

CRC

METHODOLOGY  
for  
ANALYTICAL  
TOXICOLOGY

I. Sunshine

CRC

PRESS

# Methodology for Analytical Toxicology

Editor

**Irving Sunshine**

Chief Toxicologist  
Cuyahoga County Coroner's Office  
Cleveland, Ohio  
Professor of Toxicology  
Institute of Pathology, School of Medicine  
Case Western Reserve University  
Cleveland, Ohio



Published by

CRC PRESS, Inc.  
2255 Palm Beach Lakes Blvd. · West Palm Beach, Florida 33409

**Library of Congress Cataloging in Publication Data**

Main entry under title:

Methodology for analytical toxicology.

At head of title: CRC.

Includes bibliographies and index.

1. Poisons — Analysis. 2. Toxicology — Laboratory manuals. I. Sunshine, Irving. II. Chemical Rubber Company, Cleveland.

RA1221.M44

615.9'07

74-30747

ISBN 0-8493-0716-3

Former ISBN 0-87819-716-8

This book represents information obtained from authentic and highly regarded sources. Reprinted material is quoted with permission, and sources are indicated. A wide variety of references are listed. Every reasonable effort has been made to give reliable data and information, but the author and the publisher cannot assume responsibility for the validity of all materials or for the consequences of their use.

All rights reserved. This book, or any parts thereof, may not be reproduced in any form without written consent from the publisher.

© 1975 by CRC Press, Inc.

2nd Printing, April 1978

CRC Press, Inc.

Revised from *CRC Handbook of Analytical Toxicology*

© 1969 by The Chemical Rubber Co.

International Standard Book Number 0-8493-0716-3

Former International Standard Book Number 0-87819-716-8

Library of Congress Card Number 74-30747

Printed in the United States



# **Methodology for Analytical Toxicology**



## PREFACE TO METHODOLOGY FOR ANALYTICAL TOXICOLOGY

The current and growing interest in determinations for anticonvulsant drugs, digoxin and digitoxin, procaine amide, lidocaine, and theophylline indicates that monitoring drug therapy is an increasing challenge to clinical laboratory scientists. Physicians are anxious to have this laboratory support which they can use to better understand a patient who has not achieved the expected results from a prescribed therapeutic regimen. Among the several questions related to this problem are these. Was the patient taking the drug? Was the prescribed dose sufficient? Was the patient taking some other medication which could affect his proper utilization of the prescribed drug? (Polypharmacology is practiced by many, and seldom do they deem it necessary to inform the physician that they are taking medications other than those he prescribed.)

One of the objectives of this volume is to present acceptable methods for the analysis of therapeutic agents in biological fluids. By utilizing these procedures, the chemist can provide the physician with objective laboratory data which can be used to answer some of the questions postulated above. In the several laboratories where these analyses have been instituted the demand for them has been overwhelming. One of the contributions of this volume is to present the analyst with several methods for the analysis of therapeutic agents and present the physician with reasonable interpretations of the results.

Procedures for many substances have been included in this volume so that methods for the analysis of the many products involved in acute poisonings are more easily available to those who want to use them. The described methods are the essence of the pragmatic experience of many active analysts. They will yield a reasonable result when carried out exactly as described in the text. Subsequently, some may wish to modify these methods to suit their local needs; however, this should be done only after establishing that the proposed modifications are preferable. The exception to this rule must be those methods which use gas chromatography. Many different columns are described, and no laboratory should have access to all of them. Hence, the reader is advised to become familiar with the columns he has available and expand their use for as many substances as he can. A table of McReynold's Constants has been included in the text. Using this, one should be able to determine which column packings are comparable and interchangeable.

In many instances a given procedure is really a prototype for many other chemically related substances. The expanded index, therefore, indicates all the so-called "interferences" to a given procedure. If a substance is listed as interfering with a given determination, it may be determinable by the same procedure, providing the prototype is not present. One should verify this and then proceed with the analysis.

