

# INTERNATIONAL HIGHER SCHOOL OF MEDICINE

## Department of Fundamental disciplines

### SYLLABUS

Biochemistry


2025-2026 academic year

for students of medical faculty

1 course 2nd semester, groups 1-3

Credits: 4 (120 h, including auditorial - 72 h, independent work - 48 h)

- Lecturer:** Zhaparalieva Cholpon Omorbekovna  
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Email: [cholpona0702@gmail.com](mailto:cholpona0702@gmail.com)
- Zoom link for the lectures** <https://us05web.zoom.us/j/2890044155?pwd=SXkxUTNTQncyMnh2V0ZYN2Jlb0NwZz09>  
**Groups: 1-3**
- Practical classes:** Alymkul kyzy Narynkul  
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**Groups: 1-3**
- Venue:** Educational and Morphological Center  
Lev Tolstoy street 114/1  
Room № 301

The Syllabus is considered  
at the meeting of Fundamental Disciplines Department  
Protocol № 1 dated 30.08.2025  
Head of the department  A.M. Satarkulova

**Course objective:** The purpose of mastering the academic discipline "Biochemistry" is to master the fundamentals of classical and modern biochemistry; formation of skills and abilities to work with biochemical equipment, setting up a biochemical experiment and analyzing clinical biochemical parameters for making a preliminary diagnosis based on it.

After study of the discipline the student must:

**Knowledge:** Students should understand the structure and metabolic pathways of key biomolecules in health and disease, the integration and regulation of these pathways, diagnostically important metabolites in tissues and fluids, as well as the principles of laboratory equipment and the basics of modeling biochemical experiments.

**Skill:** Students should be able to search, analyze, evaluate, and apply knowledge to solve professional tasks while effectively using key laboratory equipment in biomedical research.

**Attitude:** Students should possess a solid medical and biological conceptual framework, along with biochemical thinking skills, and be proficient in basic biochemical laboratory methods applied in clinical practice.

**Pre-requisites:** Chemical and biological disciplines of the school educational program.

**Post-requisites:** Pathology, pharmacology, internal medicine, pediatric diseases and medical genetics.

### THEMATIC PLAN OF LECTURES

№	Theme of lecture	Hours	Date
1	Carbohydrates in the body: classification, digestion, absorption, utilization, excretion	2	01.09.25-06.09.25
2	Generation of energy in cells: mechanisms and regulation, and integration of carbohydrate, lipid and protein metabolism in the body	2	08.09.25-13.09.25
3	Disorders of intracellular energy generation	2	15.09.25-20.09.25
4	Glucose homeostasis: regulation and disorders	2	22.09.25-27.09.25
5	Pathology of carbohydrate metabolism. Testing of metabolites of carbohydrate metabolism in clinical practice	2	29.09.25-04.10.25
6	Characteristics of the main lipids in the human body. Digestion, absorption, utilization, isolation. Eicosanoids	2	06.11.25-11.10.25
7	Metabolism of lipoproteins	2	13.18.25-18.10.25
8	Disorders of lipoprotein metabolism: atherosclerosis, metabolic syndrome. Dyslipidemia: classification, causes, laboratory diagnostics	2	20.10.25-25.10.25
9	Pathology of lipid metabolism	2	27.10.25-01.11.25
10	Digestion and absorption of proteins	2	03.11.25-08.11.25
11	Metabolism of nitrogen-containing compounds in the human body	2	10.11.25-15.11.25
12	Structure and functions of haem. Porphyrin Metabolism. Metabolism. Jaundice	2	17.11.25-22.11.25
13	Nucleotide metabolism in the human body: regulation, disorders, laboratory diagnostics. Purines and pyrimidines	2	24.11.25-29.11.25
14	Molecular mechanisms of oncogenesis: biochemical tumor markers and the biochemical basis of cancer therapy	2	01.12.25- 06.12.25
15	Xenobiotics and antioxidants. Oxidative stress and its diagnosis	2	08.12.25-13.12.25
16	Bone remodeling and metabolic diseases of bone tissue	2	15.12.25-20.12.25
17	Biochemistry of the liver. Interpretation of liver function test	2	22.12.25-27.12.25
18	Biochemistry of thyroid gland	2	29.12.25-03.01.26
19	Clinical training		
	<b>Total</b>	<b>36</b>	

### THEMATIC PLAN OF PRACTICAL CLASSES

№	Theme of seminar and laboratory works	Hours	Date
1	Qualitative reactions to carbohydrates	2	01.09.25-06.09.25
2	Stages of intracellular energy generation: glycolysis in various organs and tissues	2	08.09.25-13.09.25
3	Stages of intracellular energy generation: pyruvate dehydrogenase complex, Krebs cycle, oxidative phosphorylation	2	15.09.25-20.09.25

