

Rationale

To give students insight into the biochemical basis of a wide range of clinical conditions and the application of molecular biology to medicine.

Aim

To introduce students to normal biochemical processes and to make them understand how abnormal processes can result in diseases and how metabolism changes in pathological states.

Objectives

At the end of the course the students should be able to:

1. Describe the features of high energy compounds.
2. Explain how glucose metabolism results in release of energy.
3. Comprehend the central role of the citric acid cycle in metabolism.
4. Explain how the energy of the electron-flow down gradient is converted to the universal energy currency, ATP.
5. Explain the significance of O₂ in respiration.
6. Elucidate how an alternative pathway of glucose metabolism results in formation of reducing equivalents for anabolic processes and a pentose ribose, a constituent of nucleic acids.
7. Illustrate how metabolism in the liver and kidney responds to falling blood glucose to dangerously low levels as to endanger the survival of vital organs such as the brain.
8. Describe the changes in glycogen metabolism at various times of the day.
9. Explain why fatty acids are ideal for storage of energy over a long time.
10. Describe changes in fatty acid metabolism associated with uncontrolled diabetes mellitus.
11. Illustrate the common origin of steroid hormones and how subtle differences in the position of functional groups results in functional diversity of the hormones.
12. Outline the synthesis and fate of amino acids in the body.
13. Elucidate the flow of information from DNA in the nucleus to amino acid sequence on a polypeptide in the cytosol.
14. Describe normal nutritional and deviations from the normal state which can lead to diseases.
15. Describe the genetic basis of some diseases.
16. Describe how the prosthetic group heme is synthesized and degraded.
17. Describe the mechanisms of oxygen binding to myoglobin and hemoglobin.

COURSE CONTENT

1: Biophysical chemistry

- 1.1. Properties of water as a solvent for biochemical reactions
- 1.2. Hydrogen bonding
- 1.3. Weak acids and bases
- 1.4. pH and pKa determinations
- 1.5. Buffers and their role in biological systems
- 1.6. Physiologically important buffer systems.

2: Proteins

- 2.1. Overview of proteins
- 2.2. Structure and properties of amino acids
- 2.3. Amino acids as electrolytes and titration curves
- 2.4. Structure of proteins
- 2.5. Physical and chemical properties of proteins
- 2.6. Protein separation and purification techniques
- 2.7. Qualitative and quantities analysis of proteins

3: Carbohydrates

- 3.1. Simple monosaccharides and disaccharides
- 3.2. Structure and chemical properties: oligo - and polysaccharides
- 3.3. Structure and function: sugar derivatives
- 3.4. Qualitative and quantitative analysis of carbohydrates.

4: Lipids

- 4.1. Chemical properties of fatty acids
- 4.2. Triglycerides, waxes, derived lipids, and Carotenoids
- 4.3. Functions of lipids

4.4. Quantitative and qualitative analysis of lipids.

5: Nucleic acids

5.1. Structure and properties of purine and pyrimidine bases

5.2. Nucleosides, nucleotides and Nucleic acids

5.3. Use of nucleoside analogues as therapeutics; an overview of Cancer, HIV biochemistry: genetic makeup, key proteins and current therapeutics.

6: Principles of Bioenergetics

6.1. Chemical thermodynamics

6.2. Standard free energy change of reactions

6.3. Reaction coupling mechanism

6.4. Oxidation-reduction reactions

6.5. Energy-rich compounds

6.6. Enzymes and coenzymes involved in redox reactions.

7: Enzyme classification and catalysis

7.1. Role of enzymes as biological catalysts

7.2. Nomenclature and classification

7.3. Enzyme kinetics

7.4. Effect of enzyme and substrate concentrations

7.5. Derivation and application of Michaelis-Menten equation

7.6. Effect of temperature and pH

7.7. Enzyme specificity, activation, and inhibition reactions and their kinetics

7.8. Role of coenzymes

7.9. Multi-enzyme complexes, regulatory enzymes and activity

7.10. Quantitative measurement of enzyme activity

7.11. Role of enzymes in metabolism.

8: Hemoglobin and Myoglobin

- 8.1. Structure of hemoglobin and myoglobin.
- 8.2. Mechanism of oxygen binding to hemoglobin and myoglobin.
- 8.3. Oxygen dissociation curve.
- 8.4. Carbon monoxide toxicity.
- 8.5. Cooperativity between hemoglobin subunits.
- 8.6. The Bohr Effect.
- 8.7. Fetal hemoglobin.
- 8.8. Abnormal hemoglobin.

9: Glycolysis

- 9.1. Glycolytic pathway.
- 9.2. ATP synthesis during glycolysis.
- 9.3. Red blood cells sustenance of glycolysis.
- 9.4. Glycolysis under anaerobic conditions in muscles.
- 9.5. Regulation of glycolysis.
- 9.6. Substrate level phosphorylation.