The problem for some laboratories dealing with the analysis of specimens from patients involved in acute poisonings is that the causative agent may not be known. To help resolve this problem the second section of this volume presents several approaches to the systematic analysis of a biological fluid. The approach one chooses depends on local facilities. To encompass most, procedures are described which require a minimum of special equipment (TLC), some commonly available instruments (spectrophotometry), or gas chromatography (a technique rapidly growing in popularity and value). The more experimental liquid chromatographic techniques and the more elegant, sophisticated combination of gas chromatography and mass spectrometry are not presented. Too few laboratories now have this potential, but probably the next revision of this material will find these techniques commonplace.

Coupled with the revised or new procedures are updated assessments of the interpretation of the laboratory values. Significant data have been elaborated in recent years. These results are included in the presentation, as are recent literature citations so that the readers so inclined may seek them out and digest them at leisure.

I.S.

1975

## PREFACE TO THE MANUAL OF ANALYTICAL TOXICOLOGY

Published by the Chemical Rubber Co., 1971.

A growing number of requests for toxicological analyses is being made by physicians in order to establish whether or not particular patients may have been poisoned. This is understandable, because the signs and symptoms seen in acutely ill patients are not pathognomonic of exposure to a specific exogenous chemical agent, and a reliable history of an exposure to a toxic chemical often cannot be obtained. Thus, a correct diagnosis of poisoning frequently depends on the result of a chemical analysis of a biological specimen obtained from a patient. Simple and reliable methods for these analyses are not readily available for use in clinical chemistry laboratories. This book proposes to assemble and present a number of such methods.

The comprehensive toxicological treatises that have been published to date present many methods for the analysis of toxic substances. Unfortunately, their multiplicity often leaves the clinical chemist perplexed. Which of the many methods should *he* use in *his* laboratory? This volume is designed to answer that question. The basic principles of the many published methods will not be discussed, but details of some carefully selected and tested procedures will be presented.

The choice of the described methods was based on many factors, including reliability, the availability of equipment and reagents, the simplicity of the procedure, and the relative speed with which an informative result can be obtained. These methods are mainly personal modifications of procedures originally developed by others. When applied exactly as described, they will produce meaningful and reliable data.

Three types of methods were planned for each substance: Type A, a simple, direct, and qualitative test; Type B, a quantitative procedure using facilities found in the average laboratory; and Type C, an elegant, precise procedure using whatever equipment may be required. This goal was not realized for many obvious reasons and remains as a challenge for subsequent volumes.

Because the interpretation of the results obtained from these analyses will not be within the common experience of many readers, a summary of the reported correlations between the clinical condition of the patient and the concentration of the toxic agent in a relevant specimen will be given. More detail can be obtained by referring to the bibliography following each method. The interpretive data will interest not only toxicologists, clinical chemists, and clinical pathologists, but also all physicians who face the problem of treating a symptomatic patient purportedly poisoned by the most frequently offending drugs, household products, and economic poisons.

No extensive effort will be made to present methods that are primarily concerned with industrial toxicology and the evaluation of occupational hazards.

I.S.

1971



## CONTRIBUTORS

This manual could never have been prepared without the help of the contributing authors. I and every reader of this volume are indebted to each of them for their time and effort. The procedures they contributed represent *their* considered judgment on an acceptable, reproducible, and reliable method for the substance involved.

**John K. Abbott, B.A.**

Chemist  
Federal Aviation Administration, DOT  
P.O. Box 25082  
Oklahoma City, Oklahoma 25082

**Vijay Aggarwal, B.A.**

Toxicologist  
Bureau of Forensic Science  
1 North 14th Street  
Richmond, Virginia 23219

**Steve Andryauskas**

Senior Chemist  
Office of Chief Medical Examiner  
520 First Avenue  
New York, New York 10016

**Joseph S. Annino, B.S.**

Director  
Clin-Chem Laboratories  
1106 Commonwealth Avenue  
Boston, Massachusetts 02215

**David N. Bailey, M.D.**

Clinical Fellow  
Yale University School of Medicine  
Box 1001  
New Haven, Connecticut 06510

