BASIC GUIDE TO PESTICIDES
Their Characteristics and Hazards

Shirley A. Briggs • Rachel Carson Council

BASIC GUIDE TO PESTICIDES

"It is the public that is being asked to assume the risks that the insect controllers calculate. The public must decide whether it wishes to continue on the present road, and it can do so only when in full possession of the facts. In the words of Jean Rostand, 'The obligation to endure gives us the right to know.' "

Rachel Carson, *Silent Spring*

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Shirley A. Briggs and the staff of
RACHEL CARSON COUNCIL

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Publisher's Note

The publisher has gone to great lengths to ensure the quality of this reprint but points out that some imperfections in the original may be apparent.

Contents

Foreword

Basic Guide to Pesticides is a fitting tribute to the memory of Rachel Carson. It covers all that people need to know about some 700 pesticides and their contaminants. This book is important in dealing with environmental problems both in general and in individual cases.

Rachel Carson's gifts as both poet and scientist turned *Silent Spring* into an eloquent book. Because of her, we undertook landmark hearings in the U. S. Senate that aroused Congress and the nation to the dangers she described. Her purpose, she told me before she died, was to call attention to the ever-increasing contamination on the balance of nature, global in scope and detrimental to mankind.

This present book is a guide for humanity as a whole. Ultimately, if we fail to use chemicals properly, we will injure deeply all nature and mankind.

Senator Abraham Ribicoff

Preface

THE PURPOSE OF THIS GUIDE

This book had its origin in the publication of *Silent Spring* in 1962, and more directly in the situation in which Rachel Carson found herself thereafter. She was overwhelmed by requests for information that reached her from people everywhere, and realized that no individual could deal with the amount and scope of the need. She spoke of establishing an organization that would keep abreast of new research, and would respond to requests from individuals, organizations, and governments with problems in use and control of pesticides. After her death in 1964, friends and colleagues with whom she had discussed this hope established what is now the Rachel Carson Council, an information center on chemical toxins, especially pesticides. As an independent, objective source, the Rachel Carson Council has continued to seek all sound information available, and to respond to requests from all over the world. Her book caused such a universal increase in concern with and comprehension of problems of pesticide contamination that it led to a steady growth in scientific study in the field and of government requirements for better testing. When we began, there were very few manuals and references available, and these covered limited aspects of the subject. With the help of those among our directors and consulting experts who represent pesticide toxicology, medicine, ecology, fish and wildlife, agriculture, and related subjects, we have gathered an extensive library and files over the years, assessed the reliability of the data, and continued to share the information with the public. Our library and files are available to those who wish to delve further.

Our years of dealing with the concerned public have given us insight into the problems people encounter, the kind of information they need, and the form in which it has proved most useful. Our exploration of the technical literature and attention to the ways of government regulatory agencies have expanded our understanding of the technical issues involved, and the ways in which economic and social pressures affect the way regulations are actually enforced. (Should not the information we have amassed be easily available to all from government? In an ideal world, perhaps, but much of our task has been running interference for the public against controlling groups, both inside government and out.)

Basic Guide to Pesticides is the product of all these years of gathering data and explaining them. Here we tell either the beginner or the specialist what they *need* to know, not just what is readily at hand. If key facts are not yet known, we make this clear so that caution is indicated. The final task of updating all our files for this book took place in 1990 and 1991. While we have included new information as much as possible, the formal cutoff date was September 1991.

With a wide range of potential users in mind, we have tried to arrange the facts so that a reader can quickly find just what is sought, without having to read through lengthy text material to sift out a few pertinent facts. Tabular presentations, with definitions of the categories and kinds of information given, have proved the most useful. They also show clearly where gaps in our present knowledge occur. A blank space in a column with a question mark in it shows that the trait or problem may exist, but as yet we cannot tell.

Many people will want more details than we can give in a necessarily terse presentation. Through our lists of recommended general sources and our specific references we point out further research routes. In the supplementary material in the appendices, experts in important aspects of pesticides summarize what should be understood by everyone in our increasingly chemical world.

DIMENSIONS OF THE SUBJECT

Everyone, whether consciously or not, is exposed to a large number of pesticides through many routes. Residues occur in our food, drinking water, air, clothing, and household furnishings. We may encounter more concentrated amounts in schools, churches, offices, apartment buildings, factories, golf courses, or from spraying of or run-off from agricultural lands or our neighbors' gardens. Communities have widespread spraying programs attempting to deal with nuisance insects or pests of city trees. It is often difficult to identify even the apparent sprays and dusts to which we are exposed, and the total array that may reach an individual in a short space of time is impossible to distinguish by either kind or quantity. It is this total, pervasive burden of toxic materials that we must consider when we have a decision to make about using a pesticide ourselves, or when involuntary exposure causes problems. It may not be just the latest exposure to chemicals that can have adverse effects on us, or on exposed animals and plants, but the final combination. In a world that has absorbed ever-increasing amounts of pesticides in the past 46 years—many of them synthetic toxins never before found in nature—both the immediate and the long-term reactions can be serious.

Pesticides, with few exceptions, are very biologically active substances. They can have profound effects on living matter in various ways, and are designed to kill at least certain forms. They may have different effects on different organisms, doing one thing to plants, another to birds, or poisoning the target pest by a different physiologic reaction than that caused in other forms of life. There are, however, basic similarities in the ways that cells function, whether in plants or animals, and it can be assumed that a substance that can kill one organism may have a marked effect on many others. In a few cases we do indeed have materials that affect only a narrow range of plants or animals, and these are the most desirable pesticides. It is more profitable to manufacture products with many uses, so the pesticides in common use are usually "broad spectrum," which means that they can damage plants and animals that the user may not expect or wish to harm.

