Department of Biochemistry

Syllabus

for

M. Sc. Biochemistry

To be effective from academic session 2020-2021

Central University of Rajasthan

NH-8, Bandarsindri,

Kishangarh-305817

Dist. Ajmer

Objective of the Programme: The Students of M.Sc. Biochemistry programme will learn experimentally and theoretically about the chemistry of biological phenomenon of living organisms. The course aims to provide the skills of identifying scientific issues, developing hypothesis based on literature, designing experiments and displaying results for betterment of mankind.

Programme outcomes: At the completion of this course, the students will be able to:

1. Understand the molecular structure and conformation of proteins, lipids, nucleic acids, and carbohydrates and their role in the metabolic functions of the organism.
2. Explain the biochemical processes that underlie the cellular physiology of eukaryotic and prokaryotic cells
3. Demonstrate an understanding of the principles of inheritance and can explain the relationship of genomics and proteomics
4. Explain the molecular mechanisms of different inherited diseases and metabolic disorders and conduct the biochemical tests for molecular diagnosis
5. Use modern biochemical and molecular techniques to conduct experiments to test scientific hypotheses, analyze data, do trouble-shooting and draw conclusion from the experimental data in labs.
6. Perform research thesis, and present and defend their findings to scientific audience at regional or national levels.

Employability: Students can peruse basic research work in research institutes or universities by qualifying various exams for research fellowships. Students can also work in pharmaceutical and applied biotechnological fields.

M.Sc. Biochemistry (Revised Course Structureimplemented from academic session 2020-2021 onwards)

Semester I

Code	Title of the course	Course	Type of Course	Credits
BCH-401	Fundamentals of Biochemistry	Core 1	Theory	3
BCH-402	Cell Biology	Core 2	Theory	3
BCH-403	Microbiology	Core 3	Theory	3
BCH-404	Genetics	Core 4	Theory	3
BCH-405	Molecular Biology	Core 5	Theory	3
BCH -406	Department Elective 1*	Dept. Specific Elective 1	Theory	3
BCH-407	Laboratory -1	Lab-1	Lab	3
BCH -408	Laboratory -2	Lab 2	Lab	3
			TOTAL CREDITS	**24**

Semester – II

Code	Title of the course	Course	Type of Course	Credits
BCH-409	Bioenergetics and metabolism	Core 6	Theory	3
BCH-410	Plant physiology & Biochemistry	Core 7	Theory	3
BCH-411	Enzymology	Core 8	Theory	3
BCH-412	Immunology	Core 9	Theory	3
BCH-413	Department Elective2*	Dept. Specific Elective 2	Theory	3
BCH-414	Department Elective3*	Dept. Specific Elective 3	Theory	3
BCH-415	Other Department Elective 1**	Other Dept Elective 1	Theory	3
BCH-416	Laboratory-3	Lab 3	Lab	3
BCH-417	Laboratory-4	Lab 4	Lab	3
			TOTAL CREDITS	**27**

Total credits: 27

Semester – III

Code	Title of the course	Course	Type of Course	Credits
BCH-501	Human Physiology	Core 10	Theory	3
BCH-502	Biophysics and Bioinformatics	Core 11	Theory	3
BCH-503	Analytical Biochemistry	Core 12	Theory	3
BCH-504	Clinical Biochemistry	Core 13	Theory	3
BCH-505	Department Elective 4*	Dept. Specific Elective 4	Theory	3
BCH-506	Other Department Elective 2**	Other Dept Elective 2	Theory	3
BCH- 507	Laboratory-5	Lab 5	Lab	3
BCH -508	Laboratory-6	Lab 6	Lab	3
			TOTAL CREDITS	**24**

Semester – IV

Code	Title of the course	Course	Type of Course	Credits
BCH- 509	Skill for Biological data analysis	Skill-1	Tutorial/Lab	2
BCH -510	Scientific writing skill	Skill-2	Tutorial/Theory	2
BCH -511	Scientific presentation skill	Skill-3	Tutorial/ Presentation	2
BCH -512	Major Project (Research Dissertation)	Dissertation	Tutorial/Lab	15
			TOTAL CREDITS	**21**
			GRAND TOTAL CREDITS	**96**

Fitness **Credit 2**

Offered by university. It is for all student of university. It may run for all semester.

Societal **Credit 2**

Offered by university. It is for all student of university. It may run for all semester.

Course Name	Course Type	Credits
Fitness/Societal	Practical	2 (In each semester)

* Student have to select the elective form department electives list enclosed,
** Student have to select the elective from the other departments of Central University of Rajasthan

***List of Departments Specific Electives from Department of Biochemistry**

Code	Elective Name
BCH-DE1	Agricultural Biotechnology
BCH-DE2	Antimicrobial Resistance
BCH-DE3	Applied and Environmental Microbiology
BCH-DE4	Cancer Biology
BCH-DE5	Developmental Biology
BCH-DE6	Ecology & molecular evolution
BCH-DE7	Epigenetics & stem cell biology
BCH-DE8	Host-Pathogen Interaction
BCH-DE9	Infection Biology
BCH-DE10	Molecular Endocrinology
BCH-DE11	Molecular Medicine
BCH-DE12	Protozoan Parasitology
BCH-DE13	Nanobioscience
BCH-DE14	Plant Functional Genomics
BCH-DE15	Plant Genetic Engineering & genome Editing
BCH-DE16	Plant Stress Biology
BCH-DE17	Protein Engineering
BCH-DE18	Small RNA in Health and disease
BCH-DE19	Virology and Vaccinology
BCH-DE-20	MOOC

SEMESTER I

BCH-401 Fundamentals of Biochemistry Credit 3

Learning Objective: The course is aimed to provide insight into fundamentals of structures and interactions present in various biomolecules that help in functioning and organization of living cell.

Learning Outcome

At the end of the course, students will be able to

- Know about the composition of living matters and importance of water and buffer in life.
- Interpret molecular structure and interactions present in proteins, nucleic acids, carbohydrates and lipids
- Explain organization and working principles of various components present in living cell

Unit I

Composition of living matter; properties of water; Structure and Interactions, Water as a Solvent, Proton Mobility, properties of biomolecules in aqueous environment; molecular assemblies; pH, pKa and buffer, Henderson-Hasselbatch equation, buffers and its mechanism, biological buffers, molarity and normality.Nomenclature, classification and structure of amino acids, ionization of the amino acids, isoelectric point, determination of isoelectric point of amino acid, optical activity, Chirality and Biochemistry, "Nonstandard" Amino Acids.

Unit II

Classification and structure of proteins, Primary Sructure of protein and its Determination, Peptide bond, Secondary structure, Helical Structures, Beta Structures, Nonrepetitive Structures, super secondary structures and domains, Tertiary structures, Fibrous and Globular proteins, quaternary structure, geometry, symmetry and intermolecular interfaces of quaternary structure, detection of proteins.Nomenclature, classification and structure of monosaccharides, oligosaccharides and polysaccharides, mutarotation, annomerisation, epimerization, Sugar Derivatives, Common Disaccharides and their functions, Structural Polysaccharides: Cellulose and Chitin etc; Storage Polysaccharides: Starch and Glycogen, glycoproteins, glycolipids and proteoglycans, detection of carbohydrates.

Unit III

Nomenclature, classification and structure of lipids: Fatty Acids,Triacylglycerols, Glycerophospholipids, Sphingolipids, Cholesterol, effect of composition of fatty acid and alcohol in the stability of lipids, Lipoproteins structure, Lipids as Signals, Eicosanoids and pigments, detection of lipids. Nomenclature, classification and structure of Nucleotides and Nucleic Acids, structure of nitrogenous bases, nucleosides and nucleotide, The Chemical Structures of DNA and RNA, Double Helical DNA, The Watson–Crick Structure: B-DNA, Denaturation and Renaturation, , Ionization of the bases, effect of chemicals and radiations, detection of nucleic acids. Cofactors- vitamins ADEK, Structure and properties of vitamins, co-enzymes, biochemical action of vitamins and water-soluble vitamins.Recent trends in Biochemistry research and techniques.

Books recommended:

- Voet D., Voet J.G, Biochemistry 4th Edition., John Wiley and Sons, 2011.
- Nelson, D. C. andCox, M.M., Lehninger Principles of Biochemistry, 5thEdition,W. H. Freeman, 2010.
- Berg J.M., Tymoczko J.L. and Stryer L., Biochemistry. 7th edition, W.H. Freeman and Co. New York, 2011.

BCH-402 Cell Biology Credit 3

Objectives: Understanding the cells are the smallest entities exhibiting life properties, students will realize cellular and molecular organization, variety of chemical reactions, mechanical activities, genetic programs, intracellular and intercellular communications, reproduction, and evolution of cell.

Learning outcomes: At the completion of this course, the students will be able to:

- Know the internal architecture of prokaryotic and eukaryotic cells and similarities and the differences among divers kinds of cells originating from bacteria, plant and animals
- Gain fundamental understanding of protein sorting and cell signaling.
- Concerned with the social context of living cells and the mechanism of cell division
- Update their aptitude about the renewal and regeneration of differentiated cells, stem cells and cancer cells
- Elucidate the molecular mechanism of cell cycle and cell death.

Unit-I

Cellular organization: Membrane models, chemical composition of membrane, membrane proteins, movement of small and large molecules across the cell membrane, osmosis, diffusion, endocytosis, phagocytosis, artificial liposomes and its application; Sub-cellular organelles: Structure and functions of intracellular organelles such as nucleus, mitochondria, endoplasmic reticulum, golgi apparatus, lysosomes, plastids, peroxisomes; Cytoskeleton: Structure, organization and function of microtubules and microfilaments, role of myosin, kinesin and dynein, cell movements.

Unit-II

Extracellular matrix and cell adhesion molecules: Function and composition of extracellular matrix molecules, types of cell adhesion molecules, integrin, cadherin and immunoglobin superfamily proteins.; Protein targeting: Protein synthesis on free and bound ribosomes, modification and quality control of protein in ER, secretion and transport of protein to various cell compartments, post translational modification; Signal Transduction:Receptors and ligands, cellular communication, signalling through membrane receptors like GPCR, receptor tyrosine kinase, receptor serine/threonine kinase, PI3K/Akt, MAPkinase, cytokine signalling like JAK-STAT, TCR mediated signalling.

Unit-III

Cell cycle and cell death:cell cycle, role of cyclins, cylcin dependent kinase in cell cycle progression. Apoptosis; pro-apoptotic and anti-apoptotic regulators, mechanism of necrosis and autophagy; Cancer:Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, interaction of cancer cells with normal cells, therapeutic interventions of uncontrolled cell growth, embryonic signature in cancer cells. . Recent trends in cell biology research and techniques.