**John R. Barnes, Ph.D.**

Section Chief, Biochemistry Section  
Haskell Laboratory of Industrial Medicine  
and Toxicology  
Elkton Road  
Newark, Delaware 19711

**Frank E. Barnhart, B.S.**

Forensic Toxicologist  
San Diego County Coroner's Office Laboratory  
5555 Overland Avenue  
San Diego, California 92123

**Milton L. Bastos, Ph.D.**

Director of Toxicology  
Office of the Chief Medical Examiner  
520 First Avenue  
New York, New York 10016

**Raymond J. Bath, Ph.D.**

Chief Toxicologist  
Bureau of Forensic Science  
1 North 14th Street  
Richmond, Virginia 23219

**David J. Berry, L.R.I.C.**

Chief Technician  
Poisons Unit, New Cross Hospital  
Avonley Road  
London, S.E. 14, England

**Robert V. Blanke, Ph.D.**

Professor of Pathology and Director of  
Toxicology Laboratory  
Virginia Commonwealth University  
Box 696, MCV Station  
Richmond, Virginia 23298

**Paul B. Bondo, M.S.**

Research and Development Chemist  
South Bend Medical Foundation  
531 North Main Street  
South Bend, Indiana 46601

**Robin A. Braithwaite, A.R.I.C., Ph.D.**

Senior Clinical Biochemist  
Poisons Unit, New Cross Hospital  
Avonley Road  
London, S.E. 14, England

**Robert D. Budd, B.S.**

Toxicologist  
Rancho Los Amigos Hospital  
7601 East Imperial Highway  
Downey, California 90242

**Wing Chan, M.S.**

Chemist  
New York City Department of Health  
125 Worth Street  
New York, New York 10013

**Claude Charette, Dipl. Technol.**

Chemical Technologist  
Department of National Health and Welfare  
Health Protection Branch  
Ottawa, Ontario, Canada K1A 0L2

**George Cimbura, M.Sc.Ph.m.**

Head, Toxicology Section  
The Centre of Forensic Sciences  
8 Jarvis Street  
Toronto, Ontario, Canada M5E 1M8

**John Cooper, Dipl. Technol.**

Biochemical Technologist  
Department of National Health and Welfare  
Health Protection Branch  
Ottawa, Ontario, Canada K1A 0L2

**Charles Russell Crane, Jr., Ph.D.**

Chief, Biochemistry Research  
Civil Aeromedical Institute, DOT, FAA  
P.O. Box 25082  
Oklahoma City, Oklahoma 73125

**Robert H. Cravey, B.S.**

Toxicologist  
Office of the Sheriff-Coroner  
550 North Flower Street  
Santa Ana, California 92702

**Bernard Davidow, Ph.D.**

Assistant Commissioner for Laboratories  
City of New York Department of Health  
455 First Avenue  
New York, New York 10016

**Walter A. Dechtiaruk, B.S.**

Chemist, Senior Associate  
Department of Laboratory Medicine  
601 North Broadway  
Baltimore, Maryland 21205

**Kurt M. Dubowski, Ph.D.**

Professor, Clinical Chemistry and Toxicology,  
and Director, Toxicology Laboratories  
University of Oklahoma Health Sciences Center  
P.O. Box 26901  
Oklahoma City, Oklahoma 73190

**Leslie Eidus, M.D.**

Director, Bureau of Bacteriology  
Laboratory Centre for Disease Control  
Health and Welfare Canada  
Ottawa, Ontario, Canada K1A 0L2

**John Epton, M.Sc.**

Biochemist  
Regional Toxicology Laboratory  
Dudley Road Hospital  
Birmingham, England

**Milton Feldstein, M.A., M.S.**

Deputy Air Pollution Control Officer  
Bay Area Air Pollution Control District  
939 Ellis Street  
San Francisco, California 94103

**Frank J. Fernandez, B.S.**

Applications Chemist  
Perkin-Elmer Corporation  
Main Avenue  
Norwalk, Connecticut 06856

