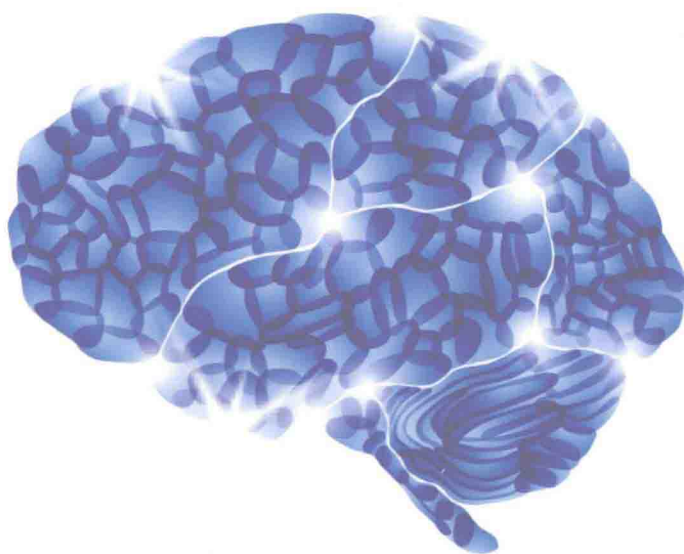


Second Edition

DRUGS, THE BRAIN, AND BEHAVIOR

The Pharmacology of Drug Use Disorders



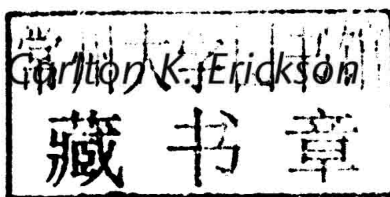
JOHN BRICK
CARLTON K. ERICKSON

DRUGS, THE BRAIN, AND BEHAVIOR

The Pharmacology of
Drug Use Disorders

Second Edition

John Brick and



Carlton K. Erickson

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DRUGS, THE BRAIN, AND BEHAVIOR

Explore the brain and discover the clinical and pharmacological issues surrounding drug abuse and dependence. The authors, research scientists with years of experience in alcohol and drug studies, provide definitions, historic discoveries about the nervous system, and original, eye-catching illustrations to discuss the brain/behavior relationship, basic neuroanatomy, neurophysiology, and the mechanistic actions of mood-altering drugs.

You will learn about:

- how psychoactive drugs affect cognition, behavior, and emotion
- the brain/behavior relationship
- the specific effects of major addictive and psychoactive drug groups
- new definitions and thinking about abuse and dependence
- the medical and forensic consequences of drug use

Drugs, the Brain, and Behavior uses a balance of instruction, illustrations, and tables and formulas that will give you a broad, lasting introduction to this intriguing subject. Whether you're a nurse, chemical dependency counselor, clinician, or other health professional, this book will be a quick reference guide long after the first reading.

John Brick, PhD, is a research scientist and educator with over 35 years of experience in alcohol and drug studies. Dr. Brick is Executive Director of Intoxikon International, and former Chief of Research, Center of Alcohol Studies, Education and Training Division, and Chairman of the Graduate Curriculum on the Biology of Alcohol at Rutgers University.

Carlton (Carl) K. Erickson, PhD, a research scientist, has been studying the effects of alcohol on the brain for over 45 years. He presently is the Pfizer Centennial Professor of Pharmacology/Toxicology, Associate Dean for Research and Graduate Studies, and Director of the Addiction Science Research and Education Center in the College of Pharmacy at the University of Texas at Austin.