Pesticides include broadly toxic substances that are released into our environment and may have effects far from the point of application, both in space and time. To gauge the whole impact of any one would require a knowledge of the intricate operation of many ecosystems far beyond our present information. It is unlikely that we shall ever have a sufficient grasp of all of these factors and their interactions to make an adequate assessment. Because Rachel Carson made the elements of such understanding clear to the public in *Silent Spring* in order to explain the scope of the danger from uncontrolled use of pesticides and the vulnerability of our living environment, she has been called the mother of the environmental movement.

AMOUNTS IN USE

Since Rachel Carson first described the problem in 1962, pesticide production and use in the United States and around the world has vastly increased. Whereas she was concerned about a U.S. total of 637,666,000 pounds a year in 1960, we now stand at 1.1 billion, and if all materials correctly designated as pesticides are included, at 2.1 billion pounds. (Originally, the figures omitted wood preservatives, disinfectants, and sulfur.) These figures are for active ingredients only, and come from the latest report from the Environmental Protection Agency for 1989 (Economic Analysis Branch, Office of Pesticide Programs). The United States produces 1.3 billion pounds, imports 200 million, and exports 400 million to reach the 1.9 billion pounds of "conventional" pesticides used. The expenditure for this use was $7.615 billion. Herbicides have become the most-used kind of pesticides, at 61%, with insecticides at 21%, fungicides at 10%, and all others at 7%. In the May 1991 *EPA Journal* summarizing pesticide programs, a graph shows the amounts for the top 10 pesticides, with a total of 44,020,000 pounds per year. Two, carbaryl and malathion, are insecticides; the rest are herbicides. They account for 40% of all U.S. usage.

alachlor 100 million pounds
atrazine 100 million pounds
2,4-D 52.67 million pounds
butylate 44.58 million pounds
metolachlor 44.55 million pounds
trifluralin 30.35 million pounds
cyanazine 20.25 million pounds
carbaryl 12.25 million pounds
malathion 15.20 million pounds
metribuzin 13.17 million pounds

Since the United States accounts for one-third of the world figure, by multiplication we now exist on an earth where 6.3 billion pounds* of these toxic materials are added every year, to join the continuing residues that make their way, like the air and ocean currents, all over the globe.

To live on such an earth, clear understanding of these materials is essential for everyone. To this end, we offer our *Basic Guide to Pesticides*.

Shirley A. Briggs

*Most estimates of world consumption are based on the shorter list of "conventional" pesticides. Data are elusive, but it is reasonable to assume that the United States uses of the three additional types in the full 2.1 billion total are proportional to world usage, thus the 6.3 billion figure.

Illustrations

To contend with the larger issues of pest control is to become enmeshed in many aspects of our attitude toward the natural world. Because she dealt with these aspects clearly and convincingly, Rachel Carson has been credited with launching what is now called the *environmental movement,* successor to previous periods of concern for our habitat called *conservation.* We must balance short-term against long-term effects and our self-centered aims against broader needs of other forms of life, and gain a concept of the dynamics of ecology—a term the book *Silent Spring* first made common currency. In selecting the illustrations for this guide, which deals mostly with the tools for pest control from which we must choose, we wish to suggest attitudes that either focus on wiping out immediate annoyances and threats or seek to promote a continuing healthy environment.

When the Rachel Carson Council was established, the now-deceased Mauritz Escher gave his support by granting permission to use his drawings in our publications. They express so well the unity of nature, the beauty of creatures that some find alien, and the sense of proportion and humor that were also fundamental to Rachel Carson's world view. Cartoons also can express these concerns pointedly, with a look at both the surface hilarity of human quirks and blindnesses and the underlying import of our behavior. Cartoons from the British magazine *Punch* are used here by permission.

"This is the dog that bit the cat that killed the rat that ate the malt that came from the grain that Jack sprayed."

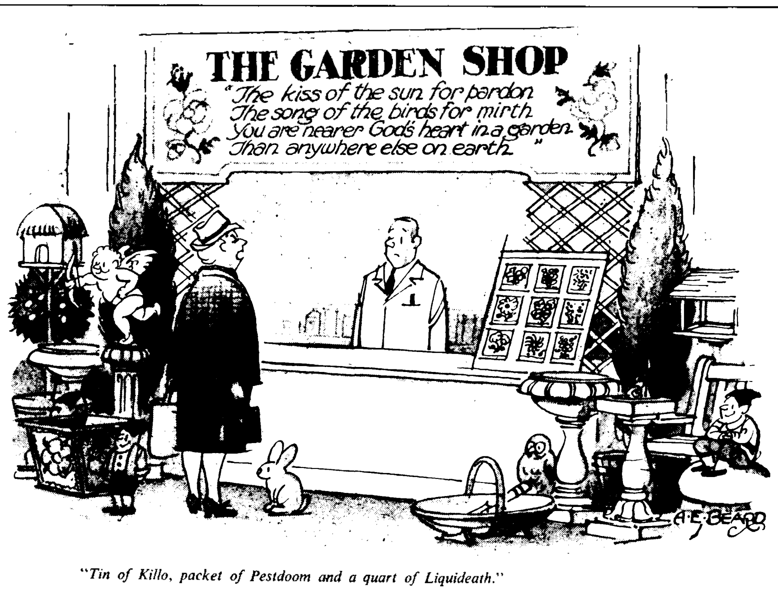
PUNCH, March 6, 1963

"*Spring is here—listen, the first crop-spraying helicopter!*"

PUNCH, March 11, 1976

"*Come on, son, eat up your Warfarin or you'll never grow up big and immune like your dad.*"

PUNCH, May 19, 1976



"*Tin of Killo, packet of Pestdoom and a quart of Liquideath.*"

PUNCH, July 27, 1966

Acknowledgments

The plan and supporting files for the *Basic Guide to Pesticides* have been developed over the past quarter century, and everyone who has been on our staff over these years has had a part in preparing for the final publication. To give special credit to those whose work pertained closely to the guide, while recognizing that we could not have done it without much help with office routine from many others, called for some close decisions. First, we must thank all of those who have served as Council officers and directors, supporting the effort with expert information as well as by keeping the organization alive.

