Biochemistry with elements of chemistry

1. IMPRINT

Academic Year	2026/2027
Department	Faculty of Medicine and Dentistry
Field of study	English Dentistry Division
Main scientific discipline	Medical sciences
Study Profile	General academic
Level of studies	Uniform Msc
Form of studies	Full-time studies
Type of module / course	Obligatory
Form of verification of learning outcomes	Exam after IV semester
Educational Unit / Educational Units	Chair and Department of Biochemistry, Faculty of Medicine 02-097 Warsaw, ul. Banacha 1 Phone: +48 (22) 57 20 693 e-mail: biochemia@wum.edu.pl https://biochemia.wum.edu.pl
Head of Educational Unit / Heads of Educational Units	Professor Marta Struga, MD, PhD
Course coordinator	Professor Marta Struga, MD, PhD; marta.struga@wum.edu.pl Phone: +48 (22) 57 20 693
Person responsible for syllabus	Ewa Usarek, PhD; ewa.usarek@wum.edu.pl

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2. BASIC INFORMATION

Year and semester of studies	II year, III and IV semester	**Number of ECTS credits**	7.00

FORMS OF CLASSES **Contacting hours with academic teacher**	**Number of hours**	**ECTS credits calculation**
Lecture (L)	35	1.4
Seminar (S)	35	1.4
Discussions (D)		
e-learning (e-L)		
Practical classes (PC)	50	2.1
Work placement (WP)		
Unassisted student's work		
Preparation for classes and completions	50	2.1

3. COURSE OBJECTIVES

O1	To develop a solid understanding of the structures, properties, and metabolism of substances present in the body: proteins, carbohydrates, lipids, nucleic acids, vitamins, hormones; control and integration of metabolic pathways.
O2	To give insight into understanding how metabolic processes can contribute to an explanation of pathological phenomena.
O3	To give the students experience in biochemical methodology to appreciate the clinical biochemistry techniques as diagnostic tools, and to be able to interpret the results for appropriate diagnosis and follow-up of patients.

4. STANDARDS OF LEARNING – DETAILED DESCRIPTION OF EFFECTS OF LEARNING

Code and number of effect of learning in accordance with standards of learning	Effects in time
Knowledge – Graduate* knows and understands:	
B.W1.	role of primary and trace elements in the body's processes, including their supply, absorption, and transport;
B.W2.	role of electrolytes, buffers, and chemical reactions in biological systems;
B.W3.	biochemical basis of human body integrity;
B.W4.	structure and functions of main chemical compounds present in the human body, in particular the properties, functions, metabolism and reaction energy of proteins, nucleic acids, carbohydrates, lipids, enzymes, and hormones;
B.W5.	principles of calcium and phosphate balance;
B.W6.	role and importance of body fluids, including saliva;
B.W19.	acid-base balance and oxygen and carbon dioxide transport in the body;
B.W20.	enzymes involved in the digestive process, the mechanism of hydrochloric acid production in the stomach, the role of bile, the process of absorption of the products of digestion;
B.W21.	principles of metabolism and nutrition;
Skills– Graduate* is able to:	
G.S1	-

5. ADDITIONAL EFFECTS OF LEARNING

Number of effect of learning	Effects of learning i time
Knowledge – Graduate knows and understands:	
W1	basic biochemical laboratory techniques;
Skills– Graduate is able to:	
B.U4	relate chemical phenomena to oral processes;

B.U5	determine the pH of a solution and the effect of pH changes on inorganic and organic compounds;
B.U6	operate simple measuring instruments and assess the accuracy of the measurements taken;
Social Competencies – Graduate is ready for:	
K1	-