Books recommended:

- G.M. Cooper. 2013. The Cell - A Molecular Approach, Sunderland (MA), Sinauer Associates, Inc. USA.
- Gerald K., Cell and Molecular Biology, Concept and Experiment, 5th Edition, Wiley, 2007.
- Lodish, H., Berk A., Kaiser C. A., Krieger M., Bretscher A., Ploegh H., and Scott M.P. Molecular Cell Biology, 7th Edition, Freeman, W. H. and Co., 2013.
- Alberts B., Walter P., Johnson A., Lewis J., Morgan D., and Raff. M., RobertsK., Walter P. Molecular Biology of the Cell, 6th Edition, Garland Publishing Inc., 2014.

BCH-403 Microbiology Credit 3

Objectives: Student will learn the world microbes and modern microbiology as a subject with great impact in medicine, food science, biochemistry and molecular biology.

Learning outcomes: At the completion of this course, the students will be able to:

- Identify and classify different members of microbial world
- Understand the origin and evolution of microorganisms and major microbial habitats
- Recognize the relationship between microorganisms and disease
- Reveal catabolic and anabolic process of micro organisms
- Predict how virus and microorganisms interact with host cells and the way in which diseases arise

Unit-I

Introduction of Microbiology:Origin and evolution of microbial world; Pathway of discovery in Microbiology; Haeckel's three kingdom concept, Whittaker's five kingdom concept, three domain concept of Carl Woese. Classification and bacterial and archaea systematics: conventional and modern methods of bacterial taxonomy. Classification of bacteria according to Bergey's manual, polyphasic approach of bacterial identification, 16S rRNA, genomic similarity - content of guanine (G)+ cytosine (C) (%GC), DNA-DNA homology, fatty acid analysis; general characteristics of archaea, eubacteria, acellular life forms, metagenomics, metatranscriptomics, metaproteomics and microbiome, Microbes Growth:Definition of growth, mathematical expression of growth, growth curve, diauxic & synchronous growth, continuous culture. Effect of environmental on bacterial growth

Unit-II

Prokaryotic and Eukaryotic Microbiology:General characteristics of various groups of prokaryotes: bacteria including, Rickettsiae, Chlamydiae, Spirochaetes and Actinobacteria, Cyanobacteria and Mycoplasmas. Eubacteria: cell structure, nutrition, isolation and cultivation. Diversity, nutrition, ecology, significance of Gram-positive (Firmicutes, Actinobacteria) and Gram-negative [Proteobacteria (cyanobacteria, Rhizobia), Deinococcus-Thermus, Spirochaetes, Bacteroidetes]. Mycology and phycology: General characters of fungi and algae, cultivation, cultural characteristics, microscopic morphology, importance of fungi and algae in industry and food production. Yeasts: General characteristic, structure, classification, life cycles (important forms), sexual and asexual reproduction of yeast (*Saccharomyces cerevisiae)*

Unit-III

Virology- Structure of animal viruses and plant viruses; satellite viruses; viroids; prions; diseases caused by animal viruses and plant viruses, genome organization of animal viruses; genome organization of DNA and RNA plant viruses, bacteriophages, lytic and lysogenic cycles, cultivation of viruses, diagnosis viruses, Protozoa: Classification, morphology, reproduction, modes of nutrition, modes of transmission, life cycle, cultivation of protozoa. Structure and significance: *Leishmania*, *Entamoeba*, *Plasmodium*. . Recent trends in microbiology research and techniques.

Books recommended :

1. Michael J Pelczar, Microbiology, Tata McGraw, India.
2. Microbiology by Stuart Walker, W B Saunders
3. Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses. S. J. Flint, V. R. Racaniello, L. W. Enquist, V. R. Rancaniello, A. M. Skalka.

BCH-404 Genetics Credit 3

Objectives: With the knowledge of genes are DNA, student will comprehend how DNA does duplicate, repair mutational defects and transcribe into RNA. Furthermore students will realize the molecular machineries involved in DNA replication, transcription and translation process of genetic material.

Learning outcomes: At the completion of this course, the students will be able to:

- Visualize difficult concepts regarding DNA replication and repair, transcription and translation.
- Explore many unknown players and mechanisms involved in these complex processes.
- Determine how defects in proteins of DNA replication and repair can lead to cancer
- Understand how the central dogma of molecular biology is vastly regulated in individual steps.
- Understand the timely and dynamic protein-protein, protein-DNA and protein-RNA interactions, critical for the intricate processes of central dogma
- Predict hereditary diseases caused by genetic defects

Unit-I

Laws of inheritance: Mendel's Laws, concept of dominance, segregation, independent assortment; Types of dominance Incomplete inheritance and Codominance Concept of alleles, Multiple Alleles, lethal alleles, Allelic and non-allelic interactions, Complementary gene interaction, Supplementary gene interaction, Epistasis, Physical Basis of Inheritance: Definition, Chromosome organization: centromere and kinetochore, telomere and its maintenance, Holocentric chromosomes, Heterochromatin and euchromatin, position effect variegation, Giant chromosomes: Polytene and lampbrush chromosomes, chromosomal aberrations, Extra Chromosomal Inheritance / Cytoplasmic Inheritance, Characteristic features of Cytoplasmic Inheritance, Inheritance of Mitochondrial DNA, Chloroplast DNA, Kappa articles in Paramecium, Shell coiling in snail.

Unit-II

Organization of nuclear and organellar genomes; C-value paradox, Repetitive DNA-satellite DNAs and interspersed repeated DNAs, Transposable elements, LINES, SINES, Alu family and their application in genome mapping, Sex Determination, Chromosome theory of Sex determination: XX- XY, XX-XO, ZZ-ZW, Environment induced sex determination, Hormonal control of Sex determination (Free martins), Gynandromorphs, Dosage compensation, Linkage, Definition of Linkage, Coupling and Repulsion hypothesis, Linkage group, complete linkage and incomplete linkage, Factors affecting linkage, genetic map, Sex Linkage, Meiotic behavior of chromosome and non - disjunction. Bridges theory of non-disjunction, Sex linkage in Drosophila. Sex-linked inheritance in man (Colour-blindness, Haemophilia) Crossing over, Crossing over, Molecular mechanism of crossing over - Holiday model, Crossing over in Drosophila.

Unit-III

Bacterial Genetics: Transformation, Transduction, Conjugation: F factor-mediated, Hfr and Sexduction, Human Genetics: Normal Human Karyotype, Genetic Diseases, Autosomal inheritance, X-linked linked inheritance, Y-linked linked inheritance, Pedigree analysis for the inheritance pattern of genetic diseases, Genetic Counselling, Genetics of development in Drosophila: Early development; Origin of anterior-posterior and dorso-ventral polarity: Role of Maternal genes, Zygotic genes- Segmentation genes and Homeotic selector genes, Gene pool, Hardy-Weinberg principle. Recent trends in genetics research and techniques.

Suggested readings:

1. Concepts of Genetics Klug W. S. and Cummings M. R Prentice-Hall
2. Genetics-a Conceptual Approach Pierce B. A. Freeman
3. Genetics- Analysis of Genes and Genomes Hartle D. L. and Jones E. W. Jones & Bartlett
4. An Introduction to Genetic Analysis Griffith A. F. et al Freeman

BCH-405 Molecular Biology Credit 3

Learning Objective: The course aims are to provide basic knowledge to students about DNA replication and how genes of prokaryotes and eukaryotes are transcribed and translated to protein. The students can apply this knowledge gained from the course to solve the analytical problem and enhance the interest in the field of molecular biology to pursue research.

Learning Outcome: After completion of the course, students will be able to understand

- the basic knowledge and genome organization in various life form
- Transcription and translational process in prokaryotes and eukaryotes cell.
- Regulation of gene function and repair DNA damage in maintaining life forms.
- Post Transcriptional Modifications, transport and protein stability.

Unit I

Genome organization: Organization of bacterial genome; Structure of eukaryotic chromosomes; Role of nuclear matrix in chromosome organization and function; Matrix binding proteins; Heterochromatin and Euchromatin; DNA reassociation kinetics(Cot curve analysis); Repetitive and unique sequences; Satellite DNA; DNA melting and buoyant density; Nucleosome phasing; DNase I hypersensitive regions; DNA methylation & Imprinting

Unit II

DNA Replication, Repair and recombination: DNA Replication overview, Enzymes of replication; Details mechanism of prokaryotic and eukaryotic replication; DNA damage and repair; Recombination: Homologous and non-homologous; Site specific recombination; transposable elements and retrotransposon;

Transcription: Mechanism of Prokaryotic and Eukaryotic Transcription; Operon concept-lac, trp, ara, his, and gal operons; Attenuation; Transcriptional Regulation-Positive and negative; Termination-Rho-dependent and independent; Anti-termination; Transcriptional control in lambda phage; Transcript

processing; Processing of tRNA and rRNA Eucaryotic transcription and regulation; RNA polymerase structure and assembly; RNA polymerase I, II, III; Eukaryotic promoters and enhancers; General Transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF); Activators and repressors; Transcriptional and post-transcriptional gene silencing

Unit III

Post Transcriptional Modifications: Processing of hnRNA, tRNA, rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; Mechanism of Splicing; Alternative slicing; RNA editing; Nuclear export of mRNA; mRNA stability; Ribozyme.

Translation & Transport: Translation machinery; Ribosomes; Composition and assembly; Universal genetic code; Genetic code in mitochondria; Degeneracy of codons; Termination codons; structure of tRNA ; Wobble hypothesis; Mechanism of initiation, elongation and termination; Transport of proteins and molecular chaperones; Protein stability; Protein turnover and degradation.Recent trends in molecular biology research and techniques.

Suggested Readings:

1. Benjamin Lewin, Gene IX, 9th Edition, Jones and Barlett Publishers, 2007.
2. J.D. Watson, N.H. Hopkins, J.W Roberts, J. A. Seitz & A.M. Weiner; Molecular Biology of the Gene, 6th Edition, Benjamin Cummings Publishing Company Inc, 2007.
3. Alberts et al; Molecular Biology of the Cell, 4th edition, Garland, 2002.

BCH-406 Departmental Elective 1 Credit 3

Can be selected form the list of electivesBCH-DE-1 to BCH-DE-19

BCH-407 Biology Laboratory-1 Credit 3

Course Structure

List of laboratory practical

1. To prepare different Buffer system (e.g Acetic-Na Acetate) and validate the Henderson-Hasselbach equation.
2. Qualitative and Quantitative Analysis of Carbohydrates, proteins, Vitamin C.
3. Separation of amino acids and sugars by TLC.

