

577.1(075)
T-93

BIOLOGICAL CHEMISTRY

Yu. Gubsky

NK
PUBLISHERS



543683

UDC 577.1(075)

G93

Р93

Recommended by the High Scientific Board of the National University as a textbook for students of medical and pharmaceutical faculties of higher educational establishments of Ukraine (Report № 17 of 20.05.2016)

Recommended by the Central Commission of Experts in Biological and Medical Chemistry of Health Ministry and National Academy of Medical Sciences of Ukraine as a textbook for students of medical and pharmaceutical faculties of higher educational establishments of Ukraine (Letter № 23 of 14.04.2016)

Author:

Gubsky Yuriy I. – DSci, Professor, Corresponding Member of National Academy of Medical Sciences of Ukraine, Head of Research and Organizational Department, Presidium, NAMS of Ukraine

Reviewers:

Komisarenko Serhiy V. – DSci, Professor, Full Member (Academician) of National Academy of Sciences and National Academy of Medical Sciences of Ukraine, Director of O. Palladin Institute of Biochemistry, NAS of Ukraine.

Nizhenkovska Iryna V. – DSci, Professor, Head of Pharmaceutical, Biological and Toxicological Chemistry Department, O. O. Bogomolets National Medical University.

Erstenyuk Hanna M. – DSci, Professor, Head of Medical and Biological Chemistry Department, Vice-Rector of Ivano-Frankivsk National Medical University.

Gubsky Yu.

G93

Biological chemistry = Біологічна хімія : textbook / edited by Yu. Gubsky. – Vinnytsia : Nova Knyha, 2018. – 2nd edition. – 488 p.

ISBN 978-966-382-697-4

The textbook in Biological Chemistry consists of 30 chapters made up of text material and plentiful illustrations, including chemical formulas, reaction equations, drawings depicting complicated intracellular transformations of biomolecules, and metabolic "charts".

The textbook is intended for students of medical and pharmaceutical faculties of higher educational establishments of Ukraine.

UDC 577.1(075)

Підручник з біологічної хімії складається з 30 розділів і містить текстові матеріали та велику кількість ілюстрацій, у тому числі хімічні формули, реакції та їх рівняння, рисунки складних внутрішньоклітинних перетворень біомолекул і метаболічні "схеми".

Підручник призначений для студентів медичних та фармацевтичних факультетів вищих навчальних закладів України.

ISBN 978-966-382-697-4

© Gubsky Yu., 2018

© Nova Knyha, 2018



CONTENTS

PREFACE	10
----------------------	----

Part 1. BIOMOLECULES. CELLS. METABOLISM

Chapter 1. BIOCHEMISTRY: BIOMOLECULES, METABOLISM.....	13
1.1. Biochemistry as fundamental biomedical science.....	13
1.2. Biomolecules – major classes, representatives	14
Chapter 2. PROTEINS. AMINO ACIDS. PEPTIDES.....	19
2.1. Amino acids: structure, properties.....	19
2.2. Peptide bonds, polypeptides	24
2.3. Proteins. Levels of protein structure.....	28
Chapter 3. NUCLEIC ACIDS. NUCLEOTIDES. DNA. RNA	36
3.1. Nucleic acids and the flow of genetic information	36
3.2. Nucleotides: structure, biological functions	37
3.3. Nucleic acids as polynucleotides: DNA, RNA	42
Chapter 4. CARBOHYDRATES. SUGARS AND THEIR DERIVATIVES.....	46
4.1. Monosaccharides. Hexoses. Pentoses. Amino sugars	47
4.2. Oligosaccharides. Homopolysaccharides	49
4.3. Heteropolysaccharides. Glycoproteins	53
Chapter 5. LIPIDS. FATTY ACIDS. BIOMEMBRANES	57
5.1. General characteristics of lipids. Biological functions	57
5.2. Fatty acids: structure and properties	58
5.3. Structure and properties of special classes of lipids	61
5.4. Steroids: cholesterol, bile acids, steroid hormones	67
Chapter 6. CELLS. METABOLISM: GENERAL ASPECTS	71
6.1. Metabolism: overall conception, metabolic pathways	71
6.2. Cells. Compartmentalization of metabolic pathways.....	72