ABOUT THE AUTHORS

John Brick, Ph.D., is a research scientist and educator with over 35 years of experience in alcohol and drug studies. Dr. Brick is Executive Director of Intoxikon International. During his 27 years at Rutgers University, he was a member of the Graduate Faculty, held positions as Chief of Research at the Center of Alcohol Studies Education and Training Division, Laboratory Director of the Alcohol Behavior Research Lab, Chairman of the Graduate Curriculum on the Biology of Alcohol, Associate Director of the Advanced School of Alcohol and Drug Studies, and Forensic Psychopharmacology Consultant to the University. He holds primary professional memberships in the American Academy of Clinical Toxicology, the Research Society on Alcoholism and the American Psychological Association. Dr. Brick taught courses in neuropharmacology for 20 years at Rutgers and elsewhere, including DuPont Pharma, and Beijing Medical University as part of the World Health Organization's first medical education initiative in Asia. He co-organized and chaired the First International Symposium on Alcohol and Stress and the International Conference on Alcohol and Aggression, and was one of only six Americans invited to address the Soviet Academy of Medicine on the occasion of their Centenary Anniversary—the only American scientist working in the field of alcohol studies to receive this distinct honor. Dr. Brick is the recipient of the Addiction Service Award for Excellence in Alcohol and Drug Education, and the first New Jersey Award for Community Service (MADD). He is also a double Fellow of the American Psychological Association; first for his “outstanding and unusual contributions to the science and profession of psychology” and second in recognition of the “national impact” of his work in the field of psychopharmacology. He published his first peer reviewed scientific article before starting graduate school and is the author of more than 100 scientific publications including Socioeconomic Evaluation of Addiction Treatment (The White House), and the first and second editions of the Handbook of the Medical Consequences of Alcohol and Drug Abuse (Editor/Co-author). He completed his undergraduate studies in physiological psychology at Queens College,

City University of New York, while he simultaneously received training and conducted neuropharmacology and neurochemistry research at Rockefeller University (NYC). He completed his graduate work at Binghamton University (SUNY). A graduate of a joint Masters-Doctorate degree program in psychobiology, his training in neuroscience and psychology further focused his research on the relationship between drugs, the brain and behavior and gave him the opportunity to work as a scientific reviewer in both clinical and biological sciences for various federal grant agencies and leading journals in the field. In 1994 he founded Intoxikon International, a company that provides multi-disciplinary consulting in alcohol and drug studies to government agencies, health care professionals, law enforcement, educational institutions, and corporations. He lectures throughout the United States and lives and works in Bucks County, Pennsylvania where he lives with his wife and his two dogs, designs gardens, composes and is an amateur astronomer.

Carlton (Carl) K. Erickson, Ph.D., a research scientist, has been studying the effects of alcohol on the brain for over 45 years. Carl received his Bachelor's degree in pharmacy from Ferris State College in 1961 and his Ph.D. degree in pharmacology from Purdue University in 1965. He has held tenured teaching and research positions at The University of Kansas (1965–1977) and The University of Texas (1978–present). He presently is the Pfizer Centennial Professor of Pharmacology/Toxicology, Associate Dean for Research and Graduate Studies, and Director of the Addiction Science Research and Education Center in the College of Pharmacy at the University of Texas at Austin. He holds memberships in the American Society for Pharmacology and Experimental Therapeutics (ASPET), the Research Society on Alcoholism (RSA), and the College on Problems of Drug Dependence (CPDD), and is a member of the Executive Council of the Betty Ford Institute. Carl is broadly knowledgeable about the neurobiology of alcohol and other drugs, since he is an active scientist and publisher of over 260 scientific and professional articles. In addition to several earlier books, he is the author of *The Science of Addiction: From Neurobiology to Treatment* (W.W. Norton, 2007), which won a University of Texas Hamilton Book Award in 2008, and a newer book, *Addiction Essentials: The Go-to Guide for Clinicians and Patients* (W.W. Norton, 2011). He is a Field Editor and Highlights Editor of the scientific journal *Alcoholism: Clinical and Experimental Research*, and serves on the Editorial Board of the *Journal of Studies on Alcohol and Drugs*. He is a recipient of the Betty Ford Center Visionary Award (2000), the 2003 Pat Fields SECAD Award, the 2004 Fred French Award for Educational Achievement, the Nelson J. Bradley Award for Lifetime Achievement (2007), and the John P. McGovern Award for Excellence in Medical Education (2009). Carl has 30 years of biomedical research experience as an active pharmacologist and neuroscientist and 15 years of educational research, all in academic settings. Carl presents approximately 15–20 lectures annually to health professionals, is a frequent keynote speaker at major conferences in the U.S. and internationally, and has spoken to approximately 87,000 professionals and people in recovery since 1978. Carl lives in Austin, Texas with his wife, and has four children and 11 grandchildren.