4	Blood glucose estimation: GOD-POD method, glucometer. Interpretations	2	22.09.25-27.09.25
5	Gluconeogenesis. Glycogen metabolism	2	29.09.25-04.10.25
6	Alternative oxidation of glucose (HMP shunt) Minor carbohydrates metabolism	2	06.11.25-11.10.25
7	<b>Assessment # 4</b>	2	13.18.25-18.10.25
8	Lipogenesis. Lipolysis. Oxidation of fatty acids	2	20.10.25-25.10.25
9	Ketone bodies. Cholesterol and TAG metabolism	2	27.10.25-01.11.25
10	Determination of blood cholesterol & TAG.	2	03.11.25-08.11.25
11	<b>Assessment # 5</b>	2	10.11.25-15.11.25
12	Ammonia metabolism: production and detoxification	2	17.11.25-22.11.25
13	Amino acid products (Gly, Phe, Tyr, etc.) and inborn errors; newborn screening	2	24.11.25-29.11.25
14	Testing of glomerular filtration of the kidneys. Determination of urea and creatinine in the blood. Calculation of BUN and GFR	2	01.12.25- 06.12.25
15	<b>Assessment # 6</b>	2	08.12.25-13.12.25
16	Gene expression. Mutations. Regulation and disorders	2	15.12.25-20.12.25
17	Molecular technologies in diagnosis: recombinant DNA, PCR, microarray, FISH, and CRISPR	2	22.12.25-27.12.25
18	<b>Assessment # 7</b>	2	29.12.25-03.01.26
19	Clinical training		
	<b>Total</b>	<b>36</b>	

#### THEMATIC PLAN OF INDEPENDENT WORK OF STUDENTS

Unit	Independent work	Hours	Date
Intracellular generation of energy. Carbohydrate metabolism	1) work with tasks on the platform "Proceum" on the topic "Biological oxidation. Carbohydrate metabolism";	2	01.09.25-18.10.25
	2) work with educational literature;	2	
	3) individual assignments (PBL)	2	
	Total	6	
Lipids metabolism	1) work with tasks on the platform "Proceum" on the topic "Lipids metabolism";	2	20.10.25-15.11.25
	2) work with educational literature;	8	
	3) individual assignments (PBL)	2	
	4) Lab.w.: Digestion of nutrients by pancreatic juice	2	
	Total	14	
N-containing compounds metabolism	1) work with tasks on the platform "Proceum" on the topic "Amino acids metabolism"	3	17.11.25-13.12.25
	2) work with educational literature;	10	
	3) individual assignments (PBL)	3	
	Total	16	
Molecular biology. Clinical biochemistry	1) work with tasks on the platform "Proceum" on the topic "DNA, RNA"	2	15.12.25-03.01.26
	2) work with educational literature;	6	
	3) individual assignments (PBL)	2	
	4) Lab.w.: Determination of blood urea	2	
	<b>Total</b>	<b>12</b>	

**Recommended reading for the discipline:****1. Basic:**

1. Ferrier D.R. Lippincott's Illustrated reviews: Biochemistry (7th ed) 2017
2. Champe P.C. Lippincott's Illustrated Reviews: Biochemistry. 2005
3. Satyanaryana U. Biochemistry (5th ed) 2017
4. Murray R.K Harper's Illustrated Biochemistry (26th ed) 2003
5. Satyanaryana U. Biochemistry (2nd ed) 2005
6. Satyanaryana U. Biochemistry (4th ed) 2011
7. Mukhamedova I. Biochemistry practical book 2010
8. DM Vasudevan. Textbook of Biochemistry (4th ed) 2016

**2. Additional:**

1. Satyanaryana U. Biochemistry (6th ed) 2021
2. Chatterjea M.N. Textbook of Medical Biochemistry (8th ed) 2012
3. V.W. Rodwell, D.A. Bender, K.M.Kennely Harper's Biochemistry. (30 ed) 2015

**Grading policy and procedures for all types of work**

For the period of studying the discipline, the student gains points for the relevant parameters (per unit):

current score - 40 points

independent work - 20 points

control score (final assessment of knowledge per unit)- 40 points

Maximum score:  $100 = (40 + 20 + 40)$

**Assessment criteria:****Current academic performance and midterm assessment in the unit:**

Criteria/ Score	Intervals			
	0 – 23	24 – 30	31 – 35	36 – 40
	«Unsatisfactory»	«Satisfactory»	«Good»	«Excellent»
<b>Systematic and comprehensive knowledge regarding the objects of study</b>	Possesses partial and disparate knowledge that is not logically interconnected	Possesses the minimum set of knowledge necessary for a systematic approach to the object of study	Possesses a set of knowledge sufficient for a systematic approach to the object of study	Possesses complete knowledge and a systematic view of the object of study
Criteria/ Score	Intervals			
	0 – 23	24 – 30	31 – 35	36 – 40
	«Unsatisfactory»	«Satisfactory»	«Good»	«Excellent»
<b>Working with information</b>	Unable to find necessary information, or only find fragments of it, within the context of the task.	Can find necessary information within the context of the task.	Can interpret and organize necessary information within the context of the task.	Can find and organize necessary information, as well as identify additional sources of information within the context of the task.
<b>Scientific understanding of the phenomenon, process, or object being studied.</b>	Unable to draw scientifically correct conclusions from available information.	Able to analyze some available information.	Able to conduct a systematic and scientifically correct analysis of the information provided.	Includes new data relevant to the task in the analysis, offers new perspectives on the task.
<b>Mastering standard algorithms for solving professional problems</b>	Able to solve only fragments of a given problem in accordance with a given algorithm	Able to solve a given problem in accordance with a given algorithm	Understands the basics of the proposed algorithm and solves the given problem in accordance with it	Understands the basics of the proposed algorithm and proposes new solutions within the framework of the given problem
<b>Mastering laboratory experiment techniques</b>	Has not mastered the proposed laboratory experiment algorithm and its design.	Conducts the experiment in accordance with the proposed algorithm, but makes errors in presenting the results.	Conducts the experiment in accordance with the proposed algorithm, but makes some errors in presenting the results.	Conducts the experiment in accordance with the proposed algorithm, presents and correctly interprets the results.