**Bryan S. Finkle**

Toxicologist  
Center for Human Toxicology  
University of Utah  
Salt Lake City, Utah 84112

**Arthur J. Fisk, B.S.**

Director of Laboratories  
Dade County Medical Examiner's Office  
1700 N.W. 10th Avenue  
Miami, Florida 33136

**Robert Forney, Jr., Ph.D.**

Instructor  
Case Western Reserve University  
2065 Adelbert Road  
Cleveland, Ohio 44106

**A. W. Freireich, M.D.**

Consulting Toxicologist  
Nassau County Medical Examiner  
P.O. Box 160  
East Meadow, New York 11554

**James C. Garriott, Ph.D.**

Chief Toxicologist  
Dallas County Institute of Forensic Sciences  
5230 Medical Center Drive  
Dallas, Texas 75235

**Franklin D. Griffith, Ph.D.**

Toxicologist  
3M Company  
3M Center, Medical Department  
St. Paul, Minnesota 55101



**Jeffrey Grove, A.R.I.C.**

Senior Biochemist  
Nicholas Laboratories Ltd.  
225 Bath Road  
Slough, Berks, England SL1 4AV

**J. V. Halliwell, B.Sc.**

Chemist  
Poisons Unit, Guy's Hospital  
St. Thomas Street  
London, S.E.1., England

**Horace E. Hamilton, M.S.**

Instructor, Department of Pathology  
University of Texas Health Science Center  
7703 Floyd Curl Drive  
San Antonio, Texas 78284

**Bette L. Hamman, M.S.**

Chief Toxicologist  
National Health Laboratory  
653 North Glebe Road  
Arlington, Virginia 22203

**Keith B. Hammond, M.S.**

Director and Senior Instructor in Pediatrics  
University of Colorado Medical Center  
4200 East 9th Avenue  
Denver, Colorado 80220

**Jesse A. Hancock, Ph.D. (Deceased)**

Professor of Clinical Chemistry and Toxicology  
The University of Texas at El Paso  
P.O. Box 180  
El Paso, Texas 79999

**Anita Harnanansingh, B.S.**

Chemist  
Laboratory Centre for Disease Control  
Health and Welfare Canada  
Ottawa, Ontario, Canada K1A 0L2

**Wayne H. Harrington, Ph.D.**

Assistant Professor  
Chemistry Department  
Cleveland State University  
Cleveland, Ohio 44115

**Norman W. Henry III, B.A.**

Chemist  
Haskell Laboratory of Industrial Medicine  
and Toxicology  
Elkton Road  
Newark, Delaware, 19711

**Bradford R. Hepler, B.S.**

Assistant Director, Special Chemistry Branch  
Clinical Pathology Services  
Wilford Hall Medical Center  
Lackland AFB, Texas 78236

**Jocelyn M. Hicks, Ph.D.**

Acting Director  
Clinical Laboratories, Children's Hospital  
National Medical Center  
2125 13th Street, N.W.  
Washington, D.C. 20009

**Mary M. Hodgkin, B.Sc.**

Chemist  
Laboratory Centre for Disease Control  
Health and Welfare Canada  
Ottawa, Ontario, Canada K1A 0L2

**Naresh C. Jain, Ph.D.**

Director of Toxicology  
Rancho Los Amigos Hospital  
7601 East Imperial Highway  
Downey, California 90242

**Peter Jatlow, M.D.**

Associate Professor, Department of  
Laboratory Medicine  
Yale University School of Medicine  
789 Howard Street  
New Haven, Connecticut 06504

**George Johnson, Ph.D.**

Clinical Chemist  
The Johns Hopkins Hospital  
601 North Broadway  
Baltimore, Maryland 21205

**Susan H. Jones, B.A.**

Technician  
Dallas County Institute of Forensic Sciences  
5230 Medical Center Drive  
Dallas, Texas 75235