6. CLASSES

Form of class	Class contents	Effects of Learning
Lecture	L1 – Lecture 1 - Basics of chemistry Properties of water. Acid-base balance, pH. Buffers. Basics of organic chemistry (structure of hydrocarbons, aromatic compounds, alcohols, ethers, aldehydes, ketones, carboxylic acids, esters, amines, amides). Redox reactions.	B.W1., B.W2., B.W19.
	L2 – Lecture 2 – Proteins Amino acids and proteins structures, classification, and functions. Examples of peptides and proteins. Denaturation and coagulation of proteins.	B.W1., B.W3., B.W4.
	L3 – Lecture 3 - Enzymes Classification of enzymes. Mechanism of enzymatic reaction. Enzyme structure. Regulation of enzymatic activity. Inhibition. Specificity.	B.W2., B.W4.
	L4 – Lecture 4 - Structure of nucleic acids, DNA replication Structure and components of nucleoside and nucleotide. DNA and RNA – comparison. Genome organization. Mechanism of DNA replication in procaryotic and eucaryotic cells.	B.W2., B.W4.
	L5 – Lecture 5 - Transcription, translation Gene expression – the central dogma of molecular biology. Transcription and translation – mechanism, enzymes, substrates, inhibitors.	B.W2., B.W4.
	L6 – Lecture 6 - Tissue oxidation ATP as a high energy compound. The role of NAD and FAD in catabolism and anabolism. Cellular respiration: stages and reactions. Synthesis of ATP: substrate level phosphorylation and oxidative phosphorylation. The role and structure of mitochondrial electron transport chain.	B.W4., B.W.
	L7 - Lecture 7 - Carbohydrates metabolism – part 1. Carbohydrates – classification and functions. Digestion of carbohydrates. Glycolysis. Fates of pyruvate. Gluconeogenesis. Pentose phosphate pathway.	B.W4., B.W., B.W20.
	L8 - Lecture 8 - Carbohydrates metabolism – part 2. Biosynthesis of "active glucose" (UDPG). Glycogen structure, storage, and metabolism (glycogenesis, glycogenolysis). Glycogen storage defects. Galactose and fructose metabolism and metabolic disorders. Diabetes mellitus.	B.W4., B.W.
	L9 – Lecture 9 - Lipids metabolism – part 1. Lipids: classification, structures, and functions. Digestion of lipids and absorption from the gastrointestinal tract (chylomicrons). Biosynthesis of triacylglycerols in the liver and in the adipose tissue. Hormonal regulation of lipolysis in adipose tissue. Oxidation of fatty acids - generation of ATP. Ketogenesis. Fatty acids biosynthesis. The central role of acetyl-CoA in metabolism.	B.W4., B.W., B.W20.
	L10 – Lecture 10 - Lipids metabolism – part 2. Phospholipids, sphingolipids, prostaglandins – structure and biosynthesis. Steroid metabolism (synthesis and degradation of cholesterol). Steroid hormones. Synthesis and function of vitamin D. Blood lipoproteins.	B.W4., B.W.
	L11 – Lecture 11 - Protein turnover, digestion. Ureogenesis. Amino acids metabolism Nitrogen balance. Metabolism of amino acids. Nitrogen metabolism – ureogenesis. Amino acids as substrates for the synthesis of physiologically active products.	B.W4., B.W., B.W20.
	L12 – Lecture 12 – Blood Red blood cell metabolism. Participation of hemoglobin in the transport of oxygen and carbon dioxide. Heme synthesis and degradation in physiological and pathological states. Acid-base balance regulation.	B.W2., B.W6., B.W19.