Next are those who made the final all-out effort to bring all the data up to date within the year, and into consistent form for publication: Nathan Erwin, Theresa Laranang, Taher Husain, DaVisa Hughes, and Howard and Jane Whitlow. Dr. William Lijinsky also gave us much scientific guidance. Those who spent considerable time and skill on earlier preparations include Rubin Borasky, Martha Damon, Cynthia French, Susan Garabrant, Edwin J. Jolly, Lisa Lefferts, Margaret Quarles, Merry Rabb, Ellen Rainer, Donald Weber, Robin West, and Feseha Woldu. Others whose contribution was shorter, but appreciated, include Charlotte Aggerholm, Leith Bernard, Leah Devlin, Christina Edwards, Kathleen Lucatorto, Barbara Pitkin, Marjorie Van Nostrand, and Ann Vogel. We are especially grateful to the National Coalition Against Misuse of Pesticides for taking over responses to routine inquiries on pesticides, and for sharing their files with us. As the one who got all of these people, and other staff and volunteers, into this, I most appreciate the dedication and cheerful spirit with which the work has been sustained.

We are greatly indebted to the experts in the field who reviewed the whole manuscript: Dr. William A. Butler, Dr. John L. George, Dr. Marion Moses, Dr. David Pimentel, Dr. Frederick W. Plapp, Dr. Robert L. Rudd, Dr. Marvin Schneiderman, and Dr. Thomas G. Scott.

Financial Support

Since 1965, Rachel Carson Council has been sustained by contributions from many individuals who approve of our work and have been helped by the information we dispense. Proposals to foundations for special grants have brought in additional funds, but until the last few years these were not sufficient to raise staff and resources to the level needed for the final concentrated effort to bring the guide to publication. Credit for the recent attainment of these resources goes first to the late Louise Tomkins Smith, long one of our mainstays, who gave a matching grant that began to attract other funds, and then to Director Nancy Greenspan and Treasurer David McGrath, who launched a major campaign to build on this start. Those who have given substantial help over the years include these foundations and individuals, some of whom gave through family foundations not also listed.

Foundations: Geraldine R. Dodge Foundation, Henry Doubleday Research Association, The Charles Engelhard Foundation, The Henry P. Kendall Foundation, National Fish and Wildlife Foundation, Marjorie Mosher Schmidt Foundation, The Florence and John Schumann Foundation, The Sears Family Foundation, Towncreek Foundations, Inc., Wallace Genetic Foundation, Inc., The Waletzky Lead Trust, Westinghouse Foundation, and The Wildcat Foundation.

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PLAN AND SOURCES

Chapter One

Plan and Sources

Selection of Pesticide Materials Included

ACTIVE INGREDIENTS

Commercial pesticide products combine several kinds of ingredients, but testing for kinds of immediate and long-term toxicity is done on substances called active ingredients, which are those with pesticide action against target pests. Commercial products may include a number of very similar formulations marketed by different producers and their various components are not tested for their separate or combined effects, except as these are active ingredients. The large number of formulations marketed would present an impossible amount of testing, and the task of adequate testing of just the authorized active ingredients has been many years in reaching the present partial percentage.

A recent estimate of currently registered active ingredients is 650, though no one at the Environmental Protection Agency seems very sure of this rapidly shifting number. At one time there were about 1400, but many have been withdrawn for excessive toxic hazard or lack of use and are thus of no economic value. New testing requirements and a fee for continuing registration have contributed to major deletions in the last couple of years. New materials, perhaps 15 or 20, are added each year. The former estimate was that about 600 active ingredients were used enough to matter, and of these, perhaps 120 are major constituents of most-used products. We have chosen those most used or of special hazard, either because of toxicity or those whose persistence in our environment means that they will be with us for many years to come. We include several not permitted in the United States, but used widely in other countries, since this book is designed for readers worldwide. Where feasible, we also include common names used elsewhere. Products used only in veterinary medicine, especially internally, are omitted.

INERT INGREDIENTS

Materials in pesticide formulations that are called inert are not so classified because they are inactive, but only because they have no pesticidal effect on the target organisms. They may be solvents, propellants, surfactants, emulsifiers, wetting agents, carriers, or diluents. They may, in fact, be very active from a biological standpoint, and are sometimes the most generally toxic portion of a pesticide product. Hundreds of these are in current use, and have been considered trade secrets by the producers and therefore have not been listed on the label. EPA has recently given them more of the attention they deserve and has selected the most toxic for scrutiny, identifying first 50 substances of special concern. Almost all of these have now been removed from products by the registrants, while those still in use must be identified on labels. EPA policy now calls for using the least toxic inerts available. A second group of 65 potentially too hazardous inerts has been selected for study and testing. Uncertainty about the danger from many inerts comes from the lack of testing. Very few commercial chemical products are tested for immediate or long-term toxicity, certainly not to the extent now required for pesticides.

SYNERGISTS

These ingredients, which may not have pesticidal action by themselves, are added to heighten the effects of the active ingredients, especially when these are expensive materials. By enhancing the combined toxicity, the effect on a target pest may be increased several hundred times. Piperonyl butoxide is a member of a commonly used class of synergists, the methylenedioxyphenyls (MDPs), which are added to pyrethrum and pyrethroids commonly, and also have a strong effect on the toxicity of carbamates. They act by inhibiting the target pest's ability to detoxify the primary poison. They can also make the pesticide far more toxic to humans and other nontarget creatures by the same process. Their effects must be carefully considered in the choice of a pesticide, or in deciding whether the use of a chemical compound is justified. We have included the most commonly used of these ingredients.