Results of independent work				
Criteria/ Score	Intervals			
	0-11	12-14	15-17	18-20
	«Unsatisfactory»	«Satisfactory»	«Good»	«Excellent»
<b>Solution to the assigned problem (Clinical case)</b>	Not independent (rewritten work)	The assigned problem is defined correctly, but the proposed explanation is incorrect.	The solution to the assigned problem is provided correctly and a brief interpretation is given.	The correct solution to the assigned problem is provided, and the analysis and interpretation of the obtained results are presented fully and systematically.
Criteria/ Score	Intervals			
	0-11	12-14	15-17	18-20
	«Unsatisfactory»	«Satisfactory»	«Good»	«Excellent»
<b>Working with information</b>	Unable to find necessary information, or to find individual fragments of it, within the context of the assigned task.	Can find necessary information within the context of the assigned task.	Can interpret and organize necessary information within the context of the assigned task.	Can find and organize necessary information, as well as identify additional sources of information within the context of the assigned task.
<b>Conducting a laboratory experiment</b>	Does not participate in the laboratory experiment, but presents its results.	Conducts the experiment with the assistance of laboratory assistants.	Conducts the experiment independently and only documents the results without interpreting the results.	Conducts the experiment independently in accordance with the proposed algorithm, documents and accurately interprets the results.

**Conduct Policy: (lateness, absence, behavior in the auditorium, late submission of work).**

- Punctuality and completion of tasks.
- Mandatory attendance of classes.
- Attending class in a clean medical uniform.
- Eliminating conversations on a cell phone in the classroom.
- Active participation in the learning process.
- Doing homework on time.
- Academic detention at the time specified by the teacher.

For violations of the Conduct Policy, the total points for discipline might be reduced to 1-10 points.

**Academic Ethics Policy.**

- Be tolerant, respect the opinions of others.
- Formulate objections in the correct form.
- Constructively support feedback in all classes.
- Plagiarism and other forms of dishonest work are unacceptable. Plagiarism includes the following: the absence of references when using printed and electronic materials, quotes, thoughts and works of other authors or students.
- For violations of the Academic Ethics Policy, the total points for the discipline may be reduced to 1-10 points.

**Guidelines for the lecture classes:**

**Key questions covered in lecture N 1:** *Carbohydrates in the body: digestion, utilization, assimilation, excretion*

1. Monosaccharides: glucose, galactose, fructose, ribose. Reactions. Biological role
2. Disaccharides: maltose, lactose, sucrose. Structure. Reactions. Reducing and non-reducing sugars. Biological role.
3. Polysaccharides: starch and glycogen
4. Sources of carbohydrates in the diet. Digestion in mouth and small intestine.
5. Absorption of monosaccharides. Glucose transporters.
6. Defects in digestion and absorption of carbohydrates (lactase deficiency, monosaccharide malabsorption).
7. SGLT & GLUT transporters of glucose. Clinical aspects.
8. Assimilation & storage of carbohydrates

**Recommended reading for the lecture N1:**

1. Ferrier D.R. Lippincott's Illustrated reviews: Biochemistry. (7th ed 2017) pp.69-83

2. Champe P.C., Richard A. Harvey Lippincott's Illustrated reviews of Biochemistry 2004 pp. 119-126;
3. Satyanaryana U. Biochemistry (5th education) 2017 pp.9-28.
4. Murray R.K Harper's Illustrated Biochemistry 26th ed 2003 pp.102.

**Key questions covered in lecture N 2:** *Generation of energy in cells: mechanisms and regulation, and integration of carbohydrate, lipid and protein metabolism in the body*

1. Sources of energy in the human body. Energy balance regulation.
2. Structure of mitochondria; ATP & reducing equivalents – NADH and FADH<sub>2</sub>.
3. ATP formation in aerobic and anaerobic conditions: steps, **regulation** (overview)
4. Intracellular energy states: low & high energy status

**Recommended reading for the lecture N2:**

1. Satyanaryana U. Biochemistry (2nd education) 2005 pp.7-10;
2. Satyanaryana U., Chakrapani U. Biochemistry (4th education) 2013 pp.9-27;
3. Champe P.C., Richard A. Harvey Lippincott's Illustrated reviews of Biochemistry 2004 pp. 119-126;

**Key questions covered in lecture N 3:** *Disturbances in intracellular energy generation*

- 1 Impaired mitochondrial energy metabolism: genetic mutation. Mitochondrial diseases
2. Impaired mitochondrial energy metabolism: ETC disorders
2. Impaired energy metabolism due to enzymopathy (genetic, functional)
3. Reversible/ irreversible injury of the cells due to fall/prolonged loss of energy production.