4. Extraction of proteins, RNA and DNA from cultured cells.
5. Protein and DNA separation by gel electrophoresis.
6. Sterilization, disinfection, safety in microbiological laboratory
7. Preparation of media (plates, broth and slants) for growth of various microorganisms.
8. Determination of growth curve of bacteria and calculation of bacterial population by turbidometry
9. Effect of pH, temperature and UV irradiation in bacterial growth

BCH-408 Biology Laboratory -2 Credit 3

Course Structure

List of laboratory practical

1. Isolation and purification of plasmid and genomic DNA from bacteria.
2. Separation of protein in SDS-PAGE
3. Primer designing and PCR amplification
4. Restriction digestion
5. Cloning of PCR product
6. Expression of the protein in the bacterial system
7. Eukaryotic cell staining, cell counting and cell proliferation
8. Arrest and observation of chromosomes after colchicine treatment in onion roots.
9. Sub cellular fractionation and marker enzymes.
10. Counting of nuclei by haemocytometer
11. Effect of colchicine on mitosis.

SEMESTER II

BCH-409 Bioenergetics and Metabolism Credit 3

Objectives: Students will learn the biochemical pathways for synthesis and breakdown of complex biomolecules and metabolic disorders arise out of malfunction of metabolic pathways.

Learning outcomes: At the completion of this course, the students will be able to:

- Estimate the energy transfer for metabolic pathways of biological macromolecules and their components

- Understand the chemical reactions for synthesis and breakdown of carbohydrates, amino acids, purines and pyrimidine, and lipids.
- Analyze the mechanistic basis for the action of selected enzymes, the thermodynamic basis for the folding and assembly of proteins and other macromolecules
- Describe the biochemistry of a variety of well-characterized human physiological processes
- Grasp key concepts of metabolic disorders and their therapeutic interventions

Unit-I

Bioenergetics- concept of enthalpy, entropy, equilibrium constant and concept of free energy, standard reduction potential, relation of Gibbs free energy and standard reduction potential, High-energy compounds, energy charge, ATP as energy currency, ATP hydrolysis, coupled reaction, Group transfer energy, potential phosphoryl donor. Thermodynamic consideration of committed steps in metabolic reactions, Thermodynamics of bonding, types of boding, hydrogen bonding, van der Waals interaction, electrostatic interaction and hydrophobic interaction, role of non-covalent interaction in the stability of biomolecules, thermodynamics of antigen-antibody interaction, thermodynamics of receptor-ligand interaction, effect on temperature on pH and buffer.

Unit-II

Energy transducing membrane, electron transport system in mitochondria, structure of different electron carrier, chemiosmotic theory, Proton Motive force, oxidative phosphorylation and ATP synthesis, P/O ratio, uncouplers, ETS inhibitors, Experimental monitoring of ETS in mitochondria, Thermodynamic consideration of ETS in mitochondria, light harvesting complex in plants and ATP synthesis in thylakoid membrane. Glycolyticpathway; regulation of the hexokinase, phosphofructokinases, Kreb'scycle; Amphibolic nature of TCA cycle, Glyoxylate cycle, glycogen breakdown, glycogen synthesis, Regulation of Glycogen Metabolism, Gluconeogenesis and its Regulation, Pentose phosphate pathways

Unit-III

Oxidation of fatty acids, beta-oxidation in mitochondria and peroxisomes, Synthesis and elongation of fatty acids, Desaturation of fatty acids in microsomes, Thermodynamics and regulation of fatty acid metabolism, Cholesterol synthesis and regulation, Composition and synthesis of lipoproteins and their transport. Denovo and salvage synthesis of purine and pyrimidine nucleotides, nucleoside triphosphates and deoxynucleotides, Degradation of purine and pyrimidine nucleotides. Thermodynamics and

regulation of nucleic acid metabolism, General reactions of amino acid metabolism, synthesis of various molecules via amino acid metabolism intermediates. Recent trends in bioenergetics and metabolismresearch and techniques.

Books recommended:

1. *Voet D., Voet J.G, Biochemistry*4th Edition., John Wiley and Sons, 2011.
2. Nelson, D. C. and Cox, M.M., Lehninger Principles of Biochemistry**,** 5thEdition,W. H. Freeman, 2010.
3. *Berg J.M., Tymoczko J.L.* and *Stryer L.,* Biochemistry. 7th edition, W.H. Freeman and Co. New York, 2011.

BCH-410 Plant physiology and Biochemistry Credit 3

Objectives: Topics in this course are taught in the context of plant biology. Manor objective of this course is to provide students with fundamental knowledge of biochemistry and specific knowledge of compounds and biochemical pathways that occur in plants.

Learning outcomes: At the completion of this course, the students will be able to:

- Understand the structure of plant cell, and apply specific biochemical functions to all compartments of the plant cell.
- Learn the structure, function and biosynthetic pathways of essential biochemical molecules including their key chemical and physical properties.
- Understand how light energy is captured and used to provide chemical forms of energy to power the functions of cells and whole plants. The importance of CO_2 fixation and carbohydrate metabolism will be presented.
- Understand central metabolism for the gr, its plant-specific components, and their functional significance at multiple levels.
- Learn about the variety of secondary compounds and metabolism in plants and how those compounds are useful to human health.

Unit-I

Water movement in plant: Plant cell Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins, stomatal movement, transpiration, photoperiodism and biological

clocks, plant movement; Photosynthesis: Photoreceptorsphytochromes,Photosynthetic apparatus, pigments of photosynthesis, Calvin cycle (C3 plants), Hatch slack (C4 plants) & CAM pathways of carbon reduction and its regulation, Structure, function and regulation of RUBISCO, Crassulacean acid metabolism in plants; Photorespiration: photorespiration pathway and significance, cyanide resistance, relationship between photosynthesis, photorespiration.

Unit-II

Phytohormones: Biosynthesis, transport, physiological effects, mode of action and signal transduction of auxins, gibberlic acid, abscisic acid, ethylene and cytokinins in germination, embryogenesis, growth and development of plant; Nitrogen metabolism: Nitrogen fixation, nitrogenise complex, biochemistry and genetics of nitrogen fixation and ammonium assimilation, structure of 'NIF' genes and its regulation, structural features of nitrate reductase and nitrite reductase, regulation of nitrate and sulphate assimilation.Secondary plant metabolites: Nature, distribution, biosynthesis and function of plant metabolites, biosynthesis of nicotine. Biochemistry of plant toxins, phytohemagglutinins, lathyrogens, nitriles, protease inhibitors, protein toxins, role of secondary metabolites in chemical defence.

Unit-III

Plant stress physiology: Plant stress, plant responses to abiotic and biotic stresses, salinity, water, heat, chilling, anaerobiosis, heavy metals, radiations and their impact on plant growth and metabolism, mechanisms of resistance to biotic stress and abiotic stress, antioxidative defence mechanism; Plant defence: Genetic basis of plant-pathogen interactions, antio R-Avr gene interactions and isolation of R genes, hypersensitive response (HR), systemic acquired resistance (SAR) and induced systemic resistance (ISR).Recent trends in Plant physiology and Biochemistry research and techniques.

Suggested Readings:

1. Introduction of Plant Biochemistry, by Goodwin T. W. and E.I. Mercer, Pergamon Press, Oxford, 1983.
2. Plant Physiology, 5th Edition, by Lincoln Taiz and Eduardo Zeiger, Amazon press, 2012
3. Introduction of Plant Biochemistry, by Goodwin T. W. and E.I. Mercer, Pergamon Press, Oxford.
4. Buchanan BB, Gruissem W & Jones RL. 2000. Biochemistry and Molecular Biology of Plants. 2nd Ed. John Wiley.
5. Dey PM &Harborne JB. 1997. Plant Biochemistry. Academic Press.
6. Heldt HS. 1997. Plant Biochemistry and Molecular Biology. Oxford Univ.Press.

BCH-411 Enzymology Credit 3

Learning objectives: This course is designed to make a detailed understanding of basic and advancement in the field of enzymology and enzyme technology

Learning outcomes: At the completion of this course, the students will be able to:

- Understand the basic principle of functioning of various enzyme the biological systems
- Lear the calculation of kinetics parameter of the enzymes that will help them in hands-on training in the industry.
- Know the interaction of various inhibitor and medicine at biochemical level
- Find out how artificial enzyme can be developed that will be current need the industry.

Unit I

Enzyme definition and characteristics; activation energy; active site and its mapping; nomenclature and classification of enzyme; cofactor and coenzyme; type of enzymatic catalysis; acid-base, nucleophilic-electrophilic covalent catalysis, kinetics of single substrate reaction, rapid equilibrium and steady-state approach, enzyme kinetics parameters (Km, Vmax, Kcat, Kcat/Km), determination of kinetics parameters using Lineweaver-Burk, Eddie-Hofstee plot, Scatchard plot; mechanisms of action of chymotrypsin, lysozyme; beta-lactamase, synthetic artificial enzymes.

Unit-II

Enzyme Inhibition; mechanism and kinetics of competitive, non-competitive and un-competitive inhibition; model of enzyme inhibitions; kinetics of bi-substrate reaction, ping-pong reaction; multi-substrate reaction; therorell chance displacement. Allosteric enzymes; symmetrical and sequential model; Isozymes and their significances; Hill's coefficients; Cooperativity, positive and negative; Hemoglobin as a model for cooperativity; Enzyme regulation and feedback control, covalent modification

Unit-III

Thermostable and cryostable enzymes; Protein engineering strategies to improve enzyme stability; CRISPR-Cas system, Engineered chimeric antibody, replacement of FC domains; catalytic antibodies (abzymes); Enzymes in bacterial resistance; Engineering of therapeutics against diseases associated enzymes; Strategies for the discovery of improved and novel enzymes for industrial applications; Enzyme immobilization techniques; Industrial important enzyme; enzyme replacement therapy.Recent trends in enzymology research and techniques.

Books recommended:

1. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry by Trevor Palmer, Publisher; Horwood Publishing Limited (2004)
2. Enzymes: A Practical Introduction To Structure, Mechanism And Data Analysis by Robert A. Copeland, publisher: Wiley (2012)
3. Introduction to Enzyme and Coenzyme Chemistry, 3rd Edition by T.D.H. Bugg, publisher Wiley-Blackwell
4. Lehninger Principles of Biochemistry, Fourth Edition, David L. Nelson and Michael M. Cox. W. H. Freeman; 4th edition (2004)

BCH-412 Immunology Credit 3

Objectives: The students will be able to identify the cellular and molecular basis of immune responsiveness. Students will be able to develop the understanding of human body protection system and they will be able to understand how humoral and cellular immune molecules are necessary for the protection from human infectious diseases.

