Special Degree Programme: Biochemistry and Molecular Biology
Third year

CH 3033 Chemistry of Bio-molecules (45L, 3C)

Dependencies: First year and second year chemistry core courses
Suggested readings: Medicinal Natural Products (Paul M Dewick)

Learning Outcomes:
Upon completion of this course students will be able to:
- Classify biomolecules based on their biosynthesis
- Propose biosynthetic pathways leading to these natural organic molecules
- Demonstrate a knowledge of the reactions of simple monosaccharides and the role of carbohydrates in biological systems
- Identify the use of some of these bio-molecule

Syllabus:

Building blocks and mechanisms in secondary metabolism (04 L)
Primary and secondary metabolism, enzymes and coenzymes, Construction mechanisms in biological systems such as alkylation, Wagner-Meerwein rearrangement, Aldol and Claisen condensations, Schiff base formation, Mannich reaction, Transamination, reductions and oxidations in biosynthesis

Fatty acids and polyketides from acetate pathway (05 L)
Saturated/Unsaturated fatty acids, Prostaglandins, Aromatic polyketides (Cyclization to give simple phenols and Anthraquinones), alkylation and coupling reactions of polyketides, Macrolides and polyethers, Cyclization through Diels-Alder reaction to give statins.

Aromatic amino acids and phenylpropanoids from shikimate pathway (05 L)
Aromatic amino acids and simple benzoic acids, Lignans and lignin, Phenylpropanes, Benzoic acids from C₆C₃ compounds, Coumarins,

Terpenoids and steroids from mevalonate pathway (12 L)
Monoterprenes, Sesquiterpenoids, Diterpenoids, Sesterterpenoids, Triterpenoids, Carotenoids, Steroids. Steroid skeleton, numbering, conformations, main types of steroids and their biological functions, Important reactions and synthesis/partial synthesis of steroids.

Biosynthesis of Alkaloids from amino acids (07 L)
Chemical structure, Biosynthesis of alkaloids derived from ornithine, lysine, nicotinic acid, tyrosine, tryptophan, anthranilic acid, and histidine, Important reactions of alkaloids.

Mixed biogenesis (02 L)
Flavonoids and stilbenes, Meroterpenoids

Carbohydrates (10 L)
Nomenclature and configurational relationship of monosaccharides, Fischer projection and Haworth formula, mutarotation, Reactions of anomic and non-anomeric carbon atoms, Reactions of the hydroxyl groups, Aminosugars, Reducing and non-reducing sugars, Nature of di-, tri-, and polysaccharides,

Assessment: End of semester examination
**CH 3054 – Nutritional and Clinical Biochemistry (30L, 2C)**

**Dependencies:** None  

**Learning outcomes:**  
At the end of the lecture series the students should be able to:  
- Assess vitamins as cofactors in enzymes  
- Assess the importance of vitamin in diets  
- Evaluate the role of specific minerals in nutrition  
- Describe the principle involved in the measurement of analytes in the clinical biochemistry laboratory.  
- Outline how biochemical analysis can be employed to differentiate between normal and diseased conditions.  
- Perform practical biochemical analysis of clinical samples.  
- Perform data handling exercises associated with biochemical analysis

**Syllabus:**  
Energy and protein requirements. Fat soluble vitamins (Vitamin A, D, E and K) and Water soluble vitamins (mainly folate and vitamin B12)- sources, metabolism, biochemical function, assessment, causes and consequences of deficiency and excess. Trace elements: Iron- deficiency and consequences, bioavailability, nonheam iron and heam iron, enhancement of absorption, stages in development of deficiencies, prevention of deficiencies. Iodine-metabolism, function of thyroid hormones, assessment of thyroid function. Zinc, Selenium and fluoride. Diet and chronic disorders- obesity, diabetes mellitus type 2, cardiovascular diseases, role of lipoproteins in atherogenesis and thrombosis, role of diet; Introduction to Clinical Biochemistry. Liver disorders, renal disorders, IHD. Clinical tests versus cost. Understanding the purpose of each clinical test, accuracy, quality control, automation. Basis of common laboratory tests- blood glucose, albumin, urea, lipid profile, cardiac markers etc. Special investigations.

**Assessment:** End of semester examination.

**BC 3022-Metabolism 1 (30L, 2C)**

**Dependencies:** CH 2013 (Introduction to Biochemistry)  
**Suggested readings:** Mathews & van Holde, Biochemistry; Voet&Voet, Biochemistry.