EFFECTS OF COMBINED INGREDIENTS

With the numerous formulations on the market, many similar to each other, it is neither practical nor possible to list the comparative hazards of each one. Nor is this known, since most testing is by active ingredients separately, and not by the combination in a single product. In many cases, a fairly good estimate of the total effects of a product can be made by adding the known qualities of individual constituents. In many cases, however, a combination creates a synergistic effect and the resulting product may be many times more toxic than would be expected by the known toxicity of the several parts. Two chemicals of a low or medium range of toxicity may combine to make something that ranks as very toxic. This is true of a number of mixtures with malathion, for instance. It can also occur when a person, plant, animal, or other exposed organism is or has also been exposed to a substance that interacts with the pesticide. Contact with malathion after being exposed to parathion, for example, can cause a severe reaction, because the parathion can exhaust the body's supply of a detoxifying enzyme for the time being, and the malathion has no opposition. Many pesticides should not be used by anyone taking certain drugs or drinking alcoholic beverages. The familiar danger of combining exposures of barbituates and alcohol is an example of the kind of thing that can happen with many substances to which we may be exposed, voluntarily or involuntarily.

The wary user of pesticides should allow a wide margin of safety when there is any question of potentiation of combined toxicants either in the product or available to react with it.

PESTICIDES NOT INCLUDED

A number of pesticides are not studied in detail in this guide either because of lack of information or minor use. We maintain active files on many of these and welcome more information. Those who cannot find the pesticide they seek here may inquire directly of the Rachel Carson Council for data.

Sources of Information on Pesticides

This guide is a compilation of the best factual material that we have been able to assemble since 1965. The data base is far from ideal: we have consulted the relevant manuals, computer listings, technical journals, and experts in the field over the years, and gradually built our supporting files. The major part of the testing and other research on pesticide toxicity has been done by or for the pesticide manufacturers to provide the data required for government registration of products allowed on the market. Pesticide manufacturers have done much research themselves, hired commercial testing firms to do it, or provided grants for study in academic institutions. In some cases the possible bias suggested by this process has been found as laboratories or researchers slanted results to achieve what the producers hoped to find. The case of the Industrial Bio-Test Laboratories was most notorious in this respect. Reputable manufacturers realize the perils of incorrect testing, of course, and strive for reports that can stand close scrutiny. This testing is very expensive, justified if a company can expect to make sufficient profits from sale of the product, but beyond the capacity of most independent researchers, or even of most other national governments. The result has been a wide dependence on results obtained in the United States, so we have a worldwide responsibility to be accurate and to consider all important aspects.

A variety of manuals and directories have been published to serve the pesticide industry, agricultural users, research chemists, or the medical profession. None includes all of the kinds of information needed by the person applying the pesticide or the person who may be exposed to it. In no single source could we find all of the pesticide ingredients listed here, or all of their characteristics that should be known.

We cannot vouch for the accuracy of some of these sources. Often, manuals and compilations do not indicate their sources and many seem to have been copied from each other in long succession. Sometimes the findings of one scientist or organization contradict the conclusions of another. Research methods, if they are known at all, are not always known in enough detail to assess the validity of a study. Replicate studies may not be available to verify original experimental results, especially with the high cost of much of this testing. Little original, independent research may be done on most pesticides to give us needed comparisons. Once the evidence is provided to the Environmental Protection Agency, the federal bureau responsible for registering pesticides for use and enforcing the control rules, it has in the past remained buried in their files, much of it classified as a "trade secret" by the producer. For most of the years that we have pursued this information, it took lengthy negotiations through the Freedom of Information Act to gain access to industry test material, and then access was given only if the company in question agreed. Though the law governing pesticide regulation, the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), says that toxicology and environmental fate data should be open to the public, it took a Supreme Court decision in 1981 to confirm that this should indeed be so. It can still take months to obtain a desired document, however, since EPA still requires the Freedom of Information process.

The U.S. General Accounting Office, a congressional agency, studies ways in which laws are carried out, and makes other valuable studies of government performance. Their investigations into pesticide regulation over the years have been commendable. Two recent studies are especially valuable for the average concerned person: *Nonagricultural Pesticides; Risks and Regulation,* GAO/RCED-86-97, issued in April 1986, and *Lawn Care Pesticides; Risks Remain Uncertain While Prohibited Safety Claims Continue,* GAO/RCED-90-134, March 1990. Up to five copies of each GAO report are free on request.

The 1972 revision of FIFRA required for the first time that pesticides allowed on the market be tested for a wide range of effects, short- and long-term. Before, while this regulation was under the U.S. Department of Agriculture from 1947 until the EPA was established in 1970, only effectiveness against the target pests and simple immediate toxicity tests were done. No matter what hazards were found, no product was denied registration under USDA auspices. The 1972 law required that all active ingredients be more thoroughly tested and the risks found be balanced against the estimated benefits from use of the product. Each commercial formulation is thus not tested more than originally, as far as combined effects are concerned. EPA set about deciding which tests should be made, and on which pesticides.

Years passed while this was being decided, and the guidelines for testing were set up. The 1977 deadline, by which all registered pesticides were to be retested on the new rules, passed. Under new administrations since 1980, emphasis on limiting regulation has prevailed, and the guidelines were revised to be less stringent. A FIFRA revision in 1988 finally called EPA to stricter account, requiring that all of this reregistration of old products remaining on the market, as well as registration of new ones, be completed by 1997. So far, few products have gone through even the reduced testing now required. Pesticides used on food have priority in these rules and nonagricultural uses have much more limited requirements.