Learning outcomes: At the completion of this course, the students will be able to:

- Students may develop the knowledge of the structure and function of the major organ systems, including the molecular, biochemical and cellular mechanisms for maintaining homeostasis.
- Students may develop the knowledge of the pathogenesis of diseases, interventions for effective treatment, and mechanisms of health maintenance to prevent disease.
- Conceptualize how the innate and adaptive immune responses coordinate to fight invading pathogens.
- Determine what immunomodulatory strategies can be used to enhance immune responses or to suppress unwanted immune responses such as might be required in hypersensitivity reactions, transplantations or autoimmune diseases.
- Explore strategies to improve existing vaccines and how to approach these.

Unit-I

Introduction to Immune system: Basic concept of immune system, cells and organs of immune system, lymphoid cells (B- lymphocytes, T- lymphocytes and Null cells), mononuclear cells (phagocytic cells and their killing mechanisms), granulocytic cells (neutrophils, eosinophils and basophils), mast cells and dendritic cell. Structure and functions of primary and secondary lymphoid organs. Innate Immunity: TLR receptors and sensing of PAMPs. Opsonization, Fc Receptors, prostaglandins and leukotrienes. Antigen,

super antigens, immunogens, adjuvents, antigen processing, antibody structure and function, classification of immunoglobulins, concept of variability, cross reactivity, isotypes, allotypes and idiotypic markers, class switching, receptor and soluble form of immunoglobulins.

Unit-II

B and T cell Immunology- B and T cell development, differentiation, maturation, clonal anergy, humoral immune response, B cell differentiation, antibody engineering, BCR and pre-BCR, Receptor editing, complement system, classical and alternative pathways, concept of histocompatibility, structure and function of class I and class II MHC molecules, structure of HLA complexes. T cell receptors, Antigen presentation cells, APC-T cell interaction, T cell differentiation in thymus, Th1, Th2, Th17, Treg cells and cytokines, chemokines, cytotoxic T cells, natural killer cells, dendritic cells.

Unit-III

Antigen dependent cell cytotoxicity, cytotoxicity reactions, CD8+ T cell cytotoxicity, autoimmunity, acquired immunodeficiency, hypersensitivity reactions, grafting and transplantation immunology, host-pathogen interaction, immunotherapy, T cell immunotherapy & B cell immunotherapy. Vaccines, different types of vaccines and its significance, monoclonal and polyclonal antibody production, hybridoma technology. Recent trends in immunology research and techniques.

Books recommended:

1. Kindt, T. J.,Osborne, B. A. and Goldsby, R. A. Kuby Immunology, 6th Edition, W. H. Freeman, 2006.
2. Abbas, A. K., Lichtman, A. H. and Pillai, S., Cellular and Molecular Immunology, 6th Edition, Saunders, 2007.
3. Roitt's, Essential Immunology. Ivan M Roitt& Peter J. Delves. 10th edition. Blackwell Publishing.

BCH-413 Departmental elective 2* Credit 3

Can be selected form the list of electives BCH-DE-1 to BCH-DE-19

BCH-414 Departmental elective 3* Credit 3

Can be selected form the list of electives BCH-DE-1 to BCH-DE-19

BCH-415 Other Department elective 3 Credit 3**

Can be selected form the courses offered by other department

BCH-416 Biology Laboratory -3 Credit 3

Course Structure

List of laboratory practical

1. Plant tissue culture
2. Test of the different phytohormone in seed germination.
3. Isolation and separation plant protein under different stress conditions.
4. Isolation of peroxidase enzyme from leave tissue and determination of specific activity
5. Estimation of total chlorophyll, chlorophyll a and chlorophyll b pigments from the leaves.
6. Estimation of starch content.
7. Estimation of carotene, ascorbic acid, phenols and tannins in fruits and vegetables.
8. Antibody titer by ELISA method.
9. Precipitin reaction by double immunodiffusion and radial immunodiffusion (Ouchterlony and Mancini's methods)
10. Separation of mononuclear cells by Ficoll-Hypaque
11. Immunodiagnostics using commercial kits
12. Blood smear identification of leucocytes by Giemsa stain

BCH-417 Biology Laboratory -4 Credit 3

Course Structure

List of laboratory practical

1. Effect of substrate concentration on enzyme kinetics of beta galactosidase or beta-lactamase
2. Determination of optimum pH for enzymatic activity of beta-lactamase or beta galactosidase
3. Determination of optimum temperature for enzymatic activity of beta-lactamase or beta galactosidase.
4. Determination of dissociation constant of inhibitor of beta-lactamase or beta galactosidase.
5. Determination of allosterism in any allosteric enzyme

6. Measurement of thermodynamics parameter during enzymatic reaction
7. Quantitative analysis of carbohydrates in food samples
8. Quantitative analysis of amino acids in milk samples
9. Quantitative analysis of lipid in the mustard oils
10. Demonstration of thermodynamically driven chemical reactions

SEMESTER III

BCH-501 Human Physiology Credit 3

Learning Objective: - To provide students with the basic and advance knowledge of functions of human organs and organ system. To make understand each organ is driving to achieve the homeostasis.

Learning Outcome: -

- By the end of this course students will understand how different organ systems will work in coordination to maintain body homeostasis.
- They will have better understanding how each of the organs physiology like Neuro endocrine system, muscle skeleton system, cardio vascular system, digestive system, urinary system work in coordination and have interconnected at the physiological level.
- Students will able to identify the critical physiological processes has been evolved from anatomical structures of different organs.

Unit I

Digestive System: Anatomy and functions of alimentary canal and digestive glands, digestive processes, food intake and regulation, enzymes secretions and their function in the oral cavity, stomach and intestine, Nutritional value of micronutrients, BMR and nutritional disorders.

Cardiovascular System: Components of blood, plasma, blood groups, Rh factor, structure and function of heart and blood vessels; cardiac cycle; origin, conduction and regulation of heart beat, cardiac disorders, ECG, lymphatic system. Respiratory System: Exchange of gases, transport of O2 and CO2 in blood, O2 and CO2, dissociation curves, control and regulation of respiration, disorders associated with respiration system.

Unit II

Nervous System: Organization of nervous system-CNS, PNS. PNS, somatic nervous system; autonomic nervous system-sympathetic and parasympathetic system; enteric nervous system, structure and function of neuron and glial cells, Synapse, nerve impulse transmission, function of

voltage-dependent and neurotransmitter-gated ion channels; the role of these ion channels in synaptic transmission, synaptic modification, and neuromodulation; molecular and cellular properties of ion channels in neurons and sensory cells and their relationship to brain and sensory systems, neurotransmitters, sense organs- gustatory, olfactory, vision, hearing, touch receptors.
Musculo-skeletal System: Components of skeletal system; skeletal organization; bone structure and function, development and growth, mechanism of bone remodelling and osteoporosis, types of muscles- smooth, cardiac, skeleton muscles, muscle contraction and theory of muscle contraction.

Unit III

Uro-Genital System: structure and function of kidney and nephron, mechanism and regulation of urine formation, haemodialysis and homeostatic imbalances in excretion, reproductive cycles, reproduction, fertilization, embryogenesis and fetus development, fate maps and amniocentesis, embryonic membrane and placentation, in-vitro fertilization, regulation of fertility
Histology and functions of endocrine glands- Pituitary, Thyroid, Adrenal, Parathyroid, Pancreas; nature of hormones, regulation of hormone secretion, effects of abnormal secretions of hormones and placental hormones, peptide hormones and steroid hormones, biochemistry of hormone action.Recent trends in human physiology research and techniques.

Books recommended:

1. A text book of Medical Physiology by Guyton. A.C., H. Sanders Philadelphia.
2. Introduction to Physiology by Davidson H and Segal M. B. Academic Press.
3. Review of Medical Physiology-William F.Ganong
4. Physiological basis of Medical Practice, John.B.West.
5. Vander's Human Physiology-The mechanism of Body function, Widmaier, Raff, strang.
6. Netter's Clinical Anatomy atlas.

BCH-502 Biophysics and Bioinformatics Credit 3

Objectives: This course is designed to make a detailed understanding of in the field of biophysics and bioinformatics mainly associated with biological system and therapeutics.
Learning outcomes: At the completion of this course, the students will be able to:

- Understand the basics of structure, properties, and dynamics of biomolecules such as Protein, DNA and lipids
- Lear the molecular basis of various diseases associated with misfolding or incorrect conformation of the biomolecules.
- Design the suitable therapeutics using in-silico approach
- Understand the different databases used for DNA, protein etc.
- Learn the phylogenetic relationship among different biomolecules.

Unit-I

Conformations of peptide and proteins, alpha and Pi helix, Turns (beta, alpha, gamma etc.), Ramachandran plot, protein folds and motifs, domains and domain swapping, protein symmetry, molecular chaperons, Structure of fibrous proteins, unnatural amino acids and peptides, peptidomimetics, intrinsically disorder proteins, Protein stability and denaturation, effect of osmolytes on biomolecules stability, protein folding- rules, pathways, and kinetics, folding of RNaseA, Levinthal Paradox, Chevron plot, Φ-value analysis, m-value analysis, protein-protein interactions, Receptor agonists and antagonists. biogenetics of amyloidogenesis, stability of extreme proteins (thermophile and cryophile)

Unit-II

Torsion angles of nucleotide, sugar conformation, DNA motifs, DNA repeats and their significance chemical structure and properties of purine, pyrimidine, nucleoside, nucleotide and their derivative, structure and properties of different type of DNA and RNA, triple-helix DNA, quadraplex DNA, higher orders of DNA structure. Effect of pH, humidity, metal & salt on the conformation of DNA, protein-nucleic acid interactions. Effect of membrane composition on the Tm of membrane, trans-membrane helices, hydropathy plot and prediction of membrane spanning domains, membrane asymmetry, membrane fluidity, detergents and membrane solubilization, functional reconstitution of artificial membranes, Membrane potentials, Nernst equation, trans-membrane potential, Zeta, Stern, Donnan's equilibrium, mechanism of membrane transport

Unit-III

Databases, multiple sequence alignment, phylogenetic clustering and analysis, protein modelling, molecular docking, identification of drug targets, In-silico drug designing, Combinatorial library, molecular mechanics; molecular dynamics simulation and force fields, ADMET analysis, Chimeric vaccine design and development, Design of hybrid antibiotics; Quantitative Structure Activity

Relationship (QSAR), 3D pharmacophore, Pharmacokinetics, pharmacogenomics, chemoinformatics and chemogenomics.Recent trends in biophysics and bioinformatics research and techniques.