**Learning outcomes:**  
Upon completion of this course students will be able to:  
- Recognize how thermodynamics, electrochemistry and chemical equilibrium used in achieving biochemical reactions in metabolic pathways  
- Explain how metabolic pathways (glucose, polysaccharides and fatty acid) are used in the generation and storage of energy  
- Recognize different cycles/ pathways operates in above mentioned metabolic pathways
• Compare the effects of various disease states on the alteration of above mentioned metabolic pathways

**Syllabus:**

**Introduction (4L):** overview of metabolism; energetics of biochemical reactions, redox reactions, hydrolysis of “high energy” molecules, ATP; determination of biochemical pathways, labelling studies, **Metabolism of glucose (8L):** glycolysis, citric acid cycle, electron transport, photosynthesis, pentose phosphate pathway, gluconeogenesis, regulation of glucose metabolism, **Metabolism of polysaccharides (8L):** structure and biosynthesis of glycogen and starch, cellulose, chitin, hyaluronic acid, glycoproteins; catabolism of glycogen; regulation of carbohydrate metabolism, **Fatty acid metabolism (8L):** lipid digestion and transport; beta oxidation; fatty acid biosynthesis; Ketone body synthesis and utilization, regulation of lipid metabolism. **Metabolic disorders (2L):** Disorders of carbohydrate metabolism (glycogen storage disease, diabetes), Disorders of fatty acid oxidation and mitochondrial metabolism (Medium-chain acyl-coenzyme A dehydrogenase deficiency, MCADD).

**Assessment:** End of semester examination.

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**BC3023- Metabolism II (30L, 2C)**

**Dependencies:** BC 3022 (Metabolism I)

**Suggested readings:** Mathews & van Holde, Biochemistry; Voet&Voet, Biochemistry.

**Learning Outcomes:**

Upon completion of this course students will be able to:

• Describe how metabolic pathways (amino acid) are used in the generation and storage of energy
• Recognize different cycles/ pathways operates in metabolic pathways (Amino acid, nucleotide, heme)
• Describe the effect of fed vs fasting states on metabolic pathways
• Compare and contrast tissue-specific metabolism
• Explain the effects of various disease states on the alteration of above mentioned metabolic pathway.

**Syllabus:**

**Nitrogen metabolism (4L):** nitrogen cycle, nitrification, and nitrogen fixation; transamination and the role of glutamate; urea cycle. **Amino-acid metabolism (4L):** overview and the central role of the citric acid cycle; catabolism of individual amino-acids; anabolism of individual amino-acids, regulation of amino acid metabolism **Compounds derived from amino-acids (4L):** porphyrins; bioactive amines; tetrahydrofolate; alkaloids (overview only). **Nucleotide metabolism (4L):** biosynthesis of purines and pyrimidines and their ribonucleotides; deoxyribonucleotides; nucleotide coenzymes; catabolism of nucleotides. **Heme metabolism (4L):** Heme Synthesis, Regulation of heme synthesis, Porphyrias, Heme degradation, Hyperbilirubinemia (jaundice), Regulation and integration of mammalian metabolism (6L): Tissue specific metabolism: liver, brain, muscle, kidney and heart. Metabolism in well-fed and fasting state and during starvation. **Metabolic disorders (4L):** Disorders of amino acid metabolism (phenylketonuria, maple syrup urine)
disease, glutaric acidemia type 1), Urea Cycle Disorder or Urea Cycle Defects (Carbamoyl phosphate synthetase I deficiency), Disorders of organic acid metabolism [organic acidurias, alcaptonuria], Disorders of porphyrin metabolism (acute intermittent porphyria), Disorders of purine or pyrimidine metabolism (Lesch-Nyhan syndrome)

Assessment: End of semester examination.

BC 3024 Bio-Physical Chemistry (30L, 2C)

Dependencies: CH 2012 (Intermediate Physical Chemistry), CH 2013 (Introduction to Biochemistry)


Learning Outcomes:
Upon completion of this course students will be able to:

- Apply the concepts in thermodynamics to biological systems
- Apply thermodynamics to membrane equilibria and chemical equilibria involving macromolecules
- Explain and analyze transport processes in biological systems
- Distinguish the importance of methods for separation and characterization of macromolecules
- Identify the applications of spectroscopy in the analysis of biochemical systems
- Identify the basic concepts in radiochemistry and its applications in biochemistry
- Solve quantitative or conceptual problems in thermodynamic applications, spectroscopic methods, derive equations, and use graphical methods

Syllabus:
Review of electronic absorption spectroscopy; Applications of UV/visible spectroscopy to proteins and nucleic acids; Theory and applications of circular dichroism; Theory and applications of fluorescence. **Radioactivity** (5L): Radioactive emissions and decays; Units of radioactivity; Radiation dose; Radiation detection and measurement; Radioisotopes in research.  