For those who wish to explore just how much testing is required, and for which effects, see Section 158 of the Pesticides Registration, Data Requirements, issued by EPA with guidelines for testing, evaluation procedures, and laboratory practices, revised from time to time. In the summary section 158, charts list which tests are required for each kind of pesticide, and which are optional. Noting how many are optional, the reader then finds that a later clause lets the EPA administrator waive any required test.

Consulting the detailed volumes of the complete guidelines on all kinds of testing reveals many curious gaps. Tests for products that may cause birth defects, for example, will only be done on pesticides to which *human* females are likely to be exposed extensively in places where large numbers of them are expected to be found. No spill accidents in other places are considered and neither are venturesome women who strike out to less crowded places. Nor is it recognized that exposure of men to teratogens, substances that can cause birth defects, can be equally damaging.

When test guidelines were sent out for comment in 1982, Rachel Carson Council noticed that no provision was made to check the plant-killing potential of pesticides not registered for use as herbicides. We found 98 other pesticides known to damage plants too. These hazards were usually discovered by experience, not by comprehensive tests. This and other gaps in the requirements explain the lack of needed information in several areas, since comments from us and others did not change EPA policy.

Study of such EPA documents and submission of comments when requested have given us experience in the amount and effectiveness of current pesticide testing. In the book *Toxicity Testing*, published by the National Academy of Sciences, the estimate of the proportion of pesticides for which testing was adequate to make human health hazard assessment was only 10%. For 38% of pesticides nothing useful was known, and the rest fell somewhere in between.

Despite these discouraging conditions, it is crucial that people have the best estimate possible of the hazards of pesticides. They should also realize that the law regulating pesticides differs from those laws aiming to achieve clean air or water. FIFRA is a law to enable sale of pesticides through a balancing act between the claimed benefits (mostly to one group of people) against the known risks (usually to a completely different group.) The law specifies that no pesticide be labeled "safe," "non-toxic," "safe if used as directed," or "approved" by EPA. All pesticides exist because they are toxic to something, and EPA just registers by a marketing formula rather than approval.

FINDING AND EVALUATING DATA

If you note our list of major sources, you will find several that are compendiums of information on a wide range of pesticides and other commercial products. When we entered the final phase of compilation of this guide, we set a schedule to review every file and chart to bring each up to date within the year. Beyond the data and references we already had, we consulted such large, inclusive sources as the *Registry of Toxic Effects of Chemical Substances,* issued periodically by the National Institute of Occupational Safety and Health. Updates are available quarterly on microfiche, and all chemicals in commercial use are supposed to be listed, along with a terse summary of known toxic effects, citing the study quoted. They do not vouch for the reliability of the studies; this falls to the reader. Many times, the only study on a key point appears in a foreign journal, sometimes obscure. We then have to see whether this can be obtained from the National Library of Medicine, the USDA Library of Agriculture, or university libraries in the area. We have also gone through computer listings for Medline, Toxline, and Agricola services of libraries to ferret out journal or book articles we may have missed elsewhere. For each useful article found, we go through its list of references to be sure that we have the essential primary study for each key point on hand.

Another major source comes from EPA studies. When they single out a pesticide for special review because of its priority on their reregistration list, they issue a registration standard, showing what they know about it and where the gaps that must be filled by further testing exist. If they then decide that action should be taken to restrict or eliminate some or all uses of this pesticide, they issue position documents in a series documenting their findings and recommendations as study continues.

A final decision either to restrict, cancel, or reregister summarizes the supporting data. From all of these sources we can normally pin down specific ratings for the criteria considered, and we can usually determine their primary source. If the registration standard is not clearly documented we seek the key primary studies and cite them. We may have to cite the registration standard where it is not fully documented, if they have not provided the original source in response to inquiry or have not yet given it to us through a Freedom of Information request.

With the key studies on hand, we apply accepted rules for assessing their thoroughness, methods used, and overall credibility. Conflicting evidence is resolved by asking experts in the field, with the council's professionally expert Directors and Consulting Experts called upon first.

In these ways we have done the best we could with a large but various body of information with our first consideration the hazards to an exposed person or other creature and the surrounding environment on which we depend.

In the explanation of the pesticide charts, we give our criteria and standards. We have explored as much of the literature on these pesticides as possible, judged it by standards we can support, and consulted objective scientists.

The lists of exact references for certain points should answer the needs of most people seeking more detailed information. For those who need to have a list of references for each point on a chart, this can be provided on request for a modest handling fee. These lists give the principal, most current sources.

Our complete files for each pesticide may contain a succession of studies going back to early inquiries, all of which comprise our supporting data. Our files and library are available to anyone who needs to go into the subject at this length. We have reviewed information on all pesticides in the guide through September 1991.

LISTS OF REFERENCES

The three lists found in Chapter 6 of the guide cover our principal sources, some specific references for details on the charts, and a final list of general background material. Some of these should be available in libraries.

HOW TO USE THIS GUIDE

Chapter Two

How To Use This Guide

THE CHARTS

To find the information for a specific pesticide ingredient, first take the name or names on the label or other description, and by use of the index of names, find the official common name under which the chart is headed, listed in alphabetical order.

Use of the Index of Names

Each pesticide active ingredient can have four kinds of names: the officially designated common name, various trade names for commercial formulations, the chemical name or names, and a CAS number. These names are all listed in alphabetical order, with the CAS numbers in numerical order. Each of these then gives the common names under which the chart appears. In the charts, the common name recognized in the United States is given first, with perhaps one used in another country. Next come trade names for formulations in which it is the principal active ingredient. These are capitalized. Chemical names can be numerous and confusing, since the chemical formula may be translated into words in various ways, some of which do not look much alike. We give those most commonly used, especially on labels. Where no common name exists, the chart is headed by a prominent trade name.