**David G. Kaiser, Ph.D.**

Research Head, Drug Metabolism Research  
The Upjohn Company  
301 Henrietta  
Kalamazoo, Michigan 49001

**Gerald E. Kananen, Ph.D.**

Applications Chemist  
Hewlett-Packard Corporation  
Route 41 and Starr Road  
Avondale, Pennsylvania 19311

**Sidney Kaye, Ph.D.**

Professor of Toxicology, Pharmacology,  
and Legal Medicine  
School of Medicine  
University of Puerto Rico  
San Juan, Puerto Rico 00936

**Leo Kazyak, M.A.**

Chief Toxicologist  
Walter Reed Army Institute of Research  
Walter Reed Army Medical Center  
Washington, D.C. 20012

**Edgar W. Kivela, Ph.D.**

Chief, Division of Crime Detection  
Michigan Department of Public Health  
3500 North Logan Street  
Lansing, Michigan 48914

**David Landau, M.S.**

Toxicologist  
Nassau County Medical Examiner's Office  
P.O. Box 160  
East Meadow, New York 11554

**Charles J. Least, Jr., M.S.**

Supervisor, Therapeutic Drug Monitoring  
Laboratory  
The Johns Hopkins Hospital  
601 North Broadway  
Baltimore, Maryland 21205

**Beverly Lorenzo, B.S.**

Chemist  
Cuyahoga County Coroner's Laboratory  
2121 Adelbert Road  
Cleveland, Ohio 44106

**Robert Maes, Ph.D.**

Professor of Toxicology  
University of Utrecht  
Voldelhaan 14  
Utrecht, Holland

**Robert S. Martin, B.A.**

Biology, Biochemistry Assistant  
The Upjohn Company  
301 Henrietta  
Kalamazoo, Michigan 49001

**Arthur J. McBay, Ph.D.**

Chief Toxicologist  
Office of the Chief Medical Examiner  
P.O. Box 2488  
Chapel Hill, North Carolina 27514

**Michael McGee, B.S.**

Chemist  
Bureau of Forensic Science  
1 North 14th Street  
Richmond, Virginia 23219

**Ian J. McGilveray, Ph.D.**

Head, Biopharmaceutics Section  
Drug Research Laboratory, Health  
Protection Branch  
Health and Welfare Canada  
Ottawa, Ontario, Canada K1A 0L2

**John J. McHugh, J.D.**

Chief of Laboratory  
Department of Public Safety  
1010 Commonwealth Avenue  
Boston, Massachusetts 02215

**John M. Meola**

Assistant Director, Clinical Chemistry  
Albany Medical Center Hospital  
46 New Scotland Avenue  
Albany, New York 12208

**Kamal K. Midha, Ph.D.**

Research Scientist  
Drug Research Laboratory, Health  
Protection Branch  
Health and Welfare Canada  
Ottawa, Ontario, Canada K1A 0L2

**Joseph R. Monforte, Ph.D.**

Toxicologist  
Wayne County Medical Examiner's Office  
400 East Lafayette Street  
Detroit, Michigan 48226



**Sunil K. Niyogi, Ph.D.**

Consultant  
5247 North 10th Street  
Philadelphia, Pennsylvania 19141

**Robert J. Osiewicz, Ph.D.**

Toxicologist  
Bureau of Forensic Sciences  
401 A. Colley Avenue  
Norfolk, Virginia 23507

**Robert J. Perchalski, B.S.**

Research Chemist  
Veterans Administration Hospital  
Medical Research  
Gainesville, Florida 32602

**L. F. Prescott, M.A., M.D., F.R.C.P.**

Consultant Physician  
Department of Therapeutics  
The Royal Infirmary  
Edinburgh, Scotland EH39YW

**Arnold O. Rathje, B.S.**

Senior Industrial Hygienist  
General Electric Company  
Nela Park  
Cleveland, Ohio 44112

**Philip C. Reynolds, B.S.**

Chief Toxicologist  
Institute of Forensic Sciences  
2945 Webster Street  
Oakland, California 94609