Part 2. ENZYMES. GENERAL METABOLIC PATHWAYS

Chapter 7. METABOLISM. ENZYMATIC REACTIONS	77
---	----

7.1. Metabolism: general conceptions, metabolic pathways.....	77
7.2. Enzymes as the principal molecular devices of metabolism	80
7.3. Enzyme nomenclature and classification.....	84
7.4. Molecular mechanisms of enzyme catalysis	91
Chapter 8. COENZYMES. CONTROL OF ENZYMATIC REACTIONS	94
8.1. Coenzymes: classification, structure. Vitamins as coenzyme precursors	94
8.2. Kinetics of enzyme catalysis. Michaelis – Menten theory.....	99
8.3. Inhibition of enzymes. Kinds of inhibitors	103
8.4. Enzymic catalysis regulatory mechanisms	107
Chapter 9. BIOENERGETICS-1. CATABOLIC PATHWAYS.TRICARBOXYLIC ACID CYCLE	114
9.1. Bioenergetics. ATP and other high-energy compounds	114
9.2. Overview of catabolic pathway steps	116
9.3. Tricarboxylic acid cycle: overview	117
9.4. Tricarboxylic acid cycle: reactions and enzymes	118
Chapter 10. BIOENERGETICS-2. MITOCHONDRIAL ELECTRON TRANSPORT. OXIDATIVE PHOSPHORYLATION	124
10.1. General notions of free energy transfer in biochemical systems	124
10.2. Electron transport chain in mitochondria.....	126
10.3. Oxidative phosphorylation. ATP synthase	131

Part 3. METABOLISM OF MAJOR CLASSES OF BIOMOLECULES

Chapter 11. CARBOHYDRATE METABOLISM-1. PATHWAYS OF GLUCOSE OXIDATION	137
11.1. Major routes of carbohydrate metabolism.....	137
11.2. Aerobic and anaerobic oxidation of glucose. Glycolysis.....	139
11.3. Enzymatic reactions of glycolysis. Regulation of glycolysis	140
11.4. Aerobic oxidation of glucose. Oxidative decarboxylation of pyruvate.....	149
11.5. Pentose phosphate pathway	150
Chapter 12. CARBOHYDRATE METABOLISM-2. GLYCOGEN METABOLISM. GLUCONEOGENESIS	156
12.1. Glycogen metabolism. Glycogen-storage diseases	156
12.2. Gluconeogenesis: reactions, regulation	167

12.3. Regulation of carbohydrate metabolism	172
12.4. Control of blood plasma glucose. Diabetes mellitus.....	174
Chapter 13. LIPID METABOLISM-1. TRIACYLGLYCEROL CATABOLISM.	
OXIDATION OF FATTY ACIDS. KETOGENESIS	177
13.1. Lipids: general characteristics, biological functions	177
13.2. Fat metabolism: overview, lipolysis	179
13.3. Degradation of fatty acids (β -oxidation)	182
13.4. Ketone bodies. Ketogenesis in diabetes mellitus	188
Chapter 14. LIPID METABOLISM-2. LIPOGENESIS. CHOLESTEROL	
METABOLISM. LIPID METABOLISM PATHOLOGY	193
14.1. Biosynthesis of fatty acids: reactions, enzymes	193
14.2. Biosynthesis of acylglycerols: triglycerides, phosphoglycerides.....	197
14.3. Sphingolipids: representatives, metabolism	201
14.4. Cholesterol synthesis and biotransformation. Atherosclerosis	207
Chapter 15. AMINO ACID METABOLISM-1. AMINO ACID DEGRADATION:	
DEAMINATION, TRANSAMINATION, DECARBOXYLATION. UREA CYCLE	213
15.1. Protein turnover. Principal pathways of amino acid metabolism	213
15.2. Transamination of amino acids: reactions, enzymes.....	216
15.3. Deamination of amino acids: reactions, enzymes.....	220
15.4. Decarboxylation of amino acids: reactions, biological significance.....	221
15.5. Amino nitrogen metabolism. Urea cycle: reactions, enzymes.....	223
Chapter 16. AMINO ACID METABOLISM-2. AMINO ACID SPECIALIZED	
METABOLIC PATHWAYS. PORPHYRIN METABOLISM	228
16.1. General pathways of amino acids carbon skeleton degradation	228
16.2. Specialized pathways of individual amino acid metabolism	231
16.3. Amino acids as precursors of biologically important compounds	242
16.4. Diseases associated with abnormal amino acid metabolism.....	244
16.5. Biosynthesis and catabolism of porphyrins. Gout	245
Chapter 17. METABOLISM OF PURINE AND PYRIMIDINE	
NUCLEOTIDES. PURINE DEGRADATION. GOUT	255
17.1. Nucleotides: structure, biochemical functions	255
17.2. Biosynthesis of purine nucleotides	257

17.3. Biosynthesis of pyrimidine nucleotides	263
17.4. Catabolism of purine and pyrimidine nucleotides. Gout	265

Part 4. FUNDAMENTALS OF MOLECULAR BIOLOGY AND GENETICS

Chapter 18. GENE, GENOME. DNA REPLICATION	270
18.1. Gene, genome. DNA, RNA: structure, properties	270
18.2. Telomeres. Telomerase	281
18.3. DNA technologies	284
Chapter 19. mRNA TRANSCRIPTION. RIBOSOMAL TRANSLATION	288
19.1. mRNA. Transcription: enzymes, mechanisms	288
19.2. Genetic code. Translation in ribosomes	291
19.3. Ribosomal molecular machinery	293