**Assessment:** End of semester examination.

**BC 3025-Protein Structure and Function (30, 2C)**

**Dependencies:** CH 2013 (Introduction to Biochemistry)


**Learning Outcomes:**

Upon completion of this course students will be able to:

- Relate the properties of metal ions to their functions in biological systems
- Apply the principles of coordination chemistry to biological systems
- Explain and analyze transport processes in biological systems
- Differentiate and describe different structural stages and their importance of a given protein
- Apply their knowledge on protein structure to explain the function of selected proteins
- Explain protein folding and denaturation processes
- Explain few diseases caused due to misfolding of proteins

**Syllabus:**


**Assessment:** End of semester examination.

**BC 3030-Pracical Biochemistry and Molecular Biology (240P, 8C)**

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Practical conducted in the areas of Techniques in Recombinant DNA Technology and General Biochemistry, Plant Molecular Biology and Clinical Biochemistry.

Assessment: End of the semester examination.

**MB 3022-Gene Expression and Regulation (45L, 3C)**

Dependencies: None

Suggested Readings: Genes VIII (B. Lewin)

Learning outcomes:
Upon completion of this course students will be able to:
- Identify operon, and list its parts.
- Explain how a regulator gene controls transcription of an operon.
- Explain the regulation of the *trp* and *lac* operons.
- Identify different levels at which gene expression in eukaryotes may be regulated.
- Explain how DNA modifications, Chromatin remodeling etc., used in activation and repression of gene expression.
- Identify sequence elements, activators and repressors factors in eukaryotes and describe how they alter gene expression.
- List the different types of posttranscriptional, translational, and posttranslational control of gene expression in eukaryotes.
- Define epigenetic inheritance.

Syllabus:
Gene structure; Prokaryotic and eukaryotic gene transcription; Transcription factors, activators and repressors, Mechanism of activation and repression; DNA modifications, Chromatin remodeling; Transcription of class I, II and III genes, Posttranscriptional modifications (capping, splicing and polyadenylation); Transcriptional regulation (Myc-Max system, Yeast GAL system), Posttranscriptional regulation, Regulatory RNAs, Regulation of gene expression in development, epigenetic inheritance.

Assessment: End of semester examination.

**MB 3024-Topics in Molecular Cell Biology (30L, 2C)**

Dependencies: None

Suggested readings: Molecular Cell Biology (H Lodish, M P Scott, P Matsudaira & J Darnell)

Learning outcomes:
Upon completion of this course students will be able to:
- Explain molecular and biochemical and mechanisms involved in cell cycle regulation, apoptosis and ageing.
- Explain various levels of gene regulation and protein function including signal transduction and cell cycle control.
- Describe cellular interaction, organelle and cellular targeting.
- Discuss the various macromolecular components of cells and their functions.
- Explain molecular events during animal and plant development.
- Discuss different strategies in viral infection, replication and gene expression
- Explain bacterial conjugation, recombination and transformation

Syllabus:
Molecular and biochemical mechanisms involved in cell cycle regulation, apoptosis and ageing; protein processing and protein sorting; Molecular and cellular interaction: membrane transporters, introduction to signal transduction, molecular aspects of nuclear cytoplasmic transport; Organelle and cellular targeting: chloroplast, mitochondria, peroxisomes, ER and Golgi; Molecular developmental biology: molecular events during animal and plant development, molecular basis of cellular induction and cell differentiation, homeo box genes in development and sex determination; Viruses and subviral agents: viral infection strategy, diversity of replication strategy, strategies for viral gene expression, sub viral agents; bacterial genetics: bacterial conjugation, recombination, transformation, bacteriophage genetics; specialized cells: cancer cells and pathogen infected cells.

Assessment: End of semester examination.

MB 3025-Recombinant DNA technology and applications (45L, 3C)

Dependencies: None

Suggested readings: (i) Watson et al, Recombinant DNA (ii) Drlica, Understanding DNA & gene cloning

Learning outcomes:
Upon completion of this course students will be able to:
- Describe the different tools used in rDNA technology
- Compare the different techniques available for labelling DNA
- Compare the different strategies used for gene cloning
- Describe how genomic and cDNA libraries are constructed
- Design a PCR assay
- Explain how DNA is sequenced and analyzed
- Describe the different applications of rDNA technology

Syllabus:
Tools of Molecular Biology; Microorganisms, enzymes & vectors. Cloning; Techniques of cloning; Cutting & joining DNA molecules using enzymes, gene transferring methodologies, Gel Electrophoresis, Blotting techniques (Southern and Northern) DNA Labelling techniques, Nucleic acid Hybridization; Strategies for gene isolation, Construction and screening of genomic & cDNA libraries, DNA sequencing and analysis, Chromosome walking, PCR. DNA & protein microarray. Applications of recombinant DNA technology in Medicine, Agriculture and Industry, Recent advances in rDNA technology.

Assessment: End of semester examination.