**Fredric Rieders, Ph.D.**

Laboratory Director  
National Medical Services, Inc.  
2300 Stratford Avenue  
Willow Grove, Pennsylvania 19090

**William Robinson, B.Sc.Ph.M.**

Toxicologist  
The Centre of Forensic Sciences  
8 Jarvis Street  
Toronto, Ontario, Canada M5E 1M8

**Denis O. Rodgers, Ph.D.**

Chief of Clinical Chemistry  
The Center for the Health Sciences  
University of California at Los Angeles  
Los Angeles, California 90024

**Joseph I. Routh, Ph.D.**

Professor of Biochemistry and Pathology  
University of Iowa  
Iowa City, Iowa 52242

**Donald C. Sanders, M.S.**

Research Chemist  
Civil Aeromedical Institute, FAA  
P.O. Box 25082, AAC-114A  
Oklahoma City, Oklahoma 73125

**Phillip Santinga, B.S.**

Chemist  
Bendix Corporation  
Box 80  
Brandey Station, Virginia 22714

**Bernard Searle, Ph.D.**

106D Finderne Avenue  
Grandview Gardens, New Jersey 08876

**Paul Richard Sedgwick, B.A.**

Associate Toxicologist  
Orange County Sheriff-Coroner  
550 North Flower Street  
Santa Ana, California 92701

**Richard F. Shaw, B.S.**

Chief Toxicologist  
San Diego County Coroner's Office  
5555 Overland Avenue  
San Diego, California 92123

**Theodore J. Siek, Ph.D.**

Toxicologist  
Northern Virginia Branch, Bureau of  
Forensic Science  
P.O. Box 486  
Merrifield, Virginia 22116

**Thomas C. Sneath, B.S.**

Senior Toxicologist  
Rancho Los Amigos Hospital  
7601 East Imperial Highway  
Downey, California 90242

**Harvey M. Solomon, M.D.**

Clinical Pathologist  
The Johns Hopkins Hospital  
601 North Broadway  
Baltimore, Maryland 21205

**F. William Sunderman, Jr., M.D.**

Professor and Chairman, Department of  
Laboratory Medicine  
University of Connecticut School of Medicine  
P.O. Box G  
Farmington, Connecticut 06032

**Irving Sunshine, Ph.D.**

Chief Toxicologist  
Cuyahoga County Coroner's Office  
2121 Adelbert Road  
Cleveland, Ohio 44106

**Marjorie Q. Swift, B.S.**

Senior Chemist  
Department of Public Safety  
1010 Commonwealth Avenue  
Boston, Massachusetts 02215

**James B. Terrill, Ph.D.**

Research Toxicologist  
Haskell Laboratory, DuPont Company  
Elkton Road  
Newark, Delaware 19711

**Jerry J. Thoma, M.S.**

Research and Development Chemist  
South Bend Medical Foundation  
521 North Main Street  
South Bend, Indiana 46601

**Robert Turk, Ph.D.**

Chief Toxicologist  
Clinical Bio-Tox Laboratories, Ltd.  
1436 Old Skokie Road  
Highland Park, Illinois 60035

**James C. Valentour, Ph.D.**

Associate Toxicologist  
Cuyahoga County Coroner's Office  
2121 Adelbert Road  
Cleveland, Ohio 44106

**Michael Vanko, Ph.D.**

Assistant Director  
Albany Medical Center Hospital  
120 Mohawk Drive  
Schenectady, New York 12307

**Clifford B. Walberg, Ph.D.**

Clinical Chemist  
Toxicology Lab, LAC-USC Medical Center  
1200 North State Street  
Los Angeles, California 90033

**Jack E. Wallace, Ph.D.**

Associate Professor  
University of Texas Health Science Center  
7703 Floyd Curl Drive  
San Antonio, Texas 78284

**John Wells, Ph.D.**

Toxicologist  
The Centre of Forensic Sciences  
8 Jarvis Street  
Toronto, Ontario, Canada M5E 1M8