Trade names of products with several active ingredients, some present in small amounts, are not given, for reasons of space and clarity. To estimate the hazards and characteristics of such a product, check each of the active ingredients listed on the label. This will give a general idea, though it does not allow for interactions among the ingredients that may give unexpected effects or more toxicity.

If the only identification known is a trade name, and you cannot consult a label for a list of ingredients, start with this trade name in our index. If you cannot find it there, try to determine how old the product is. Trade names are sometimes changed or superseded, and may describe very different formulations from time to time. If you can find a corresponding edition of *Farm Chemicals Handbook,* it may have the old name. A current package of the product, or the *FCH,* may give you the name of the producer to whom you can write. You may also ask the Registration Division of the Environmental Protection Agency.

In some cases, so many brands use a particular ingredient that listing all or most brand names is impossible. These very commonly used pesticides are usually clearly listed as ingredients.

To find a chemical name in an alphabetical list requires following certain special rules. Some beginning letters or terms are not used in alphabetizing: these are in italics and include letter locants (*O-, m-, p-, sec-, tert-, N-, O-, S-,* etc.) and stereochemical descriptors (*cis-, trans-, (R)-, (S)-, (E)-, (Z)-, endo-,* etc.), and Greek letters. These are in italics, so looking past them for the key letter is not difficult. If a name begins with numerals, and there are more than one of the same name but different numerals, these will be in numerical order. Whether a Greek letter prefix is given as such or is written out (alpha, beta, gamma, etc.) the same order applies. You may find them either way, elsewhere. Greek characters used in chemical names correspond to their word designations, as written out below. Few in this guide go beyond the first six.

α	alpha	ν	nu
β	beta	ξ	xi
γ	gamma	ο	omicron
δ	delta	π	pi
ϵ	epsilon	ρ	rho
ζ	zeta	ς	sigma
η	eta	τ	tau
θ	theta	υ	upsilon
ι	iota	φ	phi
κ	kappa	χ	khi
λ	lambda	ψ	psi
μ	mu	ω	omega

An example: if you look for chlordane, a common name, you will find it directly in the index as CHLORDANE, and the capitalization tells you that this is the name of the chart. Or you may find *Kypchlor: see chlordane,* or *octochloro-4,7-methanotetra-hydroindane: see chlordane.*

CAS numbers are assigned by the Chemical Abstract Service, at Ohio State University, Columbus, Ohio. This is the most generally accepted system for sure, concise identification of chemicals in commerce. They try to give each distinct chemical substance a number so that it can be identified through whatever confusion of trade and chemical names and their many versions it may have. Some pesticide ingredients may have more than one number if it is necessary to identify their various isomers, salts, esters, or other aspects. A few may not yet have received a number. In a few cases we found a conflict in the numbers given in equally authoritative sources, so even this system for dispelling confusion may occasionally falter. In case of two possibilities, we give the one with the best authority first, and the other second. We have no way of knowing from what source our readers may start to trace a material. Even a number or a chemical name that is technically incorrect may be included if it is in common usage.

CAS numbers begin with those with the fewest number of digits, in numerical order, then to the next number of digits, etc.

Nonchemical pesticides, such as bacteria, viruses, botanical materials, and so on, do not come within the CAS system. Their scientific names may be italicized, but they are listed in clear alphabetical order—*Bacillus thuringiensis*, for example.

Transformation Products, Contaminants, Components

These related compounds that are given on the charts are treated in the index as are the alternative names: listed alphabetically, with the chart name on which they are found—*malaoxon: see malathion.*

EXPLANATION OF TERMS ON THE CHARTS

The various names described above are found in the first column, along with subsections for transformation products, contaminants, and other components of toxicological concern.

Transformation Products, Contaminants, Components

Transformation products include the many results of introducing a pesticide into the environment, even in storage. Almost all break down eventually into constituent parts, are altered by contact with light, water, and other chemicals in soil or plants, or are metabolized by animals that absorb them. Entirely new chemical compounds may result. It is not enough to test for residues of the original pesticide to know what has become of it or what further hazards it may create; the several transformation products must be known and sought also. Some of these may be more persistent than the original pesticide, and some are more toxic. We have listed those products that have had known problems result from their presence, and those with effects differing from those of the parent compound. Other names for these compounds are degradation products, derivatives, or metabolites.

Nitrosamines are a special class of transformation products, frequently found to be carcinogenic, in some cases among the most potent carcinogens known. They form when an amine in a compound comes into contact with a nitrosating agent such as nitrous acid in the saliva and stomach of ingesting animals, in soil, water, and air, and in certain industrial processes.

Production methods may create unintended *contaminants* that can have the same range of effects. These are thus included. Other unexpected toxic effects may come from constituents in the formulation or the technical grade of the active ingredient that we call *components,* also included where known to have adverse effects.

Classes of Pesticides

Column 2 in the charts tells to which general group of pesticides this ingredient belongs. In certain cases this may be almost all that we know about a certain material. If we can learn the essential characteristics of this family or class of pesticides, we can have some idea of the probable behavior of a member of the group. Some classes are well established and studied, others have not been defined. Where we find no consistent precedent, we have made categories on the basis of the toxic action of the class, since that is the primary concern of those who will use this guide. The class name in column 2 refers to the later section of the guide called Toxic Characteristics of Classes of Pesticides, where we give the following information for each group:

All pesticides in the guide that fall into this class
The way in which these toxicants work, where known
Immediate toxicity, symptoms and effects, since this may be too long to include on the original chart
Long-term toxicity, kinds and eventual effects
Environmental effects, where known

Sources come from tests on appropriate test animals, and also on evidence of human effects where this is known. We cannot test people as we do laboratory animals, but we can compile the evidence of many medical records.

This is all given in necessarily condensed form. For more details see the list of principal references.