**Recommended reading for the lecture N3:**

1. Ferrier D.R. Lippincott's Illustrated reviews: Biochemistry. (7th ed 2017) pp.91;
2. Champe P.C., Richard A. Harvey Lippincott's Illustrated reviews of Biochemistry 2004 pp. 87-97;
3. Satyanaryana U. Biochemistry (5th education) 2017 pp.239-242; 242-284;
4. Murray R.K Harper's Illustrated Biochemistry 26th ed 2003 pp.122-136;

**Key questions covered in lecture N 4:** *Glucose homeostasis: regulation and disorders*

- 1 Sources of blood glucose, normal range, measurement units
2. Glucose homeostasis. Regulation
- 3 Hypo- & Hyperglycemia
4. Diabetes Mellitus

**Recommended reading for the lecture N4:**

1. Champe P.C., Richard A. Harvey Lippincott's Illustrated reviews of Biochemistry 2004 pp. 119-126;
2. Satyanaryana U. Biochemistry (5th education) 2017 pp.9-28;
3. Murray R. K Harper's Illustrated Biochemistry 26th ed 2003 pp.102;
4. Satyanaryana U. Biochemistry (2nd education) 2005 pp.7-10;

**Key questions covered in lecture N 5:** *Pathology of carbohydrate metabolism. Testing of metabolites of carbohydrate metabolism in clinical practice*

- 1 Glucose metabolism in cancer cells. Warburg effects
- 2 Lactic acidosis: types, pathological effects
3. Impaired carbohydrate metabolism due to enzymopathy and vitamin deficiency
4. Glycogenesis

**Recommended reading for the lecture N 5:**

1. Ferrier D.R. Lippincott's Illustrated reviews: Biochemistry. (7th ed 2017) pp.91;
2. Champe P.C., Richard A. Harvey Lippincott's Illustrated reviews of Biochemistry 2004 pp. 87-97;
3. Satyanaryana U. Biochemistry (5th education) 2017 pp.239-242, Pp.242-284;
4. Murray R. K Harper's Illustrated Biochemistry 26th ed 2003 pp.122-136;

**Key questions covered in lecture N 6:** *Characteristics of the main lipids in the human body. Digestion, absorption, utilization, isolation. Eicosanoids*

1. Lipids. Short characteristics. Classification of lipids.
2. Fatty acids. Types (SCFA, MCFA, LCFAs). Neutral fats.  $\omega$ -3 &  $\omega$ -6-fatty acids.
3. Eicosanoids: PGs, LTs, TX. Biological role
4. Digestion, re-synthesis, chylomicrons formation, circulation, utilization

**Recommended reading for the lecture N 6:**

1. Ferrier D.R. Lippincott's Illustrated reviews: Biochemistry. (7th ed 2017) pp.173-181
2. Champe P.C., Richard A. Harvey Lippincott's Illustrated reviews of Biochemistry 2004 pp. 171-186;
3. Satyanaryana U. Biochemistry (5th education) 2017 pp.29-44.
4. Murray R.K Harper's Illustrated Biochemistry 26th ed 2003 pp.111-122; 205.
5. Mukhamedova I. Biochemistry practical book 2010 pp.142-146
6. DM Vasudevan. Textbook of Biochemistry 4th ed. 2016 pp. 72; 127; 141;

**Key questions covered in lecture N 7:** *Metabolism of lipoproteins*

1. Lipoproteins: composition of lipoprotein complexes. Types
2. Exogenous lipids transport system (chylomicrons metabolism)
3. Endogenous lipids transport system (metabolism of VLDL, LDL)
4. Biological role of HDL

**Recommended reading for the lecture N7:**

1. Murray R. K Harper's Illustrated Biochemistry 26th ed 2003 pp.111-122; 205;
2. Satyanaryana U. Biochemistry (2nd education) 2005 pp.29-44;
3. Satyanaryana U., Chakrapani U. Biochemistry (4th education) 2013 pp. 28-42;

**Key questions covered in lecture N 8:** *Disorders of lipoprotein metabolism: atherosclerosis, metabolic syndrome. Dyslipidemia: classification, causes, laboratory diagnostics*

1. Plasma lipid profile. Atherogenic & antiatherogenic indexes
2. Atherosclerosis: basic molecular aspects
3. Obesity. Metabolic complications. DM & obesity
4. Wasting syndrome. Biochemical aspect
5. Metabolic syndrome. Biochemical aspect

**Recommended reading for the lecture N 8:**

1. Satyanaryana U. Biochemistry. 6th ed. 2021. Pp. 29; 285;
2. Chatterjea M.N. Textbook of Medical Biochemistry. 8th ed. 2012 pp.44; 350-370;
3. V.W. Rodwell, D.A. Bender, K.M.Kennely. Harper's Biochemistry 30ed. 2015 pp. 211-280;

**Key questions covered in lecture N 9:** *Pathology of lipid metabolism*

1. Hyperlipoproteinemias: primary, secondary.
2. Primary lipoproteinemias: lipid phenotype, defect of enzymes, analysis of lipoproteins, clinical features.
3. Hypolipoproteinemias: hypobetalipoproteinemia Tangier disease, fish-eye, disease.
4. Alcohol metabolism. Alcoholic & non-alcoholic hepatosteatoses: biochemical aspects.

**Recommended reading for the lecture N9:**

1. Ferrier D.R. Lippincott's Illustrated reviews: Biochemistry. (7th ed 2017) pp.173- 219;
2. Champe P.C., Richard A. Harvey Lippincott's Illustrated reviews of Biochemistry 2004 pp. 171-186;
3. Satyanaryana U. Biochemistry (5th education) 2017 pp 285-330;
4. Murray R.K Harper's Illustrated Biochemistry 26th ed 2003 pp 219-230;

**Key questions covered in lecture N 10:** *Digestion and absorption of proteins*

1. Digestion and absorption of proteins. Pools of amino acids in the body. Nitrogen balance.
2. Amino acid transport system. Disorders of amino acids transport. Hartnup's disease.
3. Transamination: aminotransaminases, specificity & biological role enzymes and reaction.
4. Serum AST & ALT in clinical diagnosis of AMI and liver disease.
5. Oxidative and non-oxidative deamination of amino acids, glutamate dehydrogenase, biological importance.
6. Decarboxylation of amino acids - is pathway for biogenic amine synthesis: histidine, serotonin, GABA, catecholamines (adrenal medulla).
7. Transmethylation: methionine, SAM, synthesis of creatine, Ep, phosphatidylcholine (PL), DNA methylation, methylation of xenobiotics (liver).
8. Biological role of THF (folic acid) in one-carbon moiety reaction (NTDs synthesis), homocystein methylation.

