# Clinical Biochemistry Reviews Volume 3

Edited by

David M. Goldberg, M.D., Ph.D.

# **Clinical Biochemistry Reviews**

### Volume 3

Edited by

David M. Goldberg, M.D., Ph.D.

Professor and Chairman
The Department of Clinical Biochemistry
The University of Toronto
Biochemist-in-Chief
The Hospital for Sick Children
Toronto, Canada



A Wiley Medical Publication
JOHN WILEY & SONS
New York · Chichester · Brisbane · Toronto · Singapore

Copyright © 1982 by John Wiley & Sons, Inc.

All rights reserved. Published simultaneously in Canada.

Reproduction or translation of any part of this work beyond that permitted by Sections 107 or 108 of the 1976 United States Copyright Act without the permission of the copyright owner is unlawful. Requests for permission or further information should be addressed to the Permissions Department, John Wiley & Sons, Inc.

ISSN 0194-0538

ISBN 0-471-09868-X

Printed in the United States of America

10 9 8 7 6 5 4 3 2

### **Contributors**

Peter M.G. Broughton, F.R.C.Path.
Deputy Director
Wolfson Research Laboratories
and Department of Clinical Chemistry
Queen Elizabeth Hospital
Birmingham, England

Timothy J.N. Carter, Ph.D.
Senior Biochemist
Wolfson Research Laboratories
Queen Elizabeth Medical Centre
Birmingham, England

Michael Alan Chester, Ph.D.

Metabolic Unit
University Hospital
Lund, Sweden
Formerly, Associate Professor of Biochemistry
Faculty of Medicine
University of Kuwait

P.M. Dodson, M.R.C.P.
Research Registrar
Department of Medicine
St. Bartholomew's Hospital
London, England

John Dupré, M.A., B.Sc., F.R.C.P., F.A.C.P.
Professor of Medicine
The University of Western Ontario
Director, Clinical Investigation Unit
University Hospital
London, Ontario, Canada

Gordon G. Forstner, M.D.

Professor of Pediatrics
The University of Toronto
Director, Kinsmen Cystic Fibrosis Research Center
The Hospital for Sick Children
Toronto, Ontario, Canada

David J. Galton, M.D., F.R.C.P.
Consultant Physician
Department of Medicine
St. Bartholomew's Hospital
London, England

Arthur R. Henderson, M.B., Ch.B., Ph.D.
Professor of Biochemistry
University of Western Ontario
Chief, Department of Clinical Chemistry
University Hospital
London, Ontario

Peter I. Jatlow, M.D.
Professor of Laboratory Medicine
Yale University School of Medicine
New Haven, Connecticut

Donald J.R. Laurence, Ph.D. Scientific Staff Ludwig Institute for Cancer Research London, England

Arne Lundblad, M.D.
Associate Head
Department of Clinical Chemistry
University Hospital
Lund, Sweden

James Marigold, B.M., M.R.C.P. Senior Registrar St. Thomas' Hospital London, England

Beverley E. Pearson Murphy, M.D.
Professor of Medicine and
Professor of Obstetrics and Gynecology
McGill University
Director, Reproductive Physiology Unit.
Montreal General Hospital
Montreal, Quebec, Canada

Daniel A. Nealon, B.Sc., Ph.D.
Assistant Professor of Biochemistry
University of Western Ontario
Clinical Biochemist
University Hospital
London, Ontario, Canada

Alexander M. Neville, M.D., Ph.D.
Professor of Experimental Pathology
University of London
Administrative Director
Ludwig Institute for Cancer Research
London, England

Per-Arne Öckerman, M.D.
Professor and Head
Department of Clinical Chemistry
University Hospital
Lund, Sweden

Theodore Peters, Jr., Ph.D.
Research Biochemist
Associate Director for Research
The Mary Imogene Bassett Hospital
Cooperstown, New York

Janakiraman Ramachandran, Ph.D. Professor of Biochemistry University of California San Francisco, California

Roberta G. Reed, Ph.D.
Associate Research Biochemist
The Mary Imogene Bassett Hospital
Cooperstown, New York

N. Wilson Rodger, M.D., F.R.C.P.
Associate Professor of Medicine
Coordinator, Section of Endocrinology and Metabolism
University of Western Ontario
St. Joseph's Hospital
London, Ontario, Canada