Books recommended:

1. Thomas E. Creighton, Proteins: Structure and Molecular Properties, W H Freeman & Co, 2011.
2. Carl-IvarBrändén, John Tooze, Introduction to Protein Structure , Garland Pub., 1999.
3. Jack Kyte , Structure in Protein Chemistry , Garland Science, 2007.
4. David Whitford, Proteins-Structure and function , Wiley, 2005.
5. A. Kessel and Nir Ben-Tal, Introduction to Proteins-Structure, function and motion, CRC press, Taylor and Francis, 2011.
6. Georg E. Schulz, R. HeinerSchirmer, Principles of protein structure, Springer, 1998.

BCH-503 Analytical Biochemistry Credit 3

Objectives: This course is designed to make a detailed understanding of most of analytical experimental techniques that are currently used in research.

Learning outcomes: At the completion of this course, the students will be able to:

- Understand the underlying principles of diverse modern and classical techniques that are very useful in his future research.
- Perform these techniques once given chance for hands-on training.
- Know the applications and significances of techniques in biochemistry, molecular and structural biology research etc.
- Find out how these techniques have been developed over a span of several decades.
- Learn the basics of microscopy techniques

Unit-I

Gel filtration chromatography, Ion exchange chromatography, affinity chromatography, HPLC, Electrophoresis, SDS-PAGE, AGE, PFGE, Capillary electrophoresis, Centrifugation and Ultracentrifugation, RCF/RPM, Sedimentation (s);Different hybridization methods, Southern blotting, Northern blotting, Western blotting, South-western blotting, EMSA, Foot printing, Yeast Two hybrid system, Chromatin immuno-precipitation; Polymerase chain reaction, Thermostable polymerases and other component of PCR, Asymmetric PCR, methylation-specific PCR, Nested PCR, Inverse PCR, Anchored PCR, reverse transcriptase PCR, Real-time-PCR, efficiency of PCR,

Unit-II

Proteomics, Protein sequencing methods, Genomics, DNA sequencing methods, Next Generation Sequencing, Metagenomics. Species identification via r-RNA analysis, FAME analysis; Light microscope, Fluorescent microscopy, AFM, Phase Contrast microscopy, Confocal Microscopy, Electron microscopy, High resolution microscopy; Radioisotopes and its half-life, specific activity, scintillator counter, proposal counter, Geiger Muller counter, Cerenkov counter and autoradiography, Application of PET, MRI and CT scan.Molecular Marker Analysis -RFLP maps, RAPD markers, AFLP markers, VNTR, SNP analysis, SCAR (sequence characterized amplified regions), SSCP (single strand conformational polymorphism).

Unit-III

Principle and significance of UV-Vis spectroscopy, Fluorescence spectroscopy, FRET, Luminescence, Circular Dichroism, Infra-Red spectroscopy, Raman spectroscopy, Nuclear Magnetic Resonance, X-ray diffraction, Mass spectrometry; Immuno-electrophoresis, immune-precipitation, agglutination, RIA, ELISA, FACS, immune-fluorescence microscopy, Immuno-electron microscopy, Fluorescence In-situ hybridization (FISH).Recent trends in analytical biochemistry research and techniques.

Books recommended:

1. Christian, G. D., Analytical Chemistry, John Wiley & Sons (Asia) Pvt. Ltd., 2004.
2. Wilson, K. and Walker, J., Principles and Techniques of Practical Biochemistry and Molecular Biology, 7th Edition, Cambridge Univ. Press, 2010.
3. David Freifelder, Physical Biochemistry, 2nd edition, John Wiley and Sons 2005.

BCH-504 Clinical Biochemistry Credit 3

Objectives: This special course is offered to students for gaining the fundamental aspect of various human diseases along with diagnostic and prognostic measurement of disease developed.

Learning outcomes: At the completion of this course, the students will be able to:

- understand the molecular and biochemical basis of human diseases.
- know the fundamental deviation in biochemistry between metabolisms (carbohydrate, amino acid, nucleic acid and fats) of healthy and diseased person.

- acquire the basic knowledge about the diagnostic and prognostic tests for different diseases.
- design small projects for their summer or other training.

Unit-I

Quality control, accuracy, precision, specificity, sensitivity and limitation of errors allowable in the laboratory; Chemistry, composition & functions of lymph, CSF, and synovial fluid; Urine formation, excretion and urine analysis; collection of bloods, anti-coagulants, preservatives of blood; Composition, chemistry & functions of specialized tissues like i.e. bone, brain, adipose tissue, etc. Clinical investigation of sugar levels in blood and urine; factors influencing blood glucose level; carbohydrate tolerance tests, glycogen storage diseases; Biosynthesis of bile acids, bile pigments and steroid hormones, plasma lipoproteins, Disorders associated with lipid metabolism and its therapeutic intervention, ketone bodies and ketosis

Unit-II

Hemoglobin, Met-Hb, embryonic-Hb, heme metabolism associated diseases, sickle cell anemia, thalasemia, malnutrition, measurement of fuel values of foods, measurement and calculation of BMR, Metabolic disorders of amino acid metabolism and urea cycle, phenylketonuria, alkaptonuria, albinism, Lesch-Nyhan syndrome, disorders of nucleic acids metabolism Biochemical mechanism of blood clotting and hemorrhagic disorders, disseminated intravascular coagulation, acquired prothrombin complex disorders. Biochemistry of vitamins and micronutrients, biochemical basis of diseases with their deficiency

Unit-III

Electrolytes, reabsorption of electrolytes, acid-base balance, regulation of electrolyte content of body fluids and maintenance of pH, regulation of sodium and water balance, renin-angiotensin system, clinical investigation of sodium, potassium, chloride; Pathophysiology of different diseases like diabetes, Jaundice, Fatty liver, atherosclerosis, and osteoporosis; Functional test of liver, kidney, thyroid, gastrointestinal and pancreas, biochemical diagnosis of diseases by enzymatic assays; Clinical tissue analysis, biopsy, liquid biopsy, circulating RNA and DNA as molecular diagnosis of different diseases.
Recent trends in clinical biochemistry research and techniques.

Books recommended:

1. Harpers Illustrated Biochemistry 30th Edition, McGraw-Hill Education, 2015

2. Clinical Biochemistry and Metabolic Medicine Eighth Edition by Martin Andrew Crook, CRC Press, 2012
3. Textbook of Biochemistry for Medical Students, 7th edition, by D M Vasudevan, Sreekumari S, KannanVaidyanathan, 2010, Jaypee.
4. Clinical chemistry: Techniques, Principles, Correlations , 6th Edition, by Bishop, Fody and Schoeff, 2012, Lippincott Williams & Wilkins

BCH-505 Departmental elective 4* Credit 3

Can be selected form the list of electives BCH-DE-1 to BCH-DE-19

BCH-506 Other Department elective 3 Credit 3**

Can be selected form the courses offer by other department

BCH-507 Biology Laboratory -5 Credit 3

Course Structure

List of laboratory practical

1. Calculation of protein concentration using biophysical techniques
2. Calculation of molar extinction coefficient of protein using biophysical techniques
3. Purification of protein from different biological samples like bacteria, cell line etc.
4. Determination of secondary and tertiary structure of protein using biophysical techniques
5. Multiple sequence alignment of protein and DNA
6. Primer designing
7. Measurement of Blood Pressure by auscultatory method using sphygmomanometer.
8. Estimation of Hemoglobin by sahli's method using haemoglobinometer.
9. Enumeration of WBC and RBC using hemocytometer.
10. Measurement of Erythrocyte sedimentation by westergren method.
11. Determining pulmonary functions by spirometer.
12. Estimation of Prothrombin Time and International Normalized Ratio (PT/INR)

BCH-508 Biology Laboratory -6 Credit 3

Course Structure

List of laboratory practical

1. Plasma and Serum isolation
2. Determination of blood sugar, urea.
3. Determination of blood cholesterol, triglycerides.
4. Determination of blood uric acid, albumin, creatinine.
5. Determination of blood SGPT, SGOT.
6. Determination of blood SOD, Catalase activity
7. Determination of blood alkaline phosphatase activity
8. Determination of blood Ca2+, Na+ and K+
9. Paper chromatography – Separation of amino acids and carbohydrates in a mixture

BCH-509 Skill for biological data analysis Credit 2

Syllabus as per the content given by the course instructor

BCH-510 Scientific writing skill Credit 2

Syllabus as per the content given by the course instructor

BCH-511 Scientific presentation skill Credit 2

Syllabus as per the content given by the course instructor

BCH-512 Research Dissertation Credit 15

Fitness Credit 2

Offered by university. It is for all students of university. It may run for all semester.

Societal Credit 2

Offered by university. It is for all students of university. It may run for all semester.

Detail course content of electives BCH-DE-1 to BCH-DE-19

BCH-DE-1: Agricultural Biotechnology Credit 3

Objectives: This course will provide students with the recent knowledge of genetic engineering. Student should recognize the foundations of modern biotechnology and explain the principles that form the basis for recombinant DNA technology.

- Understand and explain the concept of genetic engineering including the techniques, applications and limitations.
- Demonstrate the ability to design recombinant molecules and apply information extracted from a variety of sources including journal articles, technical bulletins, product manuals, and drug information sheet to solve problems.
- Design an experiment with step-by-step instructions to address a research problem

Unit1

Food and Agriculture-Food and agriculture; Scenarios of rise in population and food production at National and International levels; Indian farming; Major crop plants; Achievements and limitations of conventional plant breeding science. Molecular Mapping and Marker-assisted Breeding-Marker-assisted plant breeding; Relative advantages/ disadvantages in conventional plant breeding and molecular breeding; Molecular polymorphism, Construction of genetic and physical map; Marker Assisted Selection (MAS) for genes of agronomic importance.

Unit II

Agrobacterium biology; Ti plasmid-based transformation; crown gall and hairy root disease, Ti and Ri plasmids, T-DNA genes, borders, overdrive, chromosomal and Ti plasmid virulence genes and their functions, vir gene induction, mechanism of T-DNA transfer; Tipasmid vectors, vir helper plasmid, super virulence and monocot transformation, binary vector; Floral dip transformation; Promoters and polyA signals; Protein targeting signals; Plant selectable markers; Reporter genes; Positive selection; Selectable marker elimination; Transgene silencing; Strategies to avoid transgene silencing.

Unit III

Genetic engineering of crops; Commercial status of transgenic plants; Herbicide resistance, glyphosate, sulfonyl urea, phosphinothricin, atrazine; Pest resistance, Bt toxin, synthetic Bt toxin; Protease inhibitor; GNA and other lectins; α-amylase inhibitor; nematode resistance; Genetic engineering for male sterility

Barnase-Barstar; Delay of fruit ripening; polygalacturanase, ACC synthase, ACC oxidase; Improved seed storage proteins; Improving and altering the composition of starch and plant oils; Golden rice for βcarotene accumulation; Production of antibodies and pharmaceuticals in plants; Recent trends in agricultural biotechnologyresearch and techniques.