Part 5. METABOLIC CONTROL. HORMONES AND VITAMINS

Chapter 20. HORMONES-1. BIOCHEMICAL AND CELLULAR MECHANISMS OF HORMONAL REGULATION	301
20.1. Hormones: general definitions	301
20.2. Basic principles of hormone effects	303
Chapter 21. HORMONES-2. HORMONES OF PEPTIDE AND PROTEIN NATURE	308
21.1. Peptide and protein hormones of hypothalamus and hypophysis	308
21.2. Protein hormones of pancreatic gland	321
Chapter 22. HORMONES-3. AMINO ACID DERIVED HORMONES: CATECHOLAMINES, THYREOIDS. LIPOPHILIC HORMONES	327
22.1. Catecholamines and other biogenic amines	327
22.2. Thyroid hormones: representatives, pathology	331
22.3. Steroid hormones: representatives, effects, pathology	335
22.4. Hormonal regulation of calcium homeostasis	342
22.5. Eicosanoids. Biomedical and pharmacological aspects	346
Chapter 23. BIOCHEMISTRY OF NUTRITION-1. VITAMINS AS ESSENTIAL COMPONENTS OF HUMAN DIET. WATER-SOLUBLE VITAMINS	350
23.1. Biochemistry of nutrition. Components of human diet	350
23.2. Vitamins: basic definitions, classes of vitamins	352

23.3. Water-soluble vitamins. Vitamins as coenzymes: structure, biochemical properties.....	353
---	-----

Chapter 24. BIOCHEMISTRY OF NUTRITION-2. VITAMIN C.

LIPID-SOLUBLE VITAMINS AS BIOREGULATORS AND ANTOXYDANTS	367
24.1. Vitamin C (ascorbic acid)	367
24.2. Vitamin A (retinol): structure, biochemical functions.....	370
24.3. Vitamin D (calciferol) as calcium and phosphorous homeostasis regulator ...	373
24.4. Vitamin E (tocopherol) as principal antioxidant in human body.....	375
24.5. Vitamin K: structure of vitamers. Role in blood clotting.	377

**Part 6. BIOCHEMISTRY OF SPECIALIZED TISSUES
AND PHYSIOLOGICAL FUNCTIONS**

Chapter 25. BIOCHEMISTRY OF BLOOD. HEMOSTASIS. COAGULATION

CASCADE SYSTEM	380
25.1. Blood: composition, biochemical functions.....	380
25.2. Hemoglobin: transport of oxygen. Hemoglobinopathies	382
25.3. Hemostasis: blood clotting, fibrinolysis.	389

**Chapter 26. BIOCHEMISTRY OF SPECIALIZED CELLS AND PHYSIOLOGICAL
FUNCTIONS. BIOCHEMISTRY OF LIVER. METABOLISM OF XENOBIOTICS.**

26.1. Liver: survey of major biochemical functions	398
26.2. Liver: metabolism of heme and bile pigments. Bilirubin transformation. Icterus	403
26.3. Liver detoxification function. Biotransformation of xenobiotics and endogenous waste products	408

Chapter 27. BIOCHEMISTRY OF TOOTH AND SALIVA

27.1. Anatomy and physiology of human teeth	415
27.2. Biochemical composition and molecular organization of dental tissues... .	417
27.3. Tooth enamel: properties, biochemical composition	417
27.4. Dentin: structure, biochemistry. Periodontum. Cementum	420
27.5. Tooth pulp: physiology, metabolism	426

27.6. Tooth pathology. Caries: biochemical aspects	427
27.7. Biochemical components and functions of saliva.....	428
Chapter 28. BIOCHEMISTRY OF MUSCLES. MOLECULAR PHYSIOLOGY OF MUSCLE CONTRACTION.....	430
28.1. Muscle tissue: general characteristics of functions, structure and biochemistry	430
28.2. Sliding filament model of muscle contraction. Role of calcium in muscle contraction control	440
28.3. Regulation of muscle contraction. Role of calcium in muscle contraction control.....	444
Chapter 29. BIOCHEMISTRY AND MOLECULAR PATHOLOGY OF CONNECTIVE TISSUE	446
29.1. Connective tissue: cells and biomolecules	446
29.2. Structural and adhesive proteins of connective tissue. Structural proteins of extracellular matrix	450
29.3. Biochemistry of extracellular matrix. Glycosaminoglycans and proteoglycans of connective tissue	457
29.4. Molecular pathology of connective tissue	462
Chapter 30. BIOCHEMISTRY OF SPECIALIZED CELLS AND PHYSIOLOGICAL FUNCTIONS. BIOCHEMISTRY OF NERVE TISSUE AND NEUROTRANSMITTERS... .	466
30.1. Nerve tissue: general characteristics of structure and functions	466
30.2. Peculiarities of brain biochemical composition and metabolism.....	469
30.3. Neurotransmitters: classification, receptors, representatives	470
30.4. Drugs, neurotransmitters and synapses.....	483
LIST OF REFERENCES	487