Bernard E. Statland, M.D., Ph.D.
Director of Clinical Chemistry
Associate Director of Laboratory Medicine
Department of Laboratory Medicine
Boston University Medical Center
Boston, Massachusetts

J. Stocks, M.Sc.
Biochemist
Department of Medicine
St. Bartholomew's Hospital
London, England

Richard P.H. Thompson, D.M., F.R.C.P. Consultant Physician St. Thomas' Hospital London, England

Paul L. Wolf, M.D.
Professor of Pathology
University of California
San Diego, California

#### Preface

The initial aim of this series was to gather a team of contributors who would summarize, in a critical fashion, the important papers in their area over a single calendar year. For the purpose of continuity, they were asked to serve for a three-year term. Some have persevered in this task through adversity. It is my special pleasure to acknowledge a debt of gratitude to that heroic band: Dr. Paul Wolf; Dr. Gordon Forstner; Dr. Donald Laurence and Dr. Alexander Neville; Dr. Arthur Henderson; Dr. Beverley Murphy; Dr. Janakiraman Ramachandran; Dr. Arne Lundblad and Dr. Per-Arne Öckerman. I sincerely believe that what they have accomplished in the past three years will serve as an inspiration to their readers and a model for other reviewers.

Mr. Peter Broughton, too, belongs in that distinguished company, although he has changed topics, and this year, together with his colleague Dr. Timothy Carter, has directed his perceptive analysis toward developments in the field of Instrumentation. Those authors who have returned to this assignment for a second year include Dr. John Dupré, who this year brings with him Dr. Wilson Rodger to cover "Selected Topics in Diabetes Nellitus"; Dr. Peter Jatlow, who this year has written the chapter on "Toxicology and Therapeutic Drug Monitoring" without the benefit of a co-author; and Dr. Alan Chester for a second year joins his colleagues from Lund in describing "Biochemical Aspects of Genetic Disease."

To most of our readers, the new authors will need no introduction. Dr. Bernard Statland has made many personal contributions to the theme of the first chapter. Dr. Dan nelson is, under the tutelage his mentor, fast becoming one of the most respected young clinical enzymologists in North America. Dr. David Galton and Dr. Richard Thompson exemplify the best qualities of the London Medical School - the ability of its academic leaders to integrate clinical science with basic science. Their chapters on Lipoproteins and Hepatobiliary Disease respectively demonstrate, with the aid of younger colleagues, the happy results of such an effective synthesis. Finally, Dr. Ted Peters and Dr. Roberta Reed have achieved what previous contributors informed me was impossible: complete or nearly complete coverage of the fascinating proteins which circulate in our plasma; and in so doing, they have achieved a practical balance between matters of interest to the chemist, the analyst, and the clinician.

This third volume, in my view, is the most comprehensive and well-balanced collection in the series so far. Our critics have been kind, but they have pointed out obvious shortcomings, notably, a failure to achieve the uniformity of approach originally sought; the obvious selectivity adopted by many of the authors; and the thought that perhaps in most fields, there would not be sufficient material of real interest to merit review year after year. The option is now available to publish these Reviews less than annually. Perhaps every second year would be the optimal timeframe. Perhaps, also, the rigid chapter structure can give way to a more flexible format. These matters to which I will be giving deep consideration over the next few months, and any input from readers would be very welcome. In closing, I would like to acknowledge the efforts of both Mrs. Marj Fleming and Ms. Rosalind Straley, who have helped in the publication of this volume.

# **Contents**

Chapter	Laboratory Management, Quality Assurance and Reference Values  Bernard E. Statland	
	Laboratory Management	1
	Postgraduate study in clinical chemistry Workload recording	1 1
	Optimizing admission testing	2
	Quality Assurance	
	Analyzing the components of quality control	5
	Miscellaneous issues	10
	Assessing quality requirements in clinical chemistry	12
	Preanalytical Sources of Variation	16
	Preparation of the subject	16
	Preparation of the specimen	18
	Physiologic intraindividual variation	18
	Reference Values	21
	Pregnancy	21
	Pediatric reference values	22
	Miscellaneous	23
	References	25
Chapter :	2 Instrumentation	
	Peter M.G. Broughton and	
	Timothy Carter	
	Introduction	29
	Chemical Analyses	29
	Spectroscopy	31
	Fluorescence	32
	Chemiluminescence	32
	Mass spectrometry	32
	Immunoassay	32
	Electrochemistry	37
	Chromatography	39
	Electrophoretic Techniques	40
	Miscellaneous	41
	Conclusions	42
	References	43