**Recommended reading for the lecture N10:**

1. Ferrier D.R. Lippincott's Illustrated reviews: Biochemistry. (7th ed 2017) pp.411-433;
2. Champe P.C., Richard A. Harvey Lippincott's Illustrated reviews of Biochemistry 2004 pp.357-385;
3. Satyanaryana U. Biochemistry (5th education) 2017 pp.523- 571;
4. Murray R. K Harper's Illustrated Biochemistry 26th ed 2003 pp.314-340;

**Key questions covered in lecture N 11:** *Metabolism of nitrogen-containing compounds in the human body*

1. Synthesis of specialized products from amino acids: heme synthesis.
2. Porphyrrias
3. Degradation of heme: bilirubin metabolism
4. Jaundice: types. Lab. diagnosis

**Recommended reading for the lecture N11:**

1. Ferrier D.R. Lippincott's Illustrated reviews: Biochemistry. (7th ed 2017) pp.411-433;
2. Champe P.C., Richard A. Harvey Lippincott's Illustrated reviews of Biochemistry 2004 pp.357-385;
3. Satyanaryana U. Biochemistry (5th education) 2017 pp.523- 571;
4. Murray R. K Harper's Illustrated Biochemistry 26th ed 2003 pp.314-340;

**Key questions covered in lecture N 12:** *Structure and functions of haem. Porphyrin Metabolism. Metabolism. Jaundice*

1. Characteristics of nitrogen waste products for assessment of renal function: creatinine; urea, indican; uric acid
2. Azotemia

3. GFR assessment in the clinical practice
4. Renal function testing interpretation

**Recommended reading for the lecture N12:**

1. Ferrier D.R. Lippincott's Illustrated reviews: Biochemistry. (7th ed 2017) pp.411-433;
2. Champe P.C., Richard A. Harvey Lippincott's Illustrated reviews of Biochemistry 2004 pp.357-385;
3. Satyanaryana U. Biochemistry (5th edition) 2017 pp.523- 571;
4. Murray R. K Harper's Illustrated Biochemistry 26th ed 2003 pp.314-340;

**Key questions covered in lecture N 13:** *Nucleotide metabolism in the human body: regulation, disorders, laboratory diagnostics. Purines and pyrimidines*

1. Nucleotides. Definition, structure
2. Biosynthesis of pyrimidine synthesis: sequences (overview). Anticancer drugs. Orotic aciduria
3. Purine biosynthesis (overview). Purine catabolism. Salvage pathway.
4. Lesch-Nyhan syndrome due to HGPRT deficiency. SCID due to ADA deficiency. Clinical signs.
5. Dietary sources of purines. Uric acid production and excretion.
6. Hyperuricemia: types. Influence of alcohol & lactic acidosis. Xanthinuria. Gout, treatment. Urate nephropathy.

**Recommended reading for the lecture N 13**

1. Ferrier D.R. Lippincott's Illustrated reviews: Biochemistry. (7th ed 2017) pp.411-433;
2. Champe P.C., Richard A. Harvey Lippincott's Illustrated reviews of Biochemistry 2004 pp.357-385;
3. Satyanaryana U. Biochemistry (5th edition) 2017 pp.523- 571;
4. Murray R. K Harper's Illustrated Biochemistry 26th ed 2003 pp.314-340;

**Key questions covered in lecture N 14:** *Molecular mechanisms of oncogenesis: biochemical tumor markers and the biochemical basis of cancer therapy*

1. Cell cycle, control mechanism (overview)
2. Building blocks for growing cells
3. Nutrient sensing, signaling and cell growth
4. Oncogenes, tumor suppressor, metabolic enzymes, environmental factors and tumorigenesis

**Recommended reading for the lecture N14:**

1. Satyanaryana U. Biochemistry (5<sup>th</sup> edition), 2017. – pp.85 -113
2. Chatterjea M.N. Textbook of Medical Biochemistry. 8th ed. 2012 pp. 225-241;
3. V.W. Rodwell, D.A. Bender, K.M.Kennely. Harper's Biochemistry. 30ed. 2015 pp. 370-418;

**Key questions covered in lecture N 15:** *Xenobiotics and antioxidants. Oxidative stress and its diagnosis*

1. Xenobiotics: definition, classes, metabolism
2. Responses to xenobiotics
3. Generation of ROS, NTS and antioxidant system
4. Oxidative stress, biomarkers

**Recommended reading for the lecture N15:**

1. Satyanaryana U. Biochemistry (5<sup>th</sup> edition), 2017. – pp.85 -115
2. Chatterjea M.N. Textbook of Medical Biochemistry. 8th ed. 2012 pp. 225-260;
3. V.W. Rodwell, D.A. Bender, K.M.Kennely. Harper's Biochemistry. 30ed. 2015 pp. 380-450;