In too many cases, we still do not know all that we should about the mode of action of certain classes, in different species, or what can be done to treat adverse reactions. For some, no antidote is known. Long-term effects especially need far more study.

For the intensity of immediate toxicity, and the main kinds of long-term toxicity, see columns 4 and 5. These columns give the most important warnings, while the section on Toxic Characteristics of Classes of Pesticides tells how the poison works and what the danger signals may be, as well as known precise results of exposure.

Chief Pesticide Use and Status

The overall term *pesticide* has several subdivisions indicating the pest that is its chief target and for which it is sold. This does not mean that its effect is limited to one class of pests alone. Many herbicides, for example, are especially toxic to mammals or insects, and some pesticides are so broadly lethal that they are called *biocides.* The kinds listed under column 3 include

Acaricides, which kill mites and spiders (include miticides)
Algacides, which kill algae
Antibiotics, which kill bacteria and viruses (include bactericides and disinfectants)
Avicides, which kill birds
Desiccants, which dry up animals and plants, either to kill or permit early harvesting
Fungicides, which kill fungi
Herbicides, which kill plants
Insecticides, which kill insects
Molluscicides, which kill molluscs
Nematocides, which kill nematodes
Piscicides, which kill fish
Plant Regulators, which retard or speed the growth of plants
Repellents, which drive pests away
Rodenticides, which kill rodents
Sterilants, which stop reproduction

Wood preservatives are sometimes given as a class of pesticides. They include insecticides and fungicides to delay rotting and tunneling in wood.

All of these are correctly grouped under the general term *pesticides.* It is both incorrect and confusing to use the phrase "pesticides and herbicides." It implies that herbicides are not pesticides, or are toxic only to plants, while others are more widely dangerous. Note the biocidal range of some herbicides to overcome this idea.

Column 3 also gives information on the legal status of a pesticide: if it has been banned or restricted in use in the United States, in individual states, or in other countries. EPA is directed to ban a pesticide from some or all uses when it determines that such use presents an imminent hazard. The process by which this is done can take many months or years, but in case of a severe emergency, the pesticide can be suspended—taken off the market immediately—before the whole legal process is completed. If EPA finds a pesticide to be especially hazardous but still so economically valuable that a ban is not in order, it can be labeled "restricted," which means that it may only be applied by "certified applicators." These are people trained under state auspices, in compliance with EPA rules. Even so, qualifications for certified applicators vary, and the actual application may be done by uncertified people under the supervision of a certified applicator, who may not always be on the spot. This program, designed to protect the general public from exposure to the most toxic pesticides, has some curious aspects. A certified applicator may put one of these products on a home ground, or public place, where it can remain for some time with a potential for exposing vulnerable people or animals. A pesticide known to be restricted should be avoided anywhere the public can encounter it, and especially where the most vulnerable people are found: the very young, the old, and those with special susceptibilities or illnesses that reduce resistance.

When the registration of a pesticide has been suspended, cancelled, or restricted by the full legal process, there is a conclusive designation listed on our charts. We do not include other uses of these categories employed by EPA as punitive measures for failure to provide required data, pay fees, or respond to other EPA rules, since these may be temporary and reflect on the registrants rather than on the product.

EPA registration of a pesticide for sale in the United States must balance the risk of use perceived against the estimated benefits to ensue. Risk often affects a different group of people than those who will benefit. Immediate financial gain is thus balanced against health and environmental damage that may have continuing effects. The law under which EPA regulates pesticides does not put first priority on health or environment and is the only environmental law in the United States that does not permit citizens to go to court to insist on better enforcement. Our few comments on the status of individual pesticides give only a limited review of these legal aspects, which continue to change. (See Appendix 5 on U.S. pesticide regulation.)

Statements in Quotation Marks

Where a statement in quotation marks appears on a chart instead of the standard wording, it means that no quantitative data was found to fit our rating system, but such a statement exists in a usually trustworthy source. We use it in quotation marks to show that it is not comparable, but does give a clue.

Question Marks

Where only a question mark appears in a column, we have no reliable information. Where it accompanies a word or statement, it means that this is the case in our best judgment, but there is some inadequacy in the source material.

Persistence

Persistence is the length of time that a pesticide remains in the environment, whether it stays where it was put or moves through air, soil, water, or living organisms. It is not always clear whether references to a pesticide's persistence apply only to the original formulation, or to this and its transformation products. A pesticide product, which includes the so-called inert ingredients as well as the active ones, usually moves or changes under environmental impacts. What remains after a certain span of time is the residue. As Robert Rudd defines this, "The residue itself may contain reduced portions of the original toxic ingredient, metabolic derivatives of this chemical, physically transformed derivatives of quite different chemical structure, and surviving portions of the solvent and diluent carriers of the original material. The very wide differences in chemical responses to the even wider variables of nature preclude any precise definition of the word 'residue' " (*Pesticides and the Living Landscape*). To consider the real effect of applying a pesticide we should be able to trace these stages of change, and identify and define the toxicity of the various transformation products and their persistence. Seldom is the information available to do this, especially since many inert ingredients are not required to be identified. Menzie's *Metabolism of Pesticides* covered much of the field until the series was discontinued with the author's retirement from the post of Fish and Wildlife Service pesticide toxicologist.

Persistence times usually given for pesticides seem to apply only to the original active ingredient as far as its pesticidal effectiveness lasts. These figures give us a general idea of the life of a product once it is released from the applicator's hands. Since chemicals may react differently in differing climates, soils, kinds of surfaces, and accompanying chemicals, any rating must be very general. The water solubility of a chemical can affect this—will it dissolve and run off quickly and move to other areas? If it is oil-soluble, it can be stored in the fatty tissues of animals and accumulate as exposures continue. If it is volatile, it may quickly evaporate into the air and move widely. Other factors can come from the method of application: by aerial, ground, broadcast, or precise hand application, or by its form, whether a liquid, emulsion, dust, or granules.