Suggested Readings:

1.Altman, A. Hasegawa, P. M. (2011) Plant Biotechnology and Agriculture: Prospects for the 21st Century. Academic Press, USA.

2.Gurib-Fakim, A. (2014) Novel Plant Bioresources: Applications in Food, Medicine and Cosmetics. Wiley Blackwell, USA.

3.Kirakosyan, A. (2016) Recent Advances in Plant Biotechnology. Springer, USA.

4.Stewart, C. N. (Jr.) (2016) Plant Biotechnology and Genetics: Principles, Techniques, and Applications. Wiley, USA.

BCH-DE-2 Antimicrobial Resistance Credit 3

Objectives: The objective of this course to develop the concept of molecular basis of antimicrobial molecules, emergence of antimicrobial resistance and therapeutics developments.

Learning Outcomes: At the completion of this course, the students will be able to:

- Explain key concepts of the molecular mechanism of antimicrobial molecules.
- Understand the emergence of global antibiotic resistance in different pathogens.
- Learn to develop novel therapeutics to the antimicrobial resistant pathogens

Unit I

Antibiotics; Classification of antibiotics; Natural antibiotics; Synthetic and semi-synthetic antibiotics; Mechanism of antibiotics action (inhibition of cell walls synthesis, protein synthesis, nucleic acids synthesis, metabolic reactions); Pre-antibiotics era; Bactericidal and bacteriostatic antibiotics; Molecular targets of antimicrobial like metabolic pathways, signal transduction pathways, post-translations and epigenetic modifications; Antifungal molecules, Antibiofilm molecules, Disinfectants in hospital acquired infections; Phage therapy for bacterial pathogen; Lysin therapy

Unit II

Antibiotic resistance mechanisms; Modification of antibiotic targets, Influx channel; Efflux pumps; Beta-lactamases; Alteration in antibiotics; Intrinsic and acquired resistance; Superbugs; Antibiotics use and resistance; Resistance of existing classes targeting cell wall, ribosome, nucleic acid synthesis (replication

and transcription); Role of mobile genetic elements and genetic mutation in resistance; Transmission of mutations by vertical gene transfer, Role of horizontal gene transfer in resistance; Role of evolution and natural selection in resistance; Spread of antibiotic resistance, Factor leading to overuse and misuse of antibiotics; global antibiotic surveillance; Case study of antibiotics resistance in *Acinetobacter, Staphylococcus, Salmonella* and *Mycobacterium;* WHO reports on antibiotics resistance; Resistance mechanism against antifungal agents.

Unit III

Experimentally evolving antibiotics susceptibility and resistance; Production of natural, synthetic and semi-synthetic antibiotics; Methods & barriers of development of new antibiotic and their approval; Repurposing and modification of current antibiotics for better efficacy; Chimeric antibiotics; Enhancement of efficacy of current antibiotics (Nano-capsulation, chemical modification), Case study of discovery of antibiotics from novel sources (soil, nasal etc) and extreme environments; Nanomedicine and nano-herbal formulation for drug resistant pathogens; Databases for antibiotic resistance and virulence, Use of artificial intelligence in antimicrobial resistance. Recent trends in antimicrobial resistance research and techniques.

Books recommended:

1. Prescott's Microbiology: Willey & Sherwood.
2. Brock Biology of Microorganism: Madigan &Martinko
3. Microbiology; an introduction: Tortora & Funke
4. David Freifelder, Physical Biochemistry, 2nd edition, John Wiley and Sons 2005.

BCH-DE-3 Applied and Environmental Microbiology Credit 3

Learning Objective: The students will study the use of microorganisms and their industrial applications. Further, they will learn and understand the composition of industrial waste water and xenobiotics, and their treatment using microorganisms.

Learning Outcome:

Upon successful completion of this course the student will be able to

- Get equipped with a theoretical understanding of industrial microbiology.
- Appreciate how microbiology is applied in manufacture of industrial products.

- Appreciate the diversity of microorganism and microbial communities inhabiting a multitude of habitats and occupying a wide range of ecological habitats.
- Competently explain various aspects of environmental microbiology and microbial ecology and to become familiar with current research in environmental microbiology.
- Understand various techniques used to study Molecular microbial ecology

Unit I

Scope and historical development; Sources of industrially important microbes, strain development, Fermentation process and recovery; Downstream processing of microbial products: Filtration, centrifugation, cell disruption, liquid-liquid extraction, chromatography, membrane processes, drying (lyophilization and spray drying), and crystallization. Types of fermentation systems; Bioreactor designs and operations. Industrially important enzymes, Hydrolytic enzymes from natural microbes, Isolation and application of Extremophilic microbes like thermophilic, halophilic, acidophilic organisms and their enzymes for application in industries and agriculture.

Unit II

Microbiology of Waste-water: Occurrence and distribution of microbes in water, Concepts of C-BOD, NBOD and COD, General characteristics of industrial wastewater, Disinfection of drinking water with anti-microbial agents. Primary treatment of waste water, Methods of anaerobic treatment of sludge. Bioaccumulation of heavy metal ions from industrial effluents, Determination of LD50, Effect of heavy metals, pesticides on the microbial population in air, water and soil. Water borne risk to human health. Microbial Toxicology and Degradation of Xenobiotics: General chemistry of pollutants viz., particulate matter, poly-aromatic hydrocarbons, organosulfur, organophosphorous, organohalides, organonitrogen, organometallic compounds. Ames test to determine the genotoxicity of toxicants, Microbial tolerance and resistance against heavy metals, antibiotics and pesticides, Concepts of xenobiotics, Bio-transformation and biodegradation of xenobiotics like organophosphates and organohalides compounds, plastic, paints. Topics will deal with case studies.

Unit III

Molecular Microbial Ecology: Nucleic acid extraction from environmental samples, prokaryotic systematics: PCR and sequence analysis of amplified 16s rRNA genes, DNA Fingerprinting of microbial communities, molecular typing of environmental isolates, RT-PCR and mRNA expression analysis of

functional genes, Quantitative real-time PCR, stable isotope probing, applications of nucleic acid hybridization in microbial ecology, Fluorescence in situ hybridisation for the detection of prokaryotes.
Lessons from the genomes: microbial ecology and genomics, Metagenomic libraries from uncultured microorganisms, PCR primers for functional gene analysis, Molecular detection of fungal communities in soil, Environmental assessment: bioreporter systems, Bioinformatics and web resources for the microbial ecologist.Recent trends in applied and environmental microbiology research and techniques.

Suggested Reading

1. Cruger W and Cruger A. (2004). Biotechnology - A Textbook of Industrial Microbiology. Panima.
2. Kun LY. (2006). Microbial Biotechnology. World Scientific.
3. Baker, K.H. And Herson D.S. (1994). Bioremediation. MacGraw Hill Inc. N.Y.
4. EcEldowney, S. Hardman D.J. and Waite S. (1993). Pollution: Ecology and Biotreatment, Longman Scientific Technical.
5. Christon J. Hurst (2001). A Manual of Environmental Microbiology. 2nd Edition. ASM Publications.
6. Processes in microbial ecology, David L Kirchman, Oxford ; New York : Oxford University Press, 2012.

BCH-DE-4 **Cancer Biology** **Credit 3**

Objectives: This course is formulated to know the fundamental understanding of the molecular and biochemical basis of cancer diseases.

Learning outcomes: By the end of the completion of this course, students should be able to

- learn the basic genetic, molecular and biochemical principles of cancer diseases which which certainly lead to develop their research projects
- know the fundamental differences between non-cancerous and cancerous cells.
- acquire the biochemistry and biology of cancer incidence, development, progression, and cancer metastasis.

- gain both merit and short comings of therapy used in cancer treatment.
- know the basic principles of stem cell therapy which could be used to treat cancer diseases.

Unit-I

Introduction to Cancer Biology:Definition and classification; evolution of cancer cells; cellular oncogenes; oncogene, viral-oncogene, tumorigenicity, tumor suppressor genes; p53, Rb and PTEN, micro RNAs and regulation of cancer growth; tumor suppressor microRNAs and oncomiRs. Cancer metastasis, migration & invasion, metastasis steps, epithelial to mesenchymal transition, angiogenesis; hypoxia and crosstalk between autophagy and apoptosis in mammalian cells.

Unit-II

Microenvironment of Tumor cells: Stroma interaction, adipose stromal cells, cancer associated fibroblast, tumor associated macrophages, mesenchymal stem cells, impact of tumor-stroma interaction on tumor development, tumor immunology; interferons, T cells, cancer stem cells; origin, isolation and culture of cancer stem cells, animal models of cancer study; xenograft and metastasis models.

Unit-III

Cancer growth and metastasis: Growth factor, receptors and cancer; *in vitro* testing of stemness property of cancer stem cells; detection and monitoring of metastasis process in animal models; osteoblastic & osteolytic metastasis, Success and failure of chemotherapy, targeted specific therapy, monoclonal antibody for cancer treatment, micro-RNA mediated cancer treatment and targeted drug delivery, drug resistance, molecular diagnosis and stem cell therapy. Recent trends in cancer research and therapy.Recent trends in cancer Biologyresearch and techniques.

Books recommended:

1. The Biology of Cancer, 2nd Edition, Robert A Weingberg, ISBN-10: 0815342209, ISBN-13: 978-0815342205
2. Cancer Biology, 4th Edition, Raymond W Ruddon, ISBN-10: 0195175441 | ISBN-13: 978-0195175448

BCH-DE-5 **Developmental Biology** **Credit 3**

Learning Objective:

To familiarize with the concepts of developmental biology and evolutionary principles. To make understand the cell specification mechanism, Early developments of different model organisms like *C.elegans* ,Drosophila Amphibian , fish and mouse development. Metamorphosis of the insects and amphibian organism, Different process of regeneration.

Learning Outcome:

By the end of this course students will able to understand what are stages of the animal development. Important stages like blastula, gastrula. How the egg plays a major role in the initial development of the organism. How autonomous and conditional specification works in coordination in determining the axis and fate maps of the organism. Students will also get to know different types of the metamorphosis and mechanism,anatonomical and physiological changes associated with it. To understand about the different modes of the regeneration.