**Key questions covered in lecture N 16:** *Bone remodeling and metabolic diseases of bone tissue*

1. Osteoclastogenesis, osteoblastogenesis; regulation
2. Phases of bone remodeling. Regulation
3. Metabolic bone diseases: osteoporosis, osteopetrosis, Paget's diseases, renal osteodystrophy, osteomalacia, rickets
4. Biomarkers of bone diseases

**Recommended reading for the lecture N16:**

1. Satyanaryana U. Biochemistry (5<sup>th</sup> edition), 2017. – pp.85 -115
2. Chatterjea M.N. Textbook of Medical Biochemistry. 8th ed. 2012 pp. 225-260;
3. V.W. Rodwell, D.A. Bender, K.M.Kennely. Harper's Biochemistry. 30ed. 2015 pp. 380-450;

**Key questions covered in lecture N 17:** *Biochemistry of the liver. Interpretation of liver function test*

1. Function of the liver. Impaired function of the liver
2. Liver function tests in the clinical practice: integrity of hepatocytes & cholangiocytes; excretory, synthetic.
3. Interpretation of LFT lab.data

**Recommended reading for the lecture N17:**

1. Satyanaryana U. Biochemistry (5<sup>th</sup> edition), 2017. – pp.115-125;
2. Chatterjea M.N. Textbook of Medical Biochemistry. 8th ed. 2012 pp. 225-260;
3. V.W. Rodwell, D.A. Bender, K.M.Kennely. Harper's Biochemistry. 30ed. 2015 pp. 380-450;

**Key questions covered in lecture N 18:** *Biochemistry of thyroid gland*

1. Function of the thyroid gland



2. Synthesis of thyroid hormones: mechanism, regulation
3. Transport of thyroid hormones in ECF. Disturbances in TH effects due to abnormal concentration of transport proteins
4. Effects of thyroid hormones
5. Hyperthyroidism; Hypothyroidism

**Recommended reading for the lecture N18:**

1. Satyanaryana U. Biochemistry (5<sup>th</sup> edition), 2017. – pp.113-117
2. Ferrier D.R. Lippincott's Illustrated reviews: Biochemistry. (7th ed 2017) pp.411-433;

**Guidelines for the lessons (practical class) of the discipline**

**Key questions covered in practical class N 1:** *Stages of intracellular energy generation: glycolysis in various organs and tissues*

1. Glycolytic pathway: types, conversion of glycogen, galactose, fructose to glucose – 6-phosphate.
2. Reactions of glycolysis (example in hepatocytes).
3. Kinetic properties of glycolytic enzymes, localization in RBCs, liver.
4. Regulation of glycolytic enzymes activities
5. EM pathway in RBCs
6. Disorders due to glycolytic enzymes deficiency. LDH in clinical diagnosis.

**Recommended reading for the lesson N1:**

1. Ferrier D.R. Lippincott's Illustrated reviews: Biochemistry. (7th ed 2017) pp.91
2. Champe P.C., Richard A. Harvey Lippincott's Illustrated reviews of Biochemistry 2004 pp. 87-97;
3. Satyanaryana U. Biochemistry (5th education) 2017 pp.239-242; 242-284;
4. Murray R.K Harper's Illustrated Biochemistry 26th ed 2003 pp.122-136;
5. Satyanaryana U. Biochemistry (2nd education) 2005 pp.7-28;

**Key questions covered in practical class N 2:** *Stages of intracellular energy generation: pyruvate dehydrogenase complex, Krebs cycle, oxidative phosphorylation*

1. PDH complex: structure, regulation of activities.
2. PDH deficiency pathology
3. TCA cycle: biological role, synthetic & catabolic function, anaplerotic reactions
4. Oxidation of Acetyl CoA in TCA cycle: sequence reactions, regulation
5. Mechanisms of TCA control
6. TCA cycle- deficient pathology. Tumorigenesis caused by TCA cycle defects
7. Mitochondrion: functions, general structure
8. Mitochondrial shuttle systems: glycerol-3-P shuttle, malate-aspartate shuttle
9. Electron transport system: definition, composition, substrates
10. Chemiosmotic theory of ATPs generation in the mitochondrion.
11. Coupled process ETC & OXPHOS: inhibitors, uncouplers
12. Clinical aspects: Complex II (SDH) genetics, defect and mechanism tumorigenesis
13. Clinical aspects: Generation of ROS, pathological effects

**Recommended reading for the lesson N2:**

1. Ferrier D.R. Lippincott's Illustrated reviews: Biochemistry. (7th ed 2017) pp.91
2. Champe P.C., Richard A. Harvey Lippincott's Illustrated reviews of Biochemistry 2004 pp. 87-97;
3. Satyanaryana U. Biochemistry (5th education) 2017 pp.239-242; 242-284;
4. Murray R.K Harper's Illustrated Biochemistry 26th ed 2003 pp.122-136;
5. Satyanaryana U. Biochemistry (2nd education) 2005 pp 7-28;

**Key questions covered in practical class N 3:** *Gluconeogenesis. Glycogen metabolism*

1. Gluconeogenesis: definition, site, substrates
2. Hepatic gluconeogenesis: biological role, sequences from pyruvate, lactate, alanine, glycerol; regulation.
3. Renal gluconeogenesis: biological role in well-fed, fasting, starvation, hypoglycemia, hormonal regulation
4. Intestinal gluconeogenesis: biological role
5. Structure of glycogen in muscles, liver; function
6. Metabolism of glycogen: glycogenesis, glycogenolysis: steps, enzymes, regulation
7. Clinical aspects: glycogenosis (hepatic, myopathic & miscellaneous forms).

