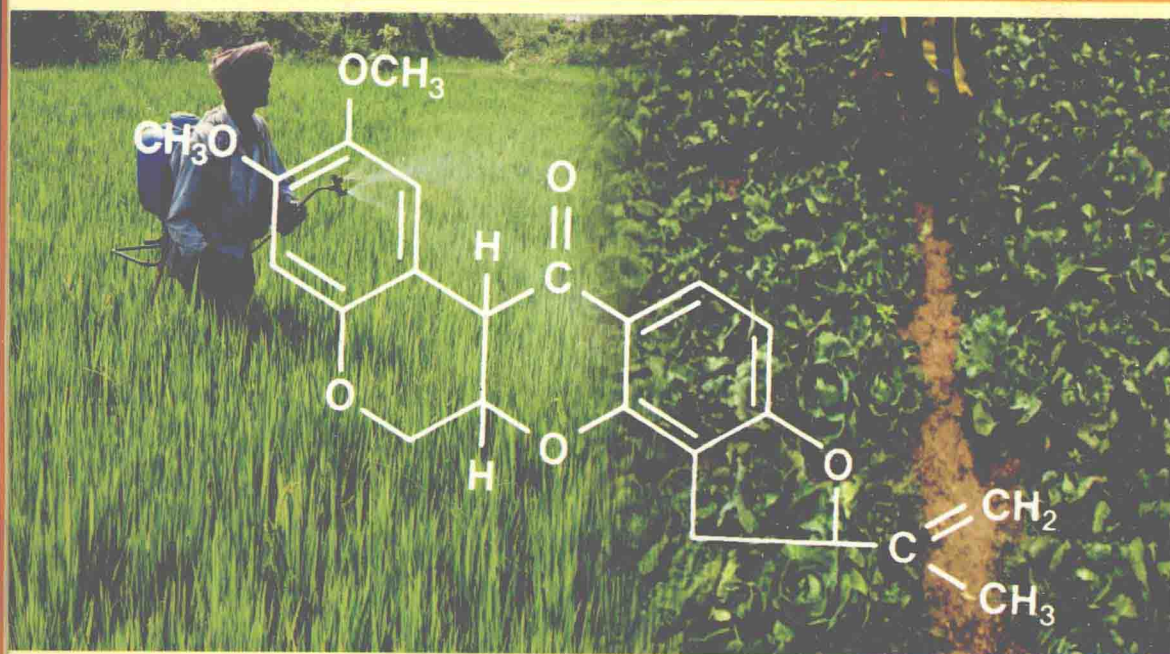


The Chemistry of Pesticides

Their Metabolism, Mode of Action and
Uses in Crop Protection



Kenneth A. Hassall

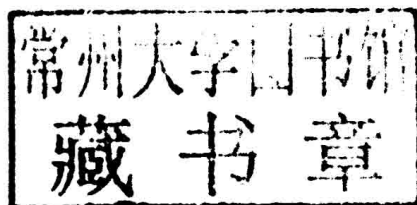
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PESTICIDES**

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To
C.H.E.

Preface

Few aspects of agriculture have advanced so rapidly or generated so much controversy as has the use of chemicals for crop protection. Such chemicals include insecticides, fungicides and herbicides, as well as several minor groups of compounds. All of these are here collectively termed *pesticides* — an unsatisfactory but useful umbrella term, from 'pest: anything noxious, mischievous or destructive'. In its early days the subject of pesticides involved little more than an enumeration of the toxic compounds used in agriculture, with lists of their chemical properties and practical uses. Such has been the progress in the subject that nowadays it is evident that an understanding of metabolism, persistence and mode of action is as essential for the safe and efficient use of pesticidal substances as it is for poisons and drugs of importance in medical toxicology.

A consequence of this progress has been that the subject has become more fascinating as it has become more complex. This book attempts to portray something of this fascination by demonstrating the multidisciplinary nature of the science of pesticides, with specific reference to substances used in crop protection. The agriculturist or his advisor normally has to handle and apply insecticides, fungicides and herbicides and will find it convenient for these three major types of agricultural pesticides to be considered under one cover. This (regrettably unusual) event is highly desirable scientifically and educationally since so many of the principles involved transcend the type of compound under discussion — the scientific aspects of formulation, application, disposition, metabolism and even mode of action, are extremely similar for insecticides, fungicides and herbicides, and one may suspect academic demarcation often separates what should naturally be united.

