A Brief
Introduction to
Contemporary
Toxicology

modern poisons

Alan S.
Kolok

MODERN POISONS

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CONTEMPORARY TOXICOLOGY

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Washington | Covelo | London

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Library of Congress Control Number: 2016933395

Printed on recycled, acid-free paper ♻️

Manufactured in the United States of America

10 9 8 7 6 5 4 3 2 1

Keywords: Toxins, dose-response relationship, endocrine disruption, pesticides, chemical resistance, epigenetics, chemical regulation, persistent organic pollutants (POPs), Paracelsus, prions.

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PREFACE

Toxicology is interdisciplinary. Other disciplines, such as anatomy, can be studied more or less in isolation, without much intellectual investment from the other major scientific fields. Students can be educated on the arrangement of bone, muscle, and the internal organs, for example, with very little mention of the underlying chemistry of the bone, or the biomechanics involved in muscular activity. Toxicology, on the other hand, is the study of the adverse effects of noxious chemicals on living organisms, and therefore cannot be encapsulated solely within the fields of biology or chemistry, but rather lives within the intersection of the two disciplines.

Toxicology is also an applied science, being responsive to changes in the human environment and to societal needs. At its inception, toxicology was intricately associated with medicine. Physicians first developed the basic principles of toxicology over 500 years ago, for toxic insults were invariably personal and medically debilitating. The adages that “a chemical dose makes the poison” and “a chemical’s nature is revealed through its structure” arose to help understand the mechanisms by which poisons were adversely affecting humans. During the early stages of its evolution as a discipline, toxicology borrowed and shared concepts with its chemically benign twin, pharmacology, the study of therapeutic effects of drugs on organisms. Indeed, the two fields are closely intertwined; the therapeutic nature of many drugs can turn toxic when the concentration of the drug’s dose is too high, or when the exposure to the drug is maintained for too long.

Despite toxicology’s historical tie with medicine, the changing nature of society’s interaction with chemicals has changed the context in which toxicity occurs. Initially, most toxic exposures occurred

on the individual level. Contact with poison ivy, the ingestion of an inedible mushroom, or a snakebite can all cause dire, and in some cases fatal, consequences; however, the chemical exposure is only directed at one person at a time. Even early historical efforts at metallurgy or manufacturing only affected those who worked at small and relatively isolated manufacturing sites. For much of human history, the exposure of humans to toxic chemicals was more personal than societal.

All of this changed with the industrial revolution. Large-scale soil, water, and air pollution began to occur as a result of heavy industries such as the production of iron and steel, as well as industrial mining and petroleum extraction. These industries distributed chemical risk beyond the individual level to that of the community. Epidemiology, the branch of medicine that deals with the incidence and distribution of disease conditions in defined human populations, joined forces with toxicology, and studies began to assess the relative risk that chemical exposures exacted upon human communities and populations.

The chemical revolution, a latter-day offspring of the industrial revolution, further changed the face of modern toxicology, as the diversity of chemicals released into the environment skyrocketed. Initially, chemical exposures were natural or were the products of relatively simple modifications of natural products, such as the enrichment of metals from ore or the burning of wood and fossil fuels. The advent of industrial organic synthesis, which occurred during the early twentieth century, ushered in a completely new suite of compounds into the toxicologist's world, and these new compounds were behaving in a very unusual manner. Rather than rapidly degrading in the environment, they persisted—in some cases, for decades. Furthermore, these compounds were also beginning to show up in the tissues of the most unlikely animals living in the most unlikely locations.

As chemical contamination increased in both scope and diversity, the very nature of the toxic response was also being turned on its

head. Far from the acute and immediate damage of a bee sting or snakebite, evidence began to mount that chemicals were exacting long-term and subtle effects. Environmental pollutants, as well as drugs and personal care products, were acting as unintended cell signals, causing nefarious miscommunications among cells. Carcinogenicity, reproductive dysfunction, and alterations in fetal development were among the consequences. Ominously, these responses were occurring long after the chemical signal had vanished—at times, even affecting the children or grandchildren of exposed individuals. Like a thief in the night, the chemical intruder was long gone by the time the impacts were realized.

The triple threat of modern toxicology—the spread of chemicals globally, the spectacular increase in chemical contaminant diversity, and the complications presented by subtle yet enduring toxic responses—has greatly muddled the toxicological field. It is no wonder that there is considerable confusion regarding the nature of modern toxicology among laypersons, students, and scientists alike. It is not unusual for individuals to misunderstand the fate, transport, absorption, excretion, and biological action that govern toxic chemicals.

This newfound complexity in toxicology, driven by the events described above, is the impetus for this book. My purpose is make some sense out of the chaos, and to present the field in a framework that can be more clearly understood by the uninitiated reader. While some may view this book as being oversimplified, it is not meant to be the definitive text on toxic compounds, but rather to introduce the uninitiated to some of the subtleties and nuances within the field.

ACKNOWLEDGMENTS

This book is dedicated to three groups of people. First, my colleagues who helped with the early chapters of the book: Shannon Bartelt-Hunt, Sherry Cherek, Steven Ress, Christine Cutucache, Paul Davis, Eleanor Rogan, Philip Smith, Jeremy White, and Heiko Schoenfuss, thanks for the editorial help and comments. Second, my brother, sister, and mother, who kept asking me, in the nicest way possible, when the book would be finished. Well, family, after years in the making, it finally is. And finally my wife and son, Wendy and Jared, thanks for all the patience. More than anyone else, they know of what I speak.