10: Citric Acid Cycle

- 10.1. Oxidation in the citric acid cycle.
- 10.2. The amphibolic role of the citric acid cycle.
- 10.3. Regulation of the citric acid cycle.

11: Electron Transport Chain

- 11.1. Flow of electrons in the electron transport chain.
- 11.2. ATP synthesis in oxidative phosphorylation.
- 11.3. O₂ in oxidative phosphorylation.
- 11.4. How electrons from the glycolytic pathway enter the electron transport chain.

11.5. Regulation of the electron transport chain.

11.6. Inhibitors of the electron transport chain.

12: The Pentose Phosphate Pathway

12.1. The pentose phosphate pathway.

12.2. Importance of the pentose phosphate pathway.

12.3. Glucose 6-phosphate dehydrogenase and the integrity of the red cell membrane and the association with malaria.

13: Gluconeogenesis

13.1. Non-carbohydrate precursors of gluconeogenesis and how they enter the gluconeogenic pathway.

13.2. Thermodynamic barriers that need to be bypassed during gluconeogenesis.

13.3. Priority tissues that are supported by gluconeogenesis.

13.4. Regulation of gluconeogenesis.

13.5. Control of blood sugar level.

13.6. Diabetes mellitus and starvation.

14: Glycogen Metabolism

14.1. Glycogenesis and glycogenolysis.

14.2. Changes in glycogen metabolism immediately after a meal and between meals.

14.3. Hormonal control of glycogen metabolism.

14.4. How glycogen metabolism in the liver differs from muscle

14.5. Glycogen storage diseases.

15: Fatty Acid Metabolism

15.1. Digestion and absorption of fatty acids

15.2. Fatty acid synthesis

15.3. Fatty acid oxidation

15.4. Regulation of fatty acid metabolism

15.5. Ketogenesis

15.6. Changes in fatty acid metabolism in uncontrolled diabetes and starvation

15.7. The fate of cholesterol.

16: Steroid Hormone Synthesis

16.1. Pathways in the biosynthesis of steroid hormones

16.2. Functions of steroid hormones

16.3. Structural differences between steroid hormones

17: Nutrition and Vitamins

17.1. Digestion, absorption and distribution and use of nutrients

17.2. Human nutritional requirements

17.3. Vitamins and minerals and their various functions

17.4. Fortified foods

17.5. Nutritional deficiency states

18: Heme Metabolism

18.1. Processes of heme synthesis and breakdown

18.2. Control of heme metabolism

18.3. Secretion and metabolism of bilirubin.

18.4. Clinical conditions associated with bilirubin metabolism and secretion

19: Amino Acid Metabolism

19.1. Essential and nonessential amino acids

19.2. The fate of the carbon skeletons and the amino groups of amino acids

19.3. Diseases that result from abnormal metabolism of amino acids

19.4. The alanine cycle

20: Nucleic Acid Metabolism

- 20.1. Steps involved in DNA and RNA synthesis
- 20.2. DNA damage and the mechanisms of repair
- 20.3. RNA processing.

21: Purine and Pyrimidine Metabolism

- 21.1 The synthesis and catabolism of pyrimidines
- 21.2 The synthesis and catabolism of purines
- 21.3 Various disorders associated with purine and pyrimidine metabolism

22: Genetic Code and Protein Synthesis

- 22.1 Features of the genetic code
- 22.2 Genetic information flow: DNA to RNA to protein
- 22.3 Mutations in nucleotide sequence
- 22.4 Steps involved in protein synthesis
- 22.5 Mechanism of antibiotics: some examples.

23: Medical Genetics

- 23.1 Overview
- 23.2 Eukaryotic genome and gene expression
- 23.3 Control of gene expression
- 23.4 Chromosomal basis of human disease
- 23.5 Dysmorphology and developmental genetics
- 23.6 Genetic screening and prenatal diagnosis
- 23.7 Oncogenes
- 23.8 Tumour suppressor genes
- 23.9 Clinical examples
- 23.10 Genetic counseling and gene therapy.

Assessment

- Continuous assessment (40% of course total):

- Assessment tests 35% (MCQs, short answer or essay),

- Laboratory reports 5%

-Final Exam (60%)

Prescribed Books

1. Lehninger Principles of Biochemistry, 8th edition. David L. Nelson; Michael M. Cox (2021)
2. Harper's Illustrated Biochemistry, 31st edition. Victor W. Rodwell, David A. Bender, Kathleen M. Botham, Peter J. Kennelly, P. Anthony Weil
3. Textbook of Biochemistry with Clinical Correlations, 7th edition. Thomas M. Devlin
4. Biochemistry, 9th edition. Lubert Stryer, Jeremy Berg, John Tymoczko, Gregory Gatto