At least three per cent of the market value of agricultural crops in technologically advanced countries is spent on toxic chemicals and their application. This large sum is spent in an effort to minimise the effects of the army of pests which find large areas of monoculture a paradise for explosive reproduction. Some of us may regret the necessity for the use of pesticides on crops, but it is a necessity arising from the fact that man has opted out of the usual constraints placed upon species equilibration; man neither wishes to limit his reproduction to two children per family nor wishes to take a cut in his (worldwide) standard of eating. Remove the chemicals and, in the present world situation, food will become scarcer for the poor nations and dearer for the rich. On the other hand, Rachel Carson and many others have pointed out that the use of toxic chemicals on crops can help to create some of the problems which perpetuate their use (the development of resistance and the destruction of competitors are two

examples). They can also pollute the environment if used in the wrong place or at the wrong time, or in the wrong amounts.

Let me make quite clear that the comments above are not to be construed as an apology; even though I am sometimes proud to wear a conservationist's hat, I have dedicated much of my life to teaching this subject and several well-known names were former students at Reading. In short, in my considered judgment chemical crop protection is both inevitable and desirable for the foreseeable future, albeit increasingly as a part of integrated pest control. So, if such substances are to be used it is imperative that all who use them, or advise about their use, are aware of the hazards which can arise and of the metabolic factors which determine their persistence, activation or degradation.

A major purpose of this book is to meet the need just described, whilst demonstrating that the underlying principles are often of intrinsic interest to the pure scientist. It is thus designed to meet the needs of those in academic, commercial or international organisations who, while expert in some other discipline, have neither the time nor the inclination to sieve through advanced texts for various types of basic information. In addition, most students studying agricultural disciplines now receive courses in Crop Protection Chemistry. Pesticides also provide excellent examples of how molecules can be designed to fulfil predetermined objectives (Biochemical and Molecular Pharmacology) and of the problems arising from the widespread use of toxic chemicals (Environmental and Pollution Chemistry).

From undergraduate teaching in both Britain and East Africa, I have found the subject both intelligible and interesting to those with a standard in chemistry approximately equivalent to Advanced Level in Britain (i.e. school chemistry to about eighteen years of age). Clearly the book is not intended to deal with this wide subject exhaustively, for merely to list the *titles* of the articles on pesticide chemistry which have appeared in the last ten years would occupy a space larger than this book. On the other hand, where chemistry (or biochemistry) is an essential vehicle to convey the rationale of structure, enzymic attack, or mode of action of a particular pesticide, chemical or biochemical discussion has not been side-stepped. However, recognising that long chemical names can break the continuity of presentation (and perhaps be rather off-putting to some non-chemists), chemical formulae have, wherever possible, been kept out of the main text but provided for reference as a part of the legend to Figures. For rather similar reasons latin names do not always accompany trivial names in the text although they have been used where ambiguity might arise. For others, cross-reference is possible through the Index.

Substances used for crop protection vary from year to year but the fundamentals governing their choice, use and metabolism evolve much more slowly. Of the hundreds of chemicals in current use as pesticides only a relatively small number have been selected to illustrate these general principles, for a lengthy catalogue would obscure rather than enlighten — and would be, one imagines, profoundly tedious. The same would apply to lists of insect pests, pathogens

and weeds together with the chemicals which have been used to control them. This is, in fact, something that is best done at the local level anyway, and in many countries Agricultural Ministries provide literature indicating how best to deal with local problems. In addition, excellent commercial literature exists on the practicalities of pest control and should always be sought and carefully read before handling any crop protection chemical. In the present book the principles already outlined are illustrated by reference to substances selected as representatives of groups or of sub-groups of pesticides and have been chosen to illustrate the widest range of structure-toxicity relationships and metabolic patterns as is reasonably possible within the space available.

No doubt these subjective choices will merit criticism. Nevertheless it is my hope that this book will be a stimulus to all who are concerned with scientific agriculture, whether as growers, governmental advisors or as representatives of commercial firms. In addition, I should regard it as a welcome bonus if its contents provide an appreciation of the subject of molecular biology, the fascination of which grows with each new discovery, and which often lies at the heart of pesticide metabolism, mechanism of action and the development of resistant strains of organisms.