	L13 – Lecture 13 - Mineral metabolism: calcium, phosphate, fluoride. Hormones Metabolic importance of macrominerals and trace minerals. Types of hormones and their mechanism of action.	B.W1., B.W4., B.W5., B.W21.
	L14 - Lecture 14 - Vitamins Metabolic role of water-soluble and lipid-soluble vitamins. Symptoms of deficiency.	B.W4., B.W21.
	L15 – Lecture 15 - Biochemistry of the oral cavity. Saliva. Types of saliva and salivary glands. Saliva formation steps. General features of saliva. Stimulation of saliva secretion. Components (inorganic, organic) and pH of saliva. Functions of saliva (protection, digestion, speaking). The role of enzymes and proteins. Saliva in preventing dental cavities. Salivary glands. Hyper- and hyposalivation states. Saliva as a fluid of diagnostic importance (examples of oral tests).	B.W1., B.W3., B.W5., B.W20., B.U4.
	L16 – Lecture 16 – Summary of the metabolism	B.W3., B.W21.
Seminar	S1 – Seminar 1 -Basics of chemistry, calculations Conversion of basic units (mass, volume). Different concentration expression methods (calculations of percent concentration and molarity, concentration conversion). Definition of pH, calculations.	B.W2., B.U5.
	S2 – Seminar 2 – Proteins Amino acids structure, classification, and properties. Isoelectric point of amino acids and proteins. Proteins classification and functions. Structure of proteins (primary, secondary, tertiary, quaternary). Structure of myoglobin and hemoglobin. Physiological and pathological types of hemoglobin. Collagen – structure and synthesis. Denaturation and coagulation of proteins.	B.W1., B.W3., B.W4.
	S3 – Seminar 3 - Enzymes General characteristic of enzymes. Exergonic and endergonic reactions. Coenzymes and prosthetic groups. Classification. Mechanism of enzyme action (energy changes, enzyme specificity, active site, enzyme-substrate interactions). Factors affecting reaction velocity (enzyme and substrate concentrations, enzyme affinity for substrate, temperature, pH, modulators). Types of inhibition. Regulation of enzyme activity. Isoenzymes.	B.W2., B.W4.
	S4 - Seminar 4 - Structure of nucleic acids, replication, transcription, translation Nucleotides and nucleosides structure. DNA and RNA primary and secondary structures. Cellular organization of DNA - chromatin structure. DNA replication (mechanism, enzymes, role of telomeres, inhibitors). Transcription (mechanism, enzymes, inhibitors). Protein synthesis (genetic code, ribosomes, posttranslational modification of proteins, inhibitors)	B.W4.
	S5 – Seminar 5 - Tissue oxidation: TCA cycle, electron transport chain, oxidative phosphorylation Localization of the electron transport chain, oxidative phosphorylation, and Krebs cycle. Organization of the electron transport chain (protein complexes). Inhibitors of electron transport. 4. Mechanisms of oxidative phosphorylation - chemiosmotic hypothesis. Oxidative decarboxylation of pyruvate. Krebs cycle (reactions, role, regulation).	B.W4., B.W21.
	S6 – Seminar 6 - Carbohydrates metabolism Chemical structure of carbohydrates. Glucose metabolism (glycolysis, gluconeogenesis, pentose phosphate pathway). The central role of glucose-6-phosphate in carbohydrates metabolism. Biosynthesis and use of "active glucose" (UDPG). Glycogen synthesis (glycogenesis) and degradation (glycogenolysis). Metabolic importance of glucuronic acid. Galactose and fructose metabolism.	B.W4., B.W20., B.W21.
	S7 – Seminar 7 - Lipids metabolism Lipids classification and structure (fatty acids, triacylglycerols, glycerophospholipids, sphingolipids). Lipids digestion and absorption from the gastrointestinal tract. Biosynthesis of triacylglycerols in the liver and adipose tissue. Hormonal regulation of lipolysis in adipose tissue (effect of insulin and epinephrine). Degradation of fatty acids (ß-oxidation, ATP generation). Ketogenesis. Fatty acids biosynthesis. Steroids metabolism (cholesterol, bile acids, steroid hormones, vitamin D3. Blood lipoproteins (chylomicrons, VLDL, LDL, HDL). The central role of acetyl-CoA in lipids metabolism.	B.W4., B.W20., B.W21.
	S8 – Seminar 8 - Ureogenesis, amino acids metabolism Biologically active non-protein nitrogen compounds. Nitrogen balance. Essential and non-essential amino acids. Glucogenic and ketogenic amino acids. Amino acid decarboxylation. Amino acid nitrogen metabolism (transamination, oxidative	B.W4., B.W20, B.W21.