Unit I

Basic concept of development: Historical view of developmental biology, Basic features of development in animals, gametogenesis, typesof eggs, fertilization, cleavage, blastula and gastrulation, evolutionary developmental biology, principles of Karl Ernst von Baer, generation of multicellular embryo, formation of germ layers, patterning of vertebrate body plan, Fate maps and cell lineages, Cell specification: Autonomous and conditional specification, Differential gene expression: Histone , DNA, RNA and Translation level of regulation, Juxtacrine and paracrine signaling in morphogenesis, Developmental signals,

Unit II

Sex determination in mammals and Drosophila: Primary and secondary sex determination, ovary and testis pathway, Mammalian gametogenesis. Extra cellular membranes of egg. Fertilization: factors critical in external fertilization and activation, fertilization in mammals. Early development in Snails and *C.elegans*cleavage and axis formation, early developmental aspects of Drosophilla, Segmentation genes, Homeotic selector genes, early development in Sea Urchins and Tunicates, early development in Amphibians and fish, Molecular mechanisms of amphibian axis formation,

Unit III

Developmental aspects of Birds and mammals, Organogenesis, Post embryonic development: Metamorphosis in Amphibian, insects and pluteus larva, Regeneration in Hydra, Flatworms, Salamanders and mammals, Aging and senescence, Teratogenesis, Geneticerrors of human development, in-vitro fertilization, environmental assaults on humandevelopment, design of future medicines like gene therapy, therapeutic cloning and regenerationtherapy.Recent trends in developmental biologyresearch and techniques.

Books recommended:

1. Developmental Biology by Scott F. Gilbert and Michael J.F. Barresi Sinauer Associates, Inc, MA, USA, 11th Edition.
2. An introduction to embryology, B I Balinsky 5th Edition.
3. Developmental Biology by Werner A. Müller.
4. CaenorhabditisElegans: Molecular Genetics and Development, second edition, By Joel H. Rothman Academic Press, 2011.
5. A. Nagy, M. Gertsenstein, K Vintersten, R. Behringer. 2003. Manipulating the mouse embryo: a laboratory manual, Cold spring Harbor Press, New York, USA.

BCH-DE-6 Ecology and Molecular Evolution Credit 3

Ecology and Molecular Evolution

Learning Objective: The objective of this course is to understand different concepts of ecology which driving the plant and interrelation between different life forms. Second and third unit will focus on the molecular evolution living organism, various theories of the evolution.

Learning Outcome: The student will understand abiotic and biotic environmental aspects. To know the characteristics of the population and its dynamics. Intra and interspecies interactions which lead to win the competition for survival in the environment which they leave. The students will able to understand the concept of energy flow and recycling of the matter are driving force of the ecosystem to function as one unit. Awareness of the pollution and its adverse effects on

the biodiversity of this planet. In molecular evolution he will able to understand the how the life has originated and evolved with time. How species get their identity and interrelationship with other species living in same niche? How mutation will change the phase of the evolution and tackling system by the organisms.

Unit I

Abiotic environment and biotic environment, concept of habitat and niche, population characteristics, population growth curves, population regulation, metapopulation, age structures. species interactions, tropic interactions, interspecific competition, mutualism, commensalism, competition and predation. Nature of communities, community structure and attributes; levels of species diversity and its measurement; edges and ecotones, ecological succession. Dynamics of ecosystems, energy flow, nutrient cycles, trophic levels, and biomes. Major terrestrial biomes, biogeographical zones of India. Environmental pollution, global change, biodiversity and principles of conservation.

Unit II

Origin of biomolecules, abiotic synthesis of organic polymers, origin of cells, evolution of prokaryotes and eukaryotes, evolution of anaerobic and aerobic metabolism, origins of unicellular and multi cellular organisms. Concepts of neutral evolution, molecular divergence and molecular clocks, selection and genetic drift on the molecular level, molecular tools in phylogeny, classification and identification, cladistics and phonetics, mutational processes, evolution of mutation rates, protein and nucleotide sequence analysis; origin of new genes and proteins, polymorphism, SNPs, gene duplication and divergence.

Unit III

Introduction to evolution, origin of earth, origins of early evolutionary thought, Darwin's evidence of evolution, variation, struggle for existence, natural selection, migration, genetic drift and adaptation radiation, concepts of speciation, allopatric and sympatric, convergent evolution, co evolution and sexual selection, Hardy-Weinberg equilibrium, mutation and gene flow. Paleontology and Evolutionary History: The evolutionary time scale; Eras, periods and epoch; Major events in the evolutionary time scale.Recent trends in ecology and molecular evolution research and techniques.

Books Recommended:

1. Evolution: What the fossils say and why it matters, by Donald Prothero.

2. On the Origin of Species, by Charles Darwin.
3. The Blind Watchmaker, by Richard Dawkins.
4. The Selfish Gene, by Richard Dawkins.
5. Evolution and the myth of creationism, by Tim M.Berra.
6. Evolution: The Human Story, by Dr. Alice Roberts .
7. Concepts of Ecology, by Kormondy Edward J.
8. Elements of Ecology, by Smith.
9. Ecology: The Experimental Analysis of Distribution and Abundance, by KREBS.
10. Ecology Paperback, by Odum.
11. The Ecology Book (Big Ideas), by Tony Juniper.
12. The Diversity of Life, by Edward O. Wilson

BCH-DE-7 Epigenetics & stem cell biology Credit 3

Objectives: This course is designed to acquire the fundamental understanding of epigenetics and stem cells in regulation of physiological and path-physiological functions of cells/tissue/organs.

Learning outcomes: By the end of the completion of this course, students should be able to

- learn the basic role of epigenetics in controlling cellular and physiological functions.
- know the fundamental role of stem cell in the development and regeneration of tissues and its application in therapy and tissue engineering.
- acquire the basic concept of how epigenetic changes regulate the stem cell functions
- gain the concept of how environmental and biological factors regulate the physiological functions by modulating epigenetic changes in the cellular system.

Unit-I

Epigenetics: Introduction to epigenetics and physiological functions, Epigenetic control of the transcription process, DNA packaging and chromatin architecture, histone modification machinery and DNA methylation; Enzymes Involved in DNA Methylation,epigenetic control of cell-specific gene expression; epigenetic control of the mitotic cell cycle; epigenetic control of cellular differentiation. Epigenetics and cancer, abnormal patterns of DNA methylation in cancer

Unit-II

Stem cell biology: Introduction to stem cell in health and disease, and regenerating organs, Bone Marrow-Derived Stem Cells, Hematopoietic Stem and Progenitor Cells in Clinical Use, Embryonic Stem Cells, Regulation of Self-Renewal and Pluripotency of stem Cells, Induced Pluripotent Stem Cells, Adult stem cells like liver, pancreas etc, Mesenchymal Stem Cells, cancer stem cell, Drug-Resistant Cancer Cells and Side-Population Cells, Elimination of Cancer Stem Cells, Stem Cells in Tissue Engineering,

Unit-III

Epigenetic and stem cell: Epigenetic control on stem cell, from cellular totipotency to pluripotency, maintenance of pluripotency in embryonic stem cells, Nuclear Cloning and Epigenetic Reprogramming, differentiation of embryonic stem cells, Non-coding RNAs and epigenetics and stem cell; Stem cell isolation, stem cell based therapy, Tools to Analyze DNA Methylation,Global DNA Methylation Analysis, Ethics of Human Stem Cell Research, Recent trends in epigenetics and stem cell research.
Recent trends in epigenetics & stem cell biology research and techniques.

Recommended books:

1. Epigenetics by Lyle Armstrong, Garland Science, Taylor and Francis
2. T. Dittmar, K.S. Zanker (eds.), *Stem Cell Biology in Health and Disease*, Springer
3. Essentials of Stem Cell Biology, *Robert Lanza, John Gearhart,Brigid Hogan, et al, Editors*, Elsevier

BCH-DE-8 Host-Pathogen Interaction Credit 3

Objectives: The objective of this course to develop the concept of interaction of different pathogens with their host. This understanding will be helpful for the designing of therapeutics targeted to lethal pathogens.
Learning Outcomes: At the completion of this course, the students will be able to:

- Explain the basic concept of interaction of different pathogens with their corresponding hosts.
- Understand different strategies of pathogen to overcome host immune system
- Learn to design novel therapeutics for pathogens targeting to the host pathogen interaction

Unit I

Molecular basis of bacterial pathogenesis, bacterial persistence,extracellularandintracellularpathogens,virulencefactors, adhesins, pathogenicity island, protein

and DNA secreting systems in pathogenicity and disease, roleofbiofilmandquorum-sensingin virulence and disease, sensors of extracellular colonization by bacteria, bacteriophage-bacterial interaction; phage tolerance and resistance; holin-endolysin system in bacteriophage; disrupting bacterial communication and quorum sensing; Evolution of CRISPR-Cas system in bacteria

Unit-II

Modelsystemstounderstandpathogenicmechanisms, modulation of host signaling system in response to infection, mechanisms of immune tolerance and alteration of host cell behaviour by pathogens; bacterial escape to autophagy and xenophagy; Role of host-pathogen interaction in human diseases caused by bacteria (*Acinetobacter, Pseudomonas, Staphylococcus, Klebsiella, Mycobacterium, Salmonella etc.)* and virus (HIV, H1N1, Coronavirus, Dengue, Zika, Ebolla etc.); Bacterial competition and evolution in similar habitat; Hospital acquired infections and ESKAPE pathogens.

Unit-III

Human microbiome and distribution in the human body; interaction of human microbiodata with the pathogenic bacteria; molecular basis of plant microbe interactions, plant immunity to pathogen; Animal model to study host-pathogen interaction; development of therapeutics (in-silico, nano-herbal) targeting to host-pathogen interaction, methods used to study host-pathogen interactions; Diagnosis of bacterial and viral infection; Role of CRISPR-Cas system in investigating host-pathogen interaction.Recent trends in host-pathogen interactionresearch and techniques.Recent trends in host-pathogen interaction research and techniques.

Books recommended:

1. Prescott's Microbiology: Willey & Sherwood.
2. Brock Biology of Microorganism: Madigan &Martinko
3. Microbiology; an introduction: Tortora & Funke
4. David Freifelder, Physical Biochemistry, 2nd edition, John Wiley and Sons 2005.

BCH-DE-9 Infection Biology Credit 3

Objectives: Students will recognize the agents causing infectious diseases in animals and humans and also study the ways in which microorganisms cause disease and can suggest

measures for prevention and cure of infectious diseases.