Taking all of this into account, and using admittedly inadequate data in many cases, we adopted a scale for rating persistence in four stages devised for the Council on Environmental Quality, of the Executive Office of the President of the United States, in their first annual report in 1970. Individual cases may not conform to these stages precisely, of course, but they give the best estimate that can be made now. This is for outdoor conditions only; indoor persistence is likely to be considerably longer but testing is not required.

Non-persistent (non-pers): effectiveness lasts from a few hours to several days, rarely more than 12 weeks
Moderately-persistent (mod-pers): from 1 to 18 months
Persistent (pers): retains toxicity for years, perhaps as many as 50 to 100
Permanent (perm): non-degradable to non-toxic materials in the environment; this includes elements like mercury

TOXICITY

Four principal questions should be answered about any toxic material to which people and the environment are exposed:

1. How does it affect mammals, the group to which humans belong?
2. What is its immediate toxicity?
3. What are its long-term effects, either from one exposure or from repeated exposures over a period of time?
4. How does it affect other non-target species, and the whole environment into which it is introduced?

Answers to these questions are presented in columns 5, 6, and 7.

Effects on Mammals

In many cases we have evidence of the effects only on certain species of mammals other than humans, while rarely do we have only human evidence. Only on laboratory animals whose reactions are known to be similar to those of humans can we conduct carefully controlled experiments to measure kind and amount of exposure and results. Only where a specific group of humans is known to have had a certain exposure that has produced consistent results can we estimate our susceptibility. But when suitable test animals have been well tested, and their reactions are known to relate to human reactions, we get as clear a warning as we are apt to have of the hazard to our species.

Immediate Toxicity

The technical term long used by toxicologists for the immediate effects of exposure to a poison is *acute*. This means what happens to the exposed creature immediately, or shortly after, contact with the poison. Since the word *acute* has other meanings in common use, and might be interpreted to mean severe or critical we use the more clearly descriptive term *immediate* with *acute* in parentheses.

Ratings are given for the amount of active ingredients involved in relation to the body weight of the exposed individual. This is done on the metric scale of milligrams of the substance in relation to kilograms of weight of the individual: mg/kg. Thus a rating can apply equally to a small test animal or an animal many times its size. A milligram (1/1000 of a gram) may be very hazardous to a mouse but not very dangerous to a 200-pound (90.72 kg) human.

Immediate toxicity is commonly measured by a test called Lethal Dose 50, (LD_{50}) or in case of creatures exposed through air or water, Lethal Concentration 50 (LC_{50}). This test, devised in 1927, tries to set the amount that will kill half of the test animals in a specified time, presumably an average. Sometimes the LDlo (low) is given, the dose at which the first animals died. The lethal dose given for humans is based on medical records. The LD_{50} test is a crude measurement, affected by many conditions: species of test animals, and their age, weight, sex, genetic strain, health, diet, temperature, housing conditions, season, and probably other environmental conditions at the time of the test. The method of administration also matters whether by various means of feeding, or by injection, exposure through skin, or inhalation. Many of the LD_{50} ratings given are based on tests done a long time ago, under less rigorous requirements than now exist.[1]

At best, the LD_{50} rating for the relative degree of toxicity of a material has many inadequacies, and can be used only as a very rough estimate. Unfortunately, it is usually all that we have. It was originally designed to check lethality of very toxic medicines, but was adopted for testing all manner of toxic materials for which it may be less appropriate. It gives an illusion of being a precise numerical rating beyond its capability, but this is often ignored by those who want a simple answer. More important, it deals only with the death of the test animals, not the immediate or lasting impairment they may suffer.

We use the LD_{50} on the scale adopted by the Environmental Protection Agency, ranging from Very High, High, Medium to Low, based on the mg/kg amount. This can tell us something about the danger of immediate exposure to a substance, but not what kind of damage it may cause short of death. (For this information, see Chapter 5 on classes of pesticide ingredients.)

Until the 1972 law required wider testing of effects of pesticides only the immediate toxicity was determined by the LD_{50} route. The test is fairly easy and inexpensive to carry out, and the U.S. Department of Agriculture, which was responsible for regulation before EPA was established, cared mainly about the ability of a pesticide to kill the pest. Whatever the immediate toxicity tests showed, USDA had never denied registration to a product because of toxicity to non-pests.

Better tests for immediate toxicity are being developed, internationally, so the LD_{50} may be superseded in the near future. It is unlikely that all toxics will be retested promptly, however.

Means of exposure may be as important as the degree of toxicity. Much illness and death from pesticide poisoning occurs because the victims did not realize that many compounds are just as or more poisonous if they touch the skin or are inhaled than if they are swallowed. Dermal toxicity refers to the ability of many toxics to penetrate intact skin. Others are especially dangerous if they touch a break in the skin. Will children or animals touch the plants or soil in your garden after you have used one of these pesticides? Will you have your hands in the soil before the end of the pesticide's period of persistence? Are you using a form of application like spraying or fogging that makes inhalation or skin contact very hard to avoid? Is the pesticide a volatile substance that will continue to give off poisonous vapors long after it has been applied? This can be especially dangerous indoors or with aerial drift that can reach unintended targets.

Under the **Immediate Toxicity** column, three categories are given: **oral**, for pesticides that are swallowed, **dermal**, for those that penetrate the skin, and **inhalation**, for those that are breathed in.

Oral exposure routes the toxic material through the digestive tract, and to the liver and kidneys that provide the principal detoxifying process. Dermal and inhalation exposure may be especially dangerous

[1]G. Zhinden and M. Flury-Roversi. 1981. Significance of the LD_{50} test for the toxicological evaluation of chemical substances. *Archives of Toxicology* 47:77–99.