	deamination, ureogenesis. Metabolism of individual amino acids – synthesis of physiologically active products (Arg, Gly, Ser, Met, Cys, Phe, Tyr, Trp). Defects in amino acid metabolism (phenylketonuria, albinism).	
	S9 – Seminar 9 – Blood Functions of blood. Plasma chemical components (proteins, glucose, lipids, ions). Diagnostic enzymes. Hemoglobin (types of hemoglobin, transport of oxygen and carbon dioxide - mechanism and regulation). Heme (structure and degradation, bilirubin circulation, jaundice). Transport of CO_2 in the blood. Maintenance of acid-base balance. Acidosis and alkalosis	B.W2., B.W6., B.W19.
	S10 – Seminar 10 - Metabolism of vitamins and minerals Vitamins: definition, classification. Water-soluble vitamins: structure, physiological function, symptoms of deficiency (thiamine, riboflavin, niacin, pantothenic acid, pyridoxine, biotin, folic acid, cobalamin, vitamin C). Lipid-soluble vitamins: structure, physiological function, symptoms of deficiency (vitamin A, vitamin D3, vitamin K, vitamin E). Hormone-like function of vitamin A and vitamin D3. 4. Physiological function of minerals (Ca, P, Na, Cl, K, S, Fe, Cu, Mg, I, F, Zn, Mn, Cr, Mo, Co, Se).	B.W1., B.W3., B.W4., B.W5., B.W21.
	S11 – Seminar 11 - Hormones Mechanism of action and metabolic effects of peptide hormones (insulin, glucagon, PTH), amino acid derived hormones (T4, T3, epinephrine), steroid hormones (glucocorticoids, mineralocorticoids, androgens, estrogens).	B.W3., B.W4., B.W21.
Practical class	PC1 – Practical class 1 - Biochemical calculations Calculations – practical tasks (percent concentration, molarity). Calculation of pH. Calculation of enzymatic activity (international unit, specific activity, concentrations of activity).	B.W2., B.U5.
	PC2 - Practical class 2 - Proteins Amino acids structures. Structure and conformation of proteins. Detection of proteins. Determination of protein concentration. Methods of protein separation and identification. Denaturation and precipitation (coagulation) of proteins. Blood plasma proteins: concentration, structure, properties, methods of separation, physiological function. Isoelectric point determination.	B.W4., W1, B.U6.
	PC3 - Practical class 3 - Enzymes Enzyme structure (characteristic of apoenzyme, coenzyme, and prosthetic group). Mechanism of enzyme catalysis (enzyme specificity, active site). Classification of enzymes. Methods of enzyme activity determination and calculation (units of enzyme activity). Isoenzymes.	B.W4., W1, B.U6.
	PC4 - Practical class 4 - Carbohydrates Carbohydrates: biological role in humans. Starch: structure and digestion. Glucose: metabolism and regulation of blood level. Glycogen: structure and metabolism. Glycogen storage diseases. Glucose-6-phosphatase and alpha-1,4-glucosidase activity determination.	B.W4., B.W21., W1, B.U6.
	PC5 - Practical class 5 - Lipids Lipids - structure, function, classification, digestion, and solubility in different solvents. Plasma lipids transport – structure, function, and metabolism of lipoproteins. Cholesterol – function, synthesis, degradation. Determination of cholesterol and lipids concentration in blood plasma. The role of bile and bile acids. Gallstones: types, analysis. Steroid hormones - classification. Diagnostic value of 17-ketosteroids determination.	B.W4., B.W21., W1, B.U6.
	PC6 - Practical class 6 - Digestive enzymes. Saliva Components and role of saliva, gastric and pancreatic juices. Proteolytic cleavage as a mechanism of digestive enzymes activation. The enzymatic digestion of carbohydrates, proteins, and lipids. The components and function of bile in lipids digestion. The role of hydrochloric acid. Determination of the acidity of gastric juice. Determination of the enzymatic activity of digestive enzymes (salivary amylase, pepsin, pancreatic lipase)	B.W6., B.W20., B.W21., W1., B.U4., B.U6.
	PC7 - Practical class - Blood Function of blood. The role and detection of blood components and proteins. Hemoglobin (structure, function, methods of determination). Bilirubin detection and role in physiological and pathological states (jaundices). Hemolysis.	B.W6., B.W19., W1, B.U6.
	PC8 - Practical class 8 - Urine constituents Renal threshold. Clearance: definition, methods of determination. Physiological (normal) and pathological (abnormal) constituents of the urine – diagnostic	B.W6., W1, B.U6.

	importance. Detection of protein, glucose, ketone bodies, bilirubin, urobilinogen, and blood is a sample of urine.	
	PC9 - Practical class 9 - Biochemistry all around us Antioxidants detection. Determination of antioxidant potential. Determination of vitamin C concentration. Reducing properties of vitamin C – iodine clock reaction.	B.W21., W1, B.U6.
	PC10 - Practical class 10 - Revision	B.W21., W1., B.U6.

7. LITERATURE

Obligatory

1. Biochemistry Lippincott's Illustrated Reviews, D.R. Ferrier (R.A. Harvey ed.), Wolters Kluwer, Lippincott, Williams & Wilkins, sixth edition.
2. Harpers' biochemistry, R.K. Murray, D.K. Granner, P.A. Mayers, V.W. Rodwell, Appleton & Lange. Last edition.