**Rhondda J. Wells, B.S.**

Assistant Director  
Pediatric Microchemistry Laboratory  
University of Colorado Medical Center  
Denver, Colorado 80220

**H. R. Wetherell, Ph.D.**

Crime Laboratory Scientist  
Michigan Department of Public Health  
3500 North Logan Street  
Lansing, Michigan 48914

**B. J. Wilder, M.D.**

Chief  
Neurology Service  
Veterans Administration Hospital  
Gainesville, Florida 32802

**Louis A. Williams, B.S.**

President  
Clin-Chem Laboratories  
1106 Commonwealth Avenue  
Boston, Massachusetts 02215

**William J. Wilson, Jr., M.Sc.**

Chief Toxicologist  
Office of Bexar County Medical Examiner  
527 North Leona Street  
San Antonio, Texas 78207

**Bennie Zak, Ph.D.**

Professor of Pathology  
Wayne State University School of Medicine  
540 East Canfield  
Detroit, Michigan 48201

## ACKNOWLEDGMENT

I would like to thank Jerry Thoma and Paul Bondo for their assistance in reviewing and editing the numerous manuscripts submitted by the authors. Their diligence and expertise contributed significantly in compiling this volume.

I would also like to thank the editorial staff of CRC Press, Inc., in particular Sandy Pearlman, for their conscientious application to the many details involved in converting the first drafts of the contributors' manuscripts to a useful and practical book.

## APOLOGIA

"To err is human, . . . ." Extensive efforts have been made to insure the reliability and lucidity of the material presented in this volume. The reader is encouraged to send his observation of errors of omission or commission to the editor so that subsequent volumes will be improved. Requests for additional information on procedural details will be welcomed by the editor.

## TABLE OF CONTENTS

**Introduction**

Is My Patient Poisoned? . . . . .	3
Guidelines for Submission of Samples . . . . .	5
Monitoring Therapy . . . . .	6
Analysis . . . . .	6
Caveat Interpretor . . . . .	7

**Section I. Methods for Specific Substances**

	<b>A</b>	<b>B</b>	<b>C</b>
Acetaminophen . . . . .	13	14	15
Amitriptyline . . . . .		17	19
Amphetamines . . . . .	22	24	27
Arsenic . . . . .	30	31	
Barbiturates . . . . .	34	36	41
Benzene . . . . .	378		
Benzodiazepines . . . . .	45		
Bismuth . . . . .	48	49	
Borate . . . . .	51	52	
Bromide . . . . .	54	55	
Caffeine . . . . .		57	58
Carbamazepine . . . . .			61
Carbon monoxide . . . . .	64	67	69
Chloral hydrate . . . . .		72	
Chlordiazepoxide . . . . .	75	76	79
Chlorinated hydrocarbon pesticides . . . . .		81	
Chloroquine . . . . .			83
Cholinesterase* . . . . .	88	89, 92	96
Copper . . . . .		105	109
Cyanides . . . . .	113	114	116
Diazepam . . . . .		119	121
Digitoxin . . . . .	124		
Digoxin . . . . .	127		
Diphenhydramine . . . . .		130	
Diphenylhydantoin . . . . .		132	134
Diquat . . . . .	137	137	
Diuretics . . . . .		140	
Doxepin . . . . .			142
Ethanol . . . . .	145	146	149
Ethchlorvynol . . . . .	155	156	157
Ethosuximide . . . . .			160
Ethylene glycol . . . . .		163	165
Fluoride . . . . .	167	168	170
Fluorocarbons . . . . .	173	175	
Glutethimide . . . . .		178	180

Type A: a simple, direct qualitative test.

Type B: a quantitative procedure using facilities found in the average laboratory.

Type C: an elegant precise procedure using whatever equipment may be required.