**Recommended reading for the lesson N3:**

1. Ferrier D.R. Lippincott's Illustrated reviews: Biochemistry. (7th ed 2017) pp.117-125;
2. Champe P.C., Richard A. Harvey Lippincott's Illustrated reviews of Biochemistry 2004 pp. 99-102;
3. Satyanaryana U. Biochemistry (5th education) 2017 pp 242-284;

**Key questions covered in practical class N 4:** *Alternative oxidation of glucose (HMP shunt).*

*Minor carbohydrates metabolism*

1. HMP shunt: steps, regulation
2. Biological role of NADPH

3. NADPH and phagocytosis
4. Hemolytic anemia due to glucose-6-PDH deficiency. Types. Biochemical screening.

**Recommended reading for the lesson N4:**

1. Murray R. K Harper's Illustrated Biochemistry 26th ed 2003 pp.163-171;
2. Satyanaryana U. Biochemistry (2nd education) 2005 pp.7-28;
3. Satyanaryana U., Chakrapani U. Biochemistry (4th education) 2013 pp.244-284;
4. DM Vasudevan. Textbook of Biochemistry. 4th ed. 2016 pp. 72; 127; 141;

**Key questions covered in practical class N 5:**

**Assessment # 4**

Module by unit: Carbohydrates metabolism.

- I. MCQs
- II. Check laboratory and practical works
- III. PBL and clinical cases

**Recommended reading for the lesson N5:**

1. Ferrier D.R. Lippincott's Illustrated reviews: Biochemistry. (7th ed 2017) pp.69-83
2. Champe P.C., Richard A. Harvey Lippincott's Illustrated reviews of Biochemistry 2004 pp. 119-126;
3. Satyanaryana U. Biochemistry (5th education) 2017 pp 9-28;

**Key questions covered in practical class N 6: *Lipogenesis, lipolysis. Oxidation of fatty acids***

1. Lipolysis in adipose tissues: definition, reaction, HSL it is regulation.
2. Lipogenesis in adipose tissues: reactions and regulation
3.  $\beta$  - Oxidation of fatty acids: activation of fatty acids, translocation into the mitochondria.
4. Carnitine deficiency: myopathic, systemic, secondary.
5. Steps of  $\beta$ -oxidation of even chain saturated fatty acids. Bioenergetics.
6. Steps of  $\beta$ -oxidation of odd chain fatty acids. Bioenergetics.
7. Peroxisomal oxidation of LCFAs. Zellweger syndrome.
8. Oxidation of branched chain fatty acids. Refsum disease.

**Recommended reading for the lesson N6:**

1. Ferrier D.R. Lippincott's Illustrated reviews: Biochemistry. (7th ed 2017) pp.173-181;
2. Champe P.C., Richard A. Harvey Lippincott's Illustrated reviews of Biochemistry 2004 pp. 171-186;
3. Satyanaryana U. Biochemistry (5th education) 2017 pp 29-44;
4. Murray R.K Harper's Illustrated Biochemistry 26th ed 2003 pp.111-122; 205;

**Key questions covered in practical class N 7: *Ketone bodies. Cholesterol and TAG metabolism***

1. Ketogenesis in the liver. Reactions. Regulation.
2. Ketolysis in the extrahepatic tissues.
3. Role of oxaloacetate and blood free fatty acids
4. Biochemistry of DKA: ketonemia, ketonuria, ketoacidosis. Connection between carbohydrate, lipids and protein metabolism.
5. Cholesterol biosynthesis. Key regulatory enzymes and regulation.
6. Hypercholesterolemia - risk factor for development of atherosclerosis.
7. Cholesterol degradation. Biosynthesis of bile acids and bile salts.
8. Bile. Composition. Biological role.
9. Cholelithiasis. Major risk factors. Pathogenesis of cholesterol stones formation.
10. Cholemia. Acholia. Clinical features.

**Recommended reading for the lesson N7:**

1. Ferrier D.R. Lippincott's Illustrated reviews: Biochemistry. (7th ed 2017) pp.173- 219
2. Champe P.C., Richard A. Harvey Lippincott's Illustrated reviews of Biochemistry 2004 pp. 171-186;
3. Satyanaryana U. Biochemistry (5th education) 2017 pp.285-330;

**Key questions covered in practical class N 8:**

**Assessment # 5**

Module by unit: Lipids metabolism.

- I. MCQs
- II. Check laboratory and practical works
- III. PBL and clinical cases

**Key questions covered in practical class N 9: *Ammonia metabolism: production and detoxification***

1. Sources of ammonia in the body. Function of ammonia.
2. Glutamine: biological role in detoxification and transport of ammonia. Glutamate-GABA shunt in the brain.
3. Renal Glutaminase: activation, role in generation of ammonium ions for regulation of acidosis

4. Nitrogen Garbage collection system: liver urea cycle, sequences, regulation. Genetic disorders of urea cycle due to enzymopathy.
5. Toxic effects of ammonia: mechanism of toxicity, symptoms of ammonia intoxication (VALIAM-C), causes of hyperammonemia, treatment.