Supplementary

1. General Chemistry with Qualitative Analysis – Whitten, Davis, Peck, VI ed., Saunders College Publishing, 2000.
2. Introduction to Organic Chemistry – Brown, W.H. Saunders College Publishing, 2000.
3. Biochemistry. L. Stryer, W.H. Freeman & Company, New York.
4. Principles of Medical Biochemistry, G. Meisenberg, W.H. Simmons, Elsevier (online access + interactive extras, studentconsult.com).
5. Medical Biochemistry, J.W. Baynes, M.H. Dominiczak, Elsevier, (online access + interactive extras, studentconsult.com). Last edition.
6. Textbook of Biochemistry with clinical correlations, T.M. Devlin, Willey-Liss, Inc. Last edition.

8. VERIFYING THE EFFECT OF LEARNING

Code of the course effect of learning	Ways of verifying the effect of learning	Completion criterion
B.W1., B.W2., B.W3., B.W4., B.W5., B.W6., B.W19., B.W20., B.W21., B.U4., B.U5.	Continuous assessment during seminars – weekly tests Active discussion during seminars	At least 60% of points Credit by the teacher
	Intermediate assessment tests (3 tests, 40 questions each, test questions with one correct answer). Final exam (test, 75 questions, test questions with one correct answer). Students who fail the final examination are entitled to a second examination attempt and, if necessary, a third examination attempt. Both attempts are conducted during the retake session in September and take the form of a multiple-choice test in which each question has one correct answer.	At least 55% of points
B.W1., B.W2., B.W3., B.W4., B.W5., B.W6., B.W19., B.W20., B.W21., W1, B.U4., B.U5. B.U6.	Continuous assessment during laboratory classes – weekly tests	At least 60% of points
	Written laboratory reports	Credit by the teacher

9. ADDITIONAL INFORMATION

Biochemistry course coordinator: Ewa Usarek ewa.usarek@wum.edu.pl
Practical laboratory classes are held in the laboratory of the Biochemistry Department (Banacha St. 1, the building of the Faculty of Pharmacy, block I, the 1st floor).

Detailed schedules, updates, information, and useful files will be available on the e-learning platform from the beginning of October.

The Student is obligated to:
- attend all lectures, laboratory classes, and seminars (attendance list); being late for over 15 minutes is considered as an absence
- be prepared and participate in discussions during seminars and laboratory classes
- use university e-mail addresses s0xxxxx@student.wum.edu.pl

It is not allowed:
- to copy lab reports, assignments, test or exam answers
- to allow someone else could copy another Student's report/assignments/test/exam
- to use electronic devices to communicate or store data during the test or exam

The Student is entitled to 2 excused absences verified by a written confirmation. Absence due to illness is excused only by a medical note/doctor's certificate. The student should notify the course coordinator within three business days.
Unexcused absences from classes are not allowed and may result in failing the entire course of biochemistry.
Unexcused absence from the intermediate assessment/s or exam means failing.

Students can get the credit for the whole course and take the final exam if she/he credits laboratory classes, seminars, and three assessment tests. Students who don't achieve the credit from seminar or laboratory classes or fail assessment test(s) are allowed two retakes. A student who fails the second retake needs to repeat the course.

Students who fail the final examination are entitled to a second examination attempt and, if necessary, a third examination attempt. Both attempts are conducted during the retake session in September and take the form of a multiple-choice test in which each question has one correct answer.

The final exam and the intermediate assessment tests grading:
0 - 54 % - 2.0
55 - 63 % - 3.0
64 - 73 % - 3.5
74 - 83 % - 4.0
84 - 92 % - 4.5
93 - 100 % - 5.0

The final grade may be increased by additional points in the case of good results of the intermediate tests:
- the average grade 4.75-5.00: 5 points
- the average grade 4.50-4.74: 3 points
- the average grade 4.25-4.49: 2 points

Students may join the Biochemistry Science Club "Explore"; the person responsible: Barbara Żyżyńska-Granica, barbara.zyzynska@wum.edu.pl

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ATTENTION
The final 10 minutes of the last class in the block/semester/year should be allocated to students'
Survey of Evaluation of Classes and Academic Teachers