#### xiv Contents

## Chapter 3 Kidney Function and Renal Disease Paul L. Wolf

Enzymatic Abnormalities	53
Immunoreactive trypsin	53
Serum and urine amylase	53
Creatine kinase	54
Dopamine-β-hydroxylase	54
Proteases	55
Biochemical Hematological Abnormalities	55
Hemoglobin Alc	55
Erythropoiesis and erythropoietin	55
Erythropoiesis inhibitor	57
Erythrocyte enzymes	57
Coagulation Studies	57
β-thromboglobulin	57
Platel <b>et antige</b> n	. 58
Fibrinogen split products	59
Porphyrin Metabolism	59
Abnormalities of Mineral Metabolism	<b>6</b> 0
Hypocalcemia	60
Effect of vitamin D metabolites on	60
hypocalcemia	
Hypercalciuria	64
Magnesium	64
Aluminum	66
Fluoride	67
Lithium	67
Urinary oxalate	70
Abnormalities of Lipid Metabolism	. 70
Abnormalities of Protein Metabolism	74
β <sub>2</sub> -microglobulin	74
$\alpha_1$ -microglobulin	74
Albumin-bound fluorescence in CRF	75
Amino acid metabolism and ammonia in CRF	75
Nitrogen balance	77
Hormones in Chronic Renal Failure	78
Cortisol	78
Prolactin	79
Parathyroid hormone	80
Thyroid hormones	81
Cyclic AMP	82
Gastrin	82
Pancreatic polypeptide	82
Renin	83
Orug Metabolism	83
Hydrochlorothiazide and acetazolamide	84
Cimetidine	84
Mefenamic acid	84
Prazosin	84
Propoxyphene	85
Gentamicin and tobranycin	85
Demeclocycline	86

		Contents	vx
	Other Miscellaneous Abnormalities	86	
	Creatinine as a filtration marker	86	
	Glomerular filtration rate	87	
	Acute tubular necrosis	87	
	References	88	
Chapter 4	Diseases of the Gastrointestinal System Gordon G. Forstner		
	Introduction	93	
	The Stomach and the Duodenum	94	
	Testing for complete vagotomy:	94	
	sham feeding		
	Gastrin	95	
	In duodenal ulcer	95	
	Subtypes in peptic ulcer disease	96	
	Subtypes in the diagnosis of malignant gastrinoma	97	
	The secretin-provocative test for Zollinger-Ellison syndrome	97	
	The Pancreas	99	
	Acute pancreatitis	99	
	The morphine-prostigmin provocative test		
	Amylase assay	100	
	Kinetic assays	100	
	Serum "tryptic-like" activity	101	
	Serum specific pancreatic lipase	101	
	"Old amylase" with pancreatic	101	
	pseudocysts	101	
	Chronic pancreatitis	102	
	Lactoferrin	102	
	Pancreas-specific protein	103	
	Pancreatic insufficiency	_	
	Specific trypsin versus specific	104	
	amylase	104	
	A dual label Schilling test	105 ′	
	The Small Intestine and Colon	106	
	Sugar absorption in infants	106	
	One-hour blood xylose	106	
	Lactose tolerance	108	
	Substitutes for the fat balance test	108	
	[14C]-glyceryl triglyceride breath test	108	
	Double labeling with glyceryl triether and triolein	110	
	Bacterial overgrowth	110	
	$[^{14}C]$ -D-xylose and $[^{14}C]$ -bile acid	110	
	test compared		
•	Gas chromatographic method for urinary oxalate	112	
	Crohn's disease	112	
	Zinc deficiency	113	
	-	113	
	References	114	