**Recommended reading for the lesson N9:**

1. Ferrier D.R. Lippincott's Illustrated reviews: Biochemistry. (7th ed 2017) pp.245-277;
2. Champe P.C., Richard A. Harvey Lippincott's Illustrated reviews of Biochemistry 2004 pp. 171-186;
3. Satyanaryana U. Biochemistry (5th education) 2017 pp.331-380;
4. Murray R.K Harper's Illustrated Biochemistry 26th ed 2003 pp.249-264;
5. Satyanaryana U. Biochemistry (2nd education) 2005 pp.343- 396;

**Key questions covered in practical class N 10:** *Amino acid products (Gly, Phe, Tyr, etc.) and inborn errors; newborn screening*

1. Phenylalanine metabolism. Phenylketonuria (PKU)
2. Degradation of tyrosine. Alkaptonuria, ochronosis, tyrosinosis.
3. Formation of melanin from tyrosine. Albinism. Vitiligo.
4. Biosynthesis of catecholamines. Hormonal effect.

**Recommended reading for the lesson N10:**

1. Ferrier D.R. Lippincott's Illustrated reviews: Biochemistry. (7th ed 2017) pp.245-277;
2. Satyanaryana U. Biochemistry (5th education) 2017 pp. 331-380;
3. Murray R. K Harper's Illustrated Biochemistry 26th ed 2003 pp.249-264;
4. Satyanaryana U. Biochemistry (2nd education) 2005 pp.343- 396;

**Key questions covered in practical class N 11:**

**Assessment # 6**

Module by unit: Protein metabolism.

- I. MCQs
- II. Check laboratory and practical works
- III. PBL and clinical cases

**Key questions covered in practical class N 12:** *Gene expression. Mutations. Regulation and disorders*

1. DNA replication of prokaryotic and eukaryotic chromosome differences.
2. Steps DNA replication in the eukaryotes: recognition, initiation, elongation, proofreading and repair, termination
3. DNA repair: repair of thymine dimers. Xerodermapigmentoza due to deficiency of excision endonuclease. Lynch syndrome (hereditary nonpolyposis colorectal cancer)

**Recommended reading for the lesson N12:**

1. Ferrier D.R. Lippincott's Illustrated reviews: Biochemistry. (7th ed 2017) pp.411-433;
2. Champe P.C., Richard A. Harvey Lippincott's Illustrated reviews of Biochemistry 2004 pp.357-385;
3. Satyanaryana U. Biochemistry (5th education) 2017 pp.523- 571;
4. Satyanaryana U. Biochemistry (2nd education) 2005 pp.577-586;
5. Satyanaryana U., Chakrapani U. Biochemistry (4th education) 2013 pp.523-578

**Key questions covered in practical class N 13:** *Molecular technologies in diagnosis: recombinant DNA, PCR, microarray, FISH, and CRISPR*

1. Function of nucleic acids. Genes.
2. Prokaryotic and eukaryotic mRNA synthesis: initiation, elongation, termination
3. Reverse transcription: retroviruses.
4. Processing of eukaryotic pre-messenger RNA: formation of 7-methylguanosine cap (5'end), polyadenylate tail (3'end), snRNA action.
5. Translation of mRNA. Genetic code. t-RNA. Structure of ribosomes (eukaryotic, E. coli)
6. Activation of amino acids, initiation, elongation, termination of polypeptide chain.
7. Post- translation modification. Chaperon-chaperonin system (repeating material)
8. Ubiquitin proteasome proteolytic pathway.

**Recommended reading for the lesson N13:**

1. Ferrier D.R. Lippincott's Illustrated reviews: Biochemistry. (7th ed 2017) pp.411-433;
2. Champe P.C., Richard A. Harvey Lippincott's Illustrated reviews of Biochemistry 2004 pp.357-385;
3. Satyanaryana U. Biochemistry (5th education) 2017 pp.523- 571;
4. Satyanaryana U. Biochemistry (2nd education) 2005 pp.577-586;
5. Satyanaryana U., Chakrapani U. Biochemistry (4th education) 2013 pp.523-578

**Key questions covered in practical class N 14:**

**Assessment # 6**

Module by unit: Nucleotide metabolism.

- I. MCQs

- II. Check laboratory and practical works
- III. PBL and clinical cases

***Guidelines for the lessons (laboratory class) of the discipline***

**Laboratory class N1: *Qualitative reactions to carbohydrates***

Lab. w. Reactions of monosaccharides.

Lab. w. Reactions of disaccharides & polysaccharides

**Laboratory class N2: *Blood glucose estimation: GOD-POD method, glucometer. Interpretations***

Lab. w. Determination of blood glucose by GOD-POD method

Lab. w. Determination of urine glucose by strip set method.

**Laboratory class N3: *Determination of blood cholesterol & TAG***

Lab. w. Determination of blood cholesterol

Lab. w. Determination of blood triacylglycerides (TAG)

**Laboratory class N4: *Testing of glomerular filtration of the kidneys. Determination of urea and creatinine in the blood. Calculation of BUN and GFR***

Lab. w. Estimation of blood creatinine (Jaffe's method)

Lab. w. Urinalysis by dipstick method

**Methodological instructions for the implementation of independent work on the discipline.**

Independent extracurricular work ensures the preparation of the student for the current classroom activities and control activities for all disciplines of the curriculum. The results of this preparation are manifested in the student's activity in the classroom and in the quality of completed tests, test assignments, reports made and other forms of control.

***Independent work includes the following types of work:***

- work with lecture material, providing for the study of lecture notes and educational literature;
- search and review of literature and electronic sources of information on an individually given course problem, writing a report on a given problem;
- doing homework for class;
- preparation for laboratory work, practical and seminar classes;
- independent laboratory work on a given topic;
- preparation for control work;
- preparation for the test and certification.