Reading, May, 1981

K. A. H.

Introduction, Acknowledgments and a Disclaimer

Pesticide science is a multi-disciplinary subject and readers of this book are likely to be approaching it from a variety of scientific backgrounds. Consequently, although the book is an introductory text which is suitable for use by undergraduates for whom the subject forms part of a wider course, it is also likely that specialists in such fields as chemistry, biochemistry, agriculture, biology, toxicology and soil science may turn to it to superimpose a knowledge of pesticides upon their pre-existing expertise. Thus, for any one reader, 'introductory' is not necessarily the same as 'elementary' through all facets of the subject. This heterogeneity of background imposes a number of problems to both author and reader since a book such as this must, of necessity, assume the existence of a certain familiarity with a range of supporting sciences. To minimise such difficulties the first section of the Bibliography at the end of the book (p. 333) lists recommended texts which will, where the need arises, help individual readers quickly to acquire basic but essential knowledge in one or more basic disciplines. The latter could include entomology, genetics, plant anatomy and mycology as well as structural and metabolic biochemistry.

Other books in the Bibliography provide a wider insight into the ecological controversy which often surrounds pesticide usage, and yet others are reference books which are indispensable to all concerned with the practical use of pesticides (the present book is seldom concerned with the timing or dosage of a particular pesticide application, nor with the best application volume or spray pattern to employ). The references which occur at the end of each chapter serve a different purpose, for they give guidance to those wishing to pursue selected subjects in greater depth and to those who wish to consult original articles or more detailed reviews.

It is a pleasure to acknowledge the help provided by several colleagues in my own and other departments of the University of Reading, as well as that given by staff of the British Agrochemicals Association and members of several Research Institutes. Numerous reference books and review articles have proved invaluable as sources of information and, more importantly, have enabled me to make decisions with regard to balance and priorities of subject matter. Many of these are listed in the Bibliography at the end of the book and others appear in the references at the ends of the chapters. I should like to single out for special mention the *List of Approved Products for Farmers and Growers* (Ref. 20, p. 334).

the *British Insecticide and Fungicide Handbook* (Ref. 21) and the *British Weed Control Handbook* (Ref. 22). In addition, the book on insecticides by Matsumura (Ref. 12) and that edited by Wilkinson (Ref. 13) are valuable sources of more detailed information and list many hundreds of references to original work. The same is true of the text on antifungal compounds edited by Siegel and Sisler (Ref. 15) and those on the chemistry of herbicides edited by Audus (Ref. 16) and by Kearney and Kaufman (Ref. 17).

A few of the tables and figures in this book are based on data or diagrams of other authors. These are acknowledged where they occur, but there are a few authors to whom I am particularly indebted. Figures in table 1.1 have been selected from several tables which appear in *Chemicals for Crop Protection and Pest Control* (1977) by Green, Hartley and West (reference list, chapter 1). Many of the toxicity data in table 1.2 appeared in *World Review of Pest Control* (1966) and were collated by Edson, Sanderson and Noakes (Bibliography, p. 335, Ref. 28). Some of the data in table 5.1 are quoted from *Carbamate Insecticides: Chemistry, Biochemistry and Toxicology* (1976) by Kuhr and Dorough (reference list, chapter 5) and some of those in table 6.2 are from a review in *Environmental Toxicology of Pesticides* (1972) by Kenaga (reference list, chapter 6). I have also used several diagrams and tables from two of my earlier works, namely, *World Crop Protection: vol. 2, Pesticides* (Iliffe, 1969) and *Biochemistry and Physiology of the Cell* (Edwards and Hassall, 1980, McGraw-Hill (UK) Ltd).

Finally, because of the nature of the subject a disclaimer is necessary. This book is for educational information, not for trade; although every care has been taken to get facts right and to avoid printing errors, the ultimate responsibility in pesticide usage rests with the user, whose job it is to read the label on the container, to consult commercial or official advisors and to be acquainted with local rules and regulations. Consequently, notwithstanding any statement made in this book, *neither the author nor the publisher accept any responsibility for any damage or accident of any sort whatsoever, arising from the use of any of the pesticidal compounds mentioned in this book.*

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