FOREWORD

In the nineteenth and early twentieth centuries, medical and clinical science education often studied the disease syphilis as a vehicle for a general understanding of how the body worked. This is because syphilis was a very common disease and because, over its course, syphilis typically affected virtually every organ and system in the body.

As I read *Drugs, the Brain, and Behavior*, I realized that the study of substance use disorders is the twenty-first century vehicle for understanding brain chemistry, neurophysiology, neuroadaptation, and particularly the behaviors that are associated with those physiological processes. Again, this is because substance use disorders—tobacco, alcohol, and other drugs, both illicit and prescribed—are very common (affecting over 40 million individuals in the US) and over their course, these disorders also affect almost every organ and system in the body.

Thanks to advances in neuroscience and to the cogent writing in this fine book by the two very respected and experienced authors, John Brick and Carl Erickson, the general and specific effects of these drugs are understandable in ever-increasing detail. The reader—and this could be anyone from an advanced counselor in the substance abuse field, through graduate neurology, neurochemistry, neurophysiology, and medical students—will gain new understanding and insight about basic and advanced concepts in neurophysiology, brain chemistry, and neuroadaptation.

One of the most important contributions of *Drugs, the Brain, and Behavior* is the ways it shows that the effects of any drug—particularly psychoactive drugs—can only be fully understood by also understanding the drug taker's prior learning and experience with the drug, the drug taker's genetic heritability relevant to the drug, the situational context of the drug taking, and the drug taker's expectations about the drug's effects. These learned and contextual variables help to explain

important concepts such as the difference between “use,” “misuse,” “abuse,” and “addiction” or “dependence.” These additional variables are also critically important to understanding resulting physiological, emotional, and behavioral effects of any single drug administration—but also the changes in effects produced by the same drug over repeated administrations, and the so-called “side-effects” from taking and from stopping any drug. These important and complex issues have been widely ignored in training and teaching about basic psychopharmacology for laboratory and clinical scientists.

These contextual and cumulative effects from using any psychoactive drug are also important in understanding the etiology, course, and treatment of substance use disorders. For example, we now know from pharmacological, behavioral, and genetic research that the effects of alcohol and other drug use are cumulative, that they are most pernicious when done early in life (e.g. adolescence), and—depending upon age or onset and genetic heritability—that there are significant and sometimes long-lasting effects from even relatively low-level use.

I found *Drugs, the Brain, and Behavior* to be a remarkably clear and comprehensive resource, clearly and engagingly written, focused and specific in describing what is known and what is not known about every class of psychoactive substance. I believe it will be a trusted resource for teachers, scientists, students, and clinicians seeking better understanding of how to treat substance use disorders; but also to those with more basic interest in psychopharmacology and brain–behavior interactions.

A. Thomas McLellan
CEO, Treatment Research Institute, Philadelphia PA

PREFACE

The best investment you can make in life is in your education. The second best investment is in the education of others. That is, in part, the motivation to write *Drugs, the Brain, and Behavior*.

My undergraduate training in physiological psychology and early career training in neuropharmacology at Rockefeller University narrowed my focus on the physiological basis of behavior and in particular, how psychoactive drugs like alcohol changed the brain. As a research scientist I was unencumbered with teaching responsibilities, but somewhere along the way, I found myself teaching and enjoyed sharing my knowledge through courses such as *Drugs and the Brain*, *Neuropharmacology*, and *Clinical Psychopharmacology*. John L. Fuller, the distinguished scientist who developed the field of Behavior Genetics, told me that as a teacher, his goal was to produce students smarter than himself. Another scientist, Nobel Laureate, H. Keifer Hartline, told me that anything of scientific greatness would be difficult to summarize in a few words. The knowledge-sharing challenge inspired by these luminaries often comes to mind in my writings, lectures and when my students ask interesting and complicated questions.

