to happen in higher plants and protista; and the other, resulting in a change of chirality as in the formation of 3'-epilutein from lutein in fish for example (see Chapter 8). Considerable progress is expected from investigations in this new and exciting field.

xvi Preface to the second edition

I am grateful to a number of people for help in the preparation of this book; to Miss B. T. Foulkes for typing numerous drafts of manuscripts, Miss M. A. Ommanney for careful subediting, and Dr G. Britton for much helpful information. Finally I wish to make a special acknowledgement to my wife who has lived through thirty years of carotenoids; without her sustained support and encouragement during that period this book and very many other things in my life would have never been possible.

T.W.G.  
March, 1983