Chapter 5	Selected Topics in Diabetes Mellitus John Dupré and N. Wilson Rodger	
	Intensive Replacement Treatment with Insulin in the Management of Insulin-Requiring Diabetes Mellitus	119
	Assessment of Control of Glycemia in Diabetes Mellitus	122
·	Blood glucose concentrations by self- determined estimation of capillary blood	123
	glucose  Self-monitoring of blood glucose con- centration in the management of  diabetes mellitus	124
	Laboratory determination of capillary blood glucose concentrations in manage- ment of diabetes mellitus	125
	Glycosylated Proteins in the Blood: Indices of Glycemic Control	126
	Chromatographic assays	126
	Colorimetric methods for determination of glycosylated hemoglobins	127
	Clinical significance of the determina- tion of glycosylated hemoglobins	128
	Glycosylation of proteins other than hemoglobins	129
	References	129
Chapter 6	Biochemical Tests in Diagnosis and Monitoring of Cancer	
	Donald J.R. Laurence and Alexander M. Neville	
	Antigens	133
	Alphafetoprotein (AFP)	133
	Tumor localization	
	Liver disease	134
	Germ cell tumors	134
	Carcinoembryonic antigen (CEA)	134
	Tumor localization	135
	Analysis of malignant effusions	136
	Colorectal cancer	136
	Other digestive tract cancers	136
	Breast cancer	137
	Lung cancer	137
	Bladder cancer	137
	Gynecological cancer	137
		138
	Medullary carcinoma of the thyroid (MTC) Brain tumors	138
	Other antigens	138
	Other Tumor-Associated Substances	138
	Ferritin	141
	Milk proteins	141
		141
	Serum proteins	141
	Pregnancy-associated proteins	142

	Polyamines	142
	Viral products	142
	Herpes simplex virus (HSV-2)	142
	Epstein Barr (EV) virus	143
	Mouse mammary tumor virus (MMTV)	143
	Hormones	143
	Corticotropin (ACTH) and its cognate peptides	143
	Antidiuretic hormone (ADH)	145
	Prolactin (PRL)	145
	Calcitonin (CT)	146
	Gastrin	148
	Vasoactive intestinal peptide (VIP)	148
	Insulin	148
	Parathyroid hormone (PTH)	149
	Chorionic gonadotropin (hCG)	151
	Steroid Hormone Receptors	151
	Breast carcinoma Endometrial cancer	152
	Prostatic carcinoma	153
	Melanoma	153
	Enzymes	153
	Alkaline phosphatase (AP)	154 154
	Prostatic acid phosphatase (PAP)	154
	Glycosyl transferases	154
	γ-qlutamyl transferase (GGT)	154
	Myeloid and Lymphoid Neoplasia	155
	The myeloid and histiocytic series	155
	Lysozyme	155
	Nonspecific esterase	155
	Specific esterase and myeloperoxidase	156
	Normal cross-reacting antigen (NCA)	156
	Cell surface markers for nonlymphoid cells	156
	Leukocyte alkaline phosphatase (LAP)	156
	The lymphoid series	156
	T and B cell markers	156
	Terminal deoxynucleotidyl transferase	157 `
	Acid phosphatase	158
	Immunoglobulin (Ig)	158
	$\beta_2$ -microglobulin	161
	Conclusion	161
	References	161
Chapter 7	Clinical Enzymology Arthur R. Henderson and D.A. Nealon	
	Introduction	187
	Prostatic Acid Phosphatase	187
	The radioimmunoassay	187
	Rectal Palpation and the Diagnosis of	194
	Prostatic Carcinoma	
	Rectal Palpation of the Prostate and	195
	Prostatic Acid Phosphatase Activity in	
	the Blood	

Contents

xvii

#### xviii Contents

	Cleatine kinase	197
	Interaction of human creatine kinase	198
	isoenzymes with human immunoglobulins	
	Creatine kinase BB as a possible tumor	205
	marker	
	Storage of the human creatine kinase	208
	isoenzyme	
	Use of thiol agents	208
	Effect of temperature	210
	Effect of chelators	210
	Effect of pH	211
	The 'lag' phase of the reaction	212
	Summary of current problems	213
	Alkaline Phosphatase	214
	The monograph 'alkaline phosphatase'	214
	Purification of human alkaline phosphatase	215
	The three-gene hypothesis	217
	'Big' alkaline phosphatase	218
	Adult form of hypophosphatasia	223
	Chromatofocusing as a step in enzyme	224
	purification	224
	Conclusion	226
	References	220
	Metetelices	221
Chapter 8	Non-Polypeptide Hormones	
Chapter 5	Beverley E. Pearson Murphy	
	botoltog bi roaleon marping	
	Introduction	235
	Thyroid Hormones	236
	Neonatal screening	236
	Reverse T3	237
	Unbound thyroid hormones	238
	Urinary hormones	240
	Serum levels in health and disease	241
	Serum binding of thyroid hormones	241
	Recent technical advances	242
	Steroid Hormones	243
	Cortisol and its analogs	243
	Clinical aspects	243
	Analytical aspects	245
	Free cortisol assays	247
	Other cortisol metabolites	247
	Mineralocorticoids	247
	Androgens	250
	Clinical aspects	250
	Analytical aspects	251
	17-α-Hydroxyprogesterone	251
	Progestins	252
	Estrogens	
	Studies in nonpregnant subjects	253
	Estrogens in pregnancy	253 256
	Catecholamines	259
	Vitamin D-Related Compounds	260
	References	262