Learning outcomes: At the completion of this course, the students will be able to:

- Classify different agents causing infectious diseases and understand the mode of infection, biology and life cycle of different infectious agents.
- Understand host-parasite interaction from cellular and immunological view point
- Have a detail understanding about the epidemiology and preventive methods of different infectious diseses
- Plan and carry out laboratory experiments in order to address scientific hypothesis.
- Obtain an overview on the current challenges such as drug resistance and immune evasion for treating infectious diseases

Unit-I

Viral infection: Development of HIV virus, HIV infection to humans, Structure of HIV virus, mechanism of HIV infection, role of T cells in infection development, development of therapy against HIV, anti-retroviral therapy, HAART, economic loss by HIV at national & international level. Hepatitis virus, types of hepatitis infection, viral outbreaks such as Ebolla, H1N1, and Zika virus.

Unit-II

Bacterial infection:Development of tuberculosis infection, diagnosis of tuberculosis, epidemiology and geography of tuberculosis, treatment of tuberculosis, identification of drug targets, vaccine development for tuberculosis, mechanism of antituberculosis drug action, development of resistant, multidrug resistant, economic loss by tuberculosis at national and international level, HIV-tuberculosis co-infection.

Unit-III

Parasite infection:Parasitic infectious diseases, leishmaniasis, epidemiology and geography of leishmaniasis, vector and transmission of leishmaniasis, host-pathogen interaction, diagnosis and treatment for leishmaniasis, genetics of leishmaniasis, mechanism of drug resistance and drug susceptibility for promastigotes and amastigotes, history of malaria, life cycle of *plasmodium*, factors affecting transmission of parasite, vectors and epidemics, parasite metabolisms, secondary endosymbiosis, drug resistant parasites, identification of drug targets, amoebiasis. Recent trends in infection biology research and techniques.

Books recommended :

1. Irwin W. Sherman, Malaria Parasite Biology, Pathogenesis, andProtection, American Society for Microbiology. 1998.
2. WHO technical series-949; Control of the leishmaniasis (ISBN 978 92 4 120949 6).
3. Virology: Principles and Applications John Carter, Venetia Saunders.

BCH-DE-10 Molecular Endocrinology Credit 3

Learning Objectives: The Molecular Endocrinology Elective course is designed to provide students' knowledge about hormone synthesis, action and regulation. Giving detailed knowledge about hormone receptors and signal transduction pathways. Understanding the pathophysiological relevance of different hormone receptor signalling in various diseases.

Learning Outcomes: The successful completion of the course will enable students

- To have proper understanding of endocrine system with molecular concepts.
- To understand how different hormones, regulate the homeostasis of the body.
- Understand the hormone receptors and signaling pathways initiated.
- Learn regulation of autocrine and paracrine signaling.
- Understand diseases associated with abnormal hormonal regulation.

Unit-I:

Introduction to hormones, Definition and classification. Mechanism of action of hormones and its regulation. Hypothalamic and pituitary hormones- Diabetes insipidus and Hypo and Hyper pituitarism. Pancreatic hormones-synthesis, regulation, transport, and biological actions mechanism of Glucagons, somatostatin and insulin. Introduction and biological action of gastrointestinal hormones. Thyroid hormones –transport, metabolic fate and biological actions. Hormonal regulation of calcium and phosphate metabolism. Secrection and biological actions of PTH, Calcitonin. Adrenal cortical hormones. Adrenal medullary hormones. Gonadal hormones: Regulation, transport and biological actions of androgens. Regulation, metabolism and biological effects of osterogen and progesterone - menstrual cycle- Pregnancy.

Unit-II:

Receptors and signaling pathways: cell surface receptors. G Protein coupled receptors, regulatory GTPases, heterotrimeric G proteins and effector molecules of G Proteins. Signaling molecules cAMP, cGMP. Ca2+, DAG and NO as signaling molecules, ryanodine and other Ca2+ receptors, phosphoregulation of inositol and the calcium channel activation. Ser/Thr-specific protein kinases and phosphatases. Receptor tyrosine kinases, Role of phosphotyrosine in SH2 domain binding. Signal transmission via Ras proteins and MAP kinase pathways. Signaling by nuclear receptors: nuclear functions for hormones/metabolites - orphan receptors; cytoplasmic functions and crosstalk with signaling molecules, signaling pathway of the steroid hormone receptors. Cytokine receptors- structure and activation of cytokine receptors, Jak-Stat path way, Janus kinases, Stat proteins.

Unit-III:

Signal transduction: Hormone-receptor interactions, biochemistry of receptor activation. Signal transduction through cytoplasmic and nuclear receptors.Endocrine, paracrine and autocrine signaling. Sensory Transduction: Nerve cells, synapses, ion channels, neurotransmitters, neurotransmitter receptors and impulse transmission. Rod and cone cells in the retina, biochemical changes in the visual cycle, photochemical reaction and regulation of rhodopsin. Odor receptors. Chemistry of muscle contraction-actin and myosin filaments, theories involved in muscle contraction, mechanism of muscle contraction, energy sources for muscle contraction. Recent trends in molecular endocrinology research and techniques.

Suggested readings:

1. Molecular Endocrinology: Genetic Analysis of Hormones and Their Receptors. by Gill Rumsby and Sheelagh M. Farrow (springer)
2. Biochemistry of signal transduction and regulation. by Gerhard Krauss (Wiley)
3. Signal Transduction: Principles, Pathways, and Processes Hardcover (2014) by Lewis Cantley
4. Hormone Receptors (Advances in Experimental Medicine and Biology) Paperback (2014) by David Klachko
5. Introduction to Endocrinology Paperback – 2009 by Negi and Chandra S

BCH-DE-11 Molecular medicine Credit 3

Learning objectives: The students will possess the knowledge of the changes in cellular processes and pathophysiology of infectious diseases and metabolic disorders. The course aims to provide interdisciplinary insights which have application in the development of advanced diagnosis and treatment methods.

Learning outcomes: After this course, the students will be able to:

- Acquire a broad and comprehensive understanding of the molecular mechanism of diseases and how different cellular processes of parasites be manipulated for the development of therapeutics.
- Identify the concepts of modern diagnostic technology and new concepts to meet the demand for new diagnostic methods.
- Pick up scientific thinking and exploration needed for tomorrow medicine

Unit-I

Molecular basis of fungal, protozoan, bacterial and viral interactions with the human host that leads to infection and diseases, Role of virulence factors, Pathogenicity Island, Bacterial toxins; endotoxins and exotoxins, The mode of action of antimicrobial drugs and the mechanism of antimicrobial resistance, Identification and validation of new molecular targets for better microbial therapeutics, advanced methods of microbial diagnostics.

Unit-II

Cellular and molecular basis of major complex diseases such as diabetes, cardiovascular diseases and cancer, Genetics and epigenetics in metabolic disorders, metabolic profiling, the impact of lifestyle and environment in metabolic disorders diseases, biomarker discovery, animal model of diseases, Surveillance model for epidemiology studies.

Unit III

Therapeutics drugs and classes, Peptide therapeutics, monoclonal antibodies, the pharmacodynamics of different classes of drugs, Mechanisms of toxicity, therapeutic index, mechanisms of detoxification, Medicinal plant products or secondary metabolites, Stem Cells in therapy, Gene therapy, personalized medicine, Challenges in therapeutics and vaccine development.Recent trends in molecular medicineresearch and techniques.

Books recommended:

1. Virology: Principles and Applications John Carter, Venetia Saunders,
2. Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses. S. J. Flint, V. R. Racaniello, L. W. Enquist, V. R. Rancaniello, A. M. Skalka.
3. Microbiology, Michael J Pelczar, Tata McGraw, India.
4. Introduction to Molecular Medicine, Ross Dennis W., Springer-Verlag New York Inc
5. Molecular Medicine, R.J. Trent, Academic Press
6. Molecular Medicine: An Introduction, Jens Kurreck, Cy Aaron Stein, Wiley-Blackwell

BCH-DE-12 Protozoan parasitology Credit 3

Learning objectives: The students will know protozoan parasites, their mode of transmission, and the epidemiological aspects of protozoan diseases. They will acquire adequate knowledge of parasite biology, clinical presentation, treatment, and prevention of protozoan infections.

Learning outcomes:

After this course, the students will be able to:

- Describe the common protozoan infections and their epidemiological characteristics
- Describe the biochemical and cellular mechanisms of protozoan parasite and change of cellular processes of humans infected with parasites
- Describe the molecular and immunological methods used for diagnosis of protozoan infections
- Describe the mode of actions of different drugs/vaccine used for the treatment of protozoan infections
- Describe drug resistance and drug targets for protozoan diseases

Unit-I

Protozoan parasites, Taxonomic overview, Biodiversity**,** Modes of Transmission, Specific Morphological and Physiological Adaptations of parasites, Flexible Strategies of Reproduction, Parasite–Host Coevolution, Malaria as an Example of Coevolution, Host defence system for parasites, Immune Evasion, Virulence factors

Unit-II

Cell structure of Leishmania, Life cycle, Types of leishmaniasis, Indian scenario of leishmaniasis, Epidemiology and geography of leishmaniasis, Vector and transmission of leishmaniasis, Host pathogen interaction, Diagnosis and treatment for visceral and cutaneous leishmaniasis, Mechanism of drug resistance and drug susceptibility for promastigotes and amastigotes

Cell structure of Plasmodium, Life cycle of Plasmodium, Malaria pathology, factors affecting Transmission of parasite, Vectors and epidemics, host-parasite interactions, asymptomatic malaria, host-vector interactions, parasite metabolisms, secondary endosymbiosis, Drug-resistant parasites, identification of new drug targets

Unit-III

Cell structure of Entamoeba histolytica, Life cycle, Mode of transmission, Pathophysiology, Epidemics, Host-parasite interactions, Parasite metabolisms, Mode of actions of drugs, Drug-resistant parasites, Diagnostic tools, Preventive measures

Cell structure of Trypanosoma brucei and Trypanosoma cruzi, Life cycle, Trypanosomasis, Mode of transmission, Epidemics, Host-parasite interactions, Parasite metabolisms, Mode of action of drugs, Drug-resistant parasites, Diagnostic tools, Preventive measures. Recent trends in protozoan parasitology research and techniques.

Books recommended :

1. Parasitic Protozoa, Series Editors: Julius Kreier Hardcover ISBN: 9780124260146,eBook ISBN: 9780323139182,Imprint: Academic Press

2. Protozoa and Human Disease, Mark F Wiser, Garland Science, ISBN 9780815365006
3. Protozoan Parasitism: From Omics to Prevention and Control | Book, Edited by: Luis Miguel de PablosTorró and Jacob-Lorenzo Morales' Publisher: Caister Academic Press,ISBN: 978-1-910190-83-8

4. Parasitic Protozoa: v. 3 (Parasitic Protozoa S.) by Julius P. Kreier (Editor), Publisher: Academic Press Inc,ISBN-10: 0124260136,