Drugs, the Brain, and Behavior developed as a result of requests by students at the Rutgers University Summer Schools of Alcohol and Drug Studies, where I taught for many years, and from graduate students at Rutgers and elsewhere in the United States who wanted answers to complex questions. In the greatly expanded DBB II, we continue to provide a solid understanding of how our amazing brain works and the behavioral, medical, and physiological effects of psychoactive drugs, including therapeutic medications often used in co-morbid patients. I hope that readers enjoy learning from the second edition of *Drugs, the Brain, and Behavior* and will continue to ask questions about drugs and these phenomena.

John Brick, PhD, MA, FAPA

John Brick and I have enjoyed working together for the past 30 years (or so), and we enhance each other's abilities. I was honored when he asked me to co-author the first edition of *Drugs, the Brain, and Behavior*, for we had often talked about jointly writing something that was a reflection of our common scientific backgrounds and training. John was trained more in neuroscience and psychology than I was, and I was trained as a "pure pharmacologist and toxicologist" (a rapidly dying breed). But we have both evolved into experts in each other's primary educational areas, and have both become stronger neuroscientists as our careers have developed. This makes for a perfect collegiality and reinforcement of the material when writing this book. Indeed, we work well together, both equally adept at writing first drafts and editing each other's work. And when one gets busy, the other picks up the work, so what could be better?

What is better is the second edition of *Drugs, the Brain, and Behavior*. The reader familiar with both editions will notice that this second edition has four new chapters, and greatly expanded existing chapters. We hope that we have continued the easy readability, entertaining style, and little-known facts not found in other texts of this type. Since the first edition in 1998, pharmacology and the neuroscience of psychotropic medications and misused, abused, and overused drugs have come a long way, so there is much to write about.

Even with all the new information, scientists find themselves behind the "street drug users" (and now prescription drug misusers). Just as soon as we think we know everything, "amateur pharmacologists" come up with other chemicals to abuse their bodies and minds. I like to say that scientists are about four years behind such amateur drug designers. If we want to study the science of new drugs, it takes at least a year to write a grant application, another year for it to be reviewed and funded, and at least two years to do the work. That doesn't even include the time it takes to publish the results!

So this book is as current as we can make it, with the changing drug scene around the nation and the world. We hope you enjoy it, and share what you learn with others.

Carlton Erickson, BS, MS, PhD

ACKNOWLEDGMENTS

It gives me great pleasure to thank the following people for their help with *Drugs, the Brain, and Behavior*. Thanks to Lisa Rickert for her excellent organizational abilities and patience with near-endless rewrites. Thanks to Karen Gutwirth who illustrated most of the figures. Special thanks to my daughters, Stephanie and Kyla, who brighten every day and most of all, thanks to Laurie Stockton, my editor extraordinaire and best friend who is always there to offer a fresh perspective and support me in my many endeavors.

JB

My thanks go out to the publishers who have supported us throughout the two editions of this book, through their patience, understanding, and guidance. Both publishers showed great insight in the need for this book. Having sole-authored two books of my own, I can truthfully say it is easier and more encouraging to have a co-author with similar thoughts, abilities, and patience, and I give John my sincere thanks for inviting me to join him in this wonderful task. The real heroes in my life are my loving and understanding wife, Eunice, and my children Steig, Dirk, Annika, and Hans, who gave up many weekends and some evenings for me to work on this project, when I could have been with them and our grandchildren. Some say you can never make up for lost time, but I intend to try.

CKE

INTRODUCTION

How to Get the Most from *Drugs, the Brain, and Behavior*

The greatly expanded and updated second edition of this book is designed to provide a sound conceptual foundation of how drugs affect the brain and behavior. While it provides the reader with a quick reference for the neuropharmacology of psychoactive drugs, you will get the most from *Drugs, the Brain, and Behavior* by reading it like a story, sequentially from the beginning. We start with a historical overview of drug use, and a clarifying guide to evolving drug terminology, and moving quickly into the study of the brain itself and the emergence of scientific insight into the brain–behavior relationship. *Drugs, the Brain, and Behavior* highlights some of the most exciting neuroscientific discoveries of our lifetimes that have led to our current understanding of everyday addictions, mental illness, and psychotherapeutic drugs.

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