	A	B	C
Gold . . . . .	182		
Halogenated hydrocarbons . . . . .	184		
Haloperidol . . . . .		186	
Halothane . . . . .		188	
Hexachlorophene . . . . .			190
Imipramine . . . . .	192	913	194
Iron . . . . .	196	105, 198	
Isoniazid . . . . .		200	
Isoniazid phenotyping . . . . .		202	
Lead in biological materials . . . . .		204	207
Lead in paint chips . . . . .	210		
Lidocaine . . . . .		211	213
Lithium . . . . .		215	
Manganese . . . . .	217		
Meprobamate . . . . .	219	220	222
Mercury . . . . .	224	225	227
Methadone . . . . .	231		233
Methanol . . . . .	236	237	239
Methaqualone . . . . .		241	243
Methemoglobin . . . . .		245	
<i>N</i> -Methylbarbituric acids . . . . .		247	
Methylenedioxyamphetamine . . . . .	250		
<i>N</i> -Methylformamide and <i>N</i> -methylacetamide . . . . .	253		
Methylphenidate . . . . .	256		
Methypylon . . . . .		260	262
Metronidazole . . . . .			265
Morphine . . . . .	267		271
Nickel . . . . .			275
Nicotine . . . . .	279	280	281
<i>p</i> -Nitrophenol . . . . .		284	286
Organic thiophosphate esters . . . . .	288	290	
Orinase® . . . . .			354
Oxyphenbutazone . . . . .	302	304	306
Paramethoxyamphetamine . . . . .			292
Paraquat . . . . .	294	295	
Phencyclidine . . . . .		297	
Phenols . . . . .	299		
Phenothiazines . . . . .	301		
Phenylbutazone . . . . .	302	304	306
Phosphorus . . . . .		309	
Polychlorinated biphenyls . . . . .		311	
Primidone . . . . .			313
Procaine amide . . . . .	316		318
Propoxyphene . . . . .	320	322	324
Propranolol . . . . .		328	
Protriptyline . . . . .			332

Type A: a simple, direct qualitative test.

Type B: a quantitative procedure using facilities found in the average laboratory.

Type C: an elegant precise procedure using whatever equipment may be required.

	A	B	C
Pyrimethamine . . . . .			334
Quinine (or quinidine) . . . . .	336	338	340
Ritalinic acid . . . . .	256		
Salicylate . . . . .	342	343	
Selenium . . . . .			347
Strychnine . . . . .	349	350	
"Sulfa" compounds . . . . .	352	352	
Sulfonylureas . . . . .			354
Thallium . . . . .	357	359	363
Theophylline . . . . .	366		368
Thiamphenicol . . . . .			371
Thiopental . . . . .		373	
Thioridazine . . . . .	375	375	
Tolbutamide . . . . .			354
Tolinase <sup>®</sup> . . . . .			354
Toluene . . . . .	378		
Volatile compounds (toluene, xylene, benzene) . . . . .	378		
Warfarin . . . . .		379	380
Xylene . . . . .	378		
Zinc . . . . .		105	384

## Section II. Screening Procedures

Aside to the Analyst . . . . .	391
Alternative techniques for systematic analyses . . . . .	394
Direct nonseparation techniques . . . . .	394
Spot tests . . . . .	394
Heavy metals . . . . .	395
Immunoassays . . . . .	399
Organic volatile substances . . . . .	407
Indirect separation techniques . . . . .	412
TLC for weak acids, neutrals, and weak bases . . . . .	412
UV spectrophotometry for sedative drugs frequently in overdose emergencies . . . . .	414
GC for sedative drugs . . . . .	421
Phase selectivity data (McReynolds indices) . . . . .	429
TLC of basic organic drugs . . . . .	434
Modified Davidow TLC drug screening procedure . . . . .	443
Elution of iodoplatinate positive spots from TLC plates . . . . .	447
GC for drugs of abuse . . . . .	448
Retention indices for compound identification . . . . .	450
Adsorption procedures using a nonionic resin . . . . .	459
Adsorption procedure using charcoal . . . . .	462

Index . . . . .	467
-----------------	-----

Type A: a simple, direct qualitative test.

Type B: a quantitative procedure using facilities found in the average laboratory.

Type C: an elegant precise procedure using whatever equipment may be required.

# Introduction