	Janakiraman Ramachandran	
	Hormones of Group 1	273
	Structure and function	273
	γ-MSH and the aminoterminal fragment of POMC	273
	ACTH and CLIP	274
	The melanotropins	275
	LPH and EP	273
		277
	Biosynthesis	
	Biological studies	278
	Metabolism	278
	Regulation of fetal adrenocortical function	278
	Regulation of aldosterone secretion	280
	Clinical studies	281
	Plasma levels in health and disease	281
	Secretion from pituitary and ectopic	282
	tumors	
	Hormones of Group 2	283
	Structure and function	283
	Biological and clinical studies	285
	Size heterogeneity	285
	Regulation of cell proliferation	286
	Hormones of Group 3	287
	Structure and function	287
	Lutropin (LH)	287
	Chorionic gonadotropin (CG)	288
	Follitropin (FSH)	289
	Thyrotropin (TSH)	289
	Biological and clinical studies	290
	References	291
Chapter 10	Biochemical Aspects of Genetic Disease M. Alan Chester, Arne Lundblad and Per-Arne Öckerman	
	Turkundunakian	207
	Introduction	297
	Methods of general interest	297 297
	Prenatal diagnosis	
	Electron microscopy	298
	Glycogenoses	298
	General	298
	Glycogen storage disease type I (GSD I)	299
	Glycogen storage disease type II (GSD II)	299
	Other glycogenoses	299
	Galactosemia	300
	Mucopolysaccharidoses (MPS)	301
	MPS I (Hurler and Scheie)	301
	MPS II (Hunter)	301
	MPS III (Sanfilippo)	301
	MPS IV (Morquio)	302
	MPS VI (Maroteaux-Lamy)	302

Chapter 9 Biochemistry of Pituitary Hormones

#### xx Contents

	Other diseases involving GAG metabolism	303
	Methods	303
	Ehlers-Danlos Syndrome (EDS)	303
	Oligosaccharides	304
	Aspartylglucosaminuria	304
	Fucosidosis	304
	Mannosidosis .	304
	Sialidoses and Mucolipidoses	305
	Sialidosis and mucolipidosis I	305
	Mucolipidosis II and III (MLII and MLIII)	306
	Mucolipidosis IV	307
	Sphingolipidoses	307
	Nieman-Pick disease (NPD)	. 307
	Gaucher disease (GD)	307
	Krabbe disease (KD)	309
	GM <sub>1</sub> -gangliosidosis (GM <sub>1</sub> G)	309
	Anderson-Fabry disease (AFD)	311
	Metachromatic leucodystrophy (MLD)	311
	Methods	312
	Multiple sulphatidosis (MS)	312
	Steroid sulphatase deficiency and	312
	X-linked ichthyosis	
	Disorders of Amino Acid Metabolism	313
	Phenylketonuria and related disorders	313
	Urea cycle deficiencies	314
	Treatment	314
	Ornithine carbamoyltransferase (OCT)	314
	deficiency	314
	Gyrate atrophy of the choroid and retina	314
	Organic Acidurias	314
	Introduction	314
	Isovaleric acidemia	315
	3-Methylcrotonylglycinemia	315
	Propionic and methylmalonic acidemia	315
	Glutaric acidemia	316
	Dicarboxylic aciduria	316
	Carnitine deficiency	316
	Cystic Fibrosis (CF)	
		316
	Diagnosis	317
	Clinical aspects	317
	Pathogenesis	318
	Duchenne Muscular Dystrophy (DMD)	319
	Clinical aspects	320
	Genetics	320
	Diagnosis	320
	Pathogenesis	320
	References	321
Chapter ll	Toxicology and Therapeutic Drug Monitoring $Peter\ I\ Jatlow$	
	Introduction	341
	Fluorescence Immunoassay	342
	Automation	343

	Fast LC	344
	Prep TM I	345
	Appraisal of automated systems	347
	Lidocaine Immunoassay	347
	Phenytoin and its Metabolites	348
	Enzyme immunoassay in uremia	348
	p-Hydroxyphenylhydantoin (HPPH)	349
	Methotrexate	350
	Available assays	350
	Trimethoprim interference	351
	High pressure liquid chromatography	352
	Automation	353
	Valproic Acid - Phenobarbital Interaction	354
	Protein Binding	355
	Improved Vacutainers	357
	Analysis of Diuretics	358
	Psychotherapeutic Drugs	358
	Tricyclic antidepressants	358
	Hydroxylated metabolites of the	360
	tricyclic antidepressants	
	Haloperidol	362
	Ethylene Glycol Poisoning	364
	Resin Hemoperfusion in Ethchlorvynol	367
	Overdose	
	Benzodiazepine Overdose	369
	References	370
Chapter 12	Lipoproteins: Their Role in Enzyme Regulation D.J. Galton, J. Stocks and P.M. Dodson	
	Canada Tuba laskia	
	General Introduction	377
	Role of lipoproteins in lipid transport	377
	Catabolism of lipoproteins	378
	Enzyme regulation	378
	Nomenclature of the apoliproteins	380
	A-Apoproteins	381
	Structure and synthesis	381
	Regulation of LCAT	382
	Clinical disorders associated with	383
	A-apoproteins	202
	Primary disorders: Tangier disease	383
	Apo-A mutants	
	Apo-A mutants	383
	B-Apoproteins	384
	B-Apoproteins Structure and metabolism	384 384
	B-Apoproteins Structure and metabolism The intracellular regulation of	384
	B-Apoproteins Structure and metabolism The intracellular regulation of cholesterol synthesis	384 384 384
	B-Apoproteins Structure and metabolism The intracellular regulation of cholesterol synthesis The LDL receptor	384 384 384 386
	B-Apoproteins Structure and metabolism The intracellular regulation of cholesterol synthesis The LDL receptor Clinical disorders associated with	384 384 384
	B-Apoproteins Structure and metabolism The intracellular regulation of cholesterol synthesis The LDL receptor Clinical disorders associated with Apo B	384 384 384 386 387
	B-Apoproteins Structure and metabolism The intracellular regulation of cholesterol synthesis The LDL receptor Clinical disorders associated with Apo B Primary disorders: abetalipoproteinemia	384 384 384 386 387
	B-Apoproteins Structure and metabolism The intracellular regulation of cholesterol synthesis The LDL receptor Clinical disorders associated with Apo B	384 384 384 386 387

#### xxii Contents

	C-Apoptoceins	385
	Structure and metabolism	389
	Apo-C-1: regulation of LCAT	389
	Apoliprotein C-II: regulation of	390
	lipoprotein lipase	
	Enzyme regulation	390
	Structure-function studies	391
	Clinical disorders associated with	391
	apo C-II	391
	Primary defects	202
		391
	Secondary defects	392
	Apolipoprotein C-III	393
	Clinical disorders associated with  Apo C-III	394
	Apo C-III-0	394
	Apo C-III-2	395
	Diabetes mellitus	395
	Studies in man	395
	Chronic renal failure	396
	E-Apoprotein	397
	Structure and metabolism	397
	Clinical disorders associated with	
	E-apoproteins	399
	Primary defects - type III hyperlipidemia	399
	Conclusions	400
	References	400
Chapter 13	Hepatobiliary Disease Richard P.H. Thompson and James Marigold	
	Bilirubin	407
	Measurement of bilirubin in blood	407
	Physiology of bilirubin	
		409
	Unconjugated bilirubin in blood	411
	Bilirubin conjugates	413
	Bilirubin isomers	414
	Markers of Viral Hepatitis	414
	Hepatitis A	414
	Hepatitis B	415
	Hepatitis non-A, non-B	418
	Bile Acids	419
	Aminopyrine	422
	Autoimmune Antibodies	423
	Serum Enzymes	423
	Miscellaneous	424
	References	425
Chapter 14	Plasma Proteins	
	Roberta G. Reed and Theodore Peters, Jr.	
	Introduction	435
	Protein Assays	435
	Serum proteins	435
	Cerebrospinal fluid proteins	436
	Urinary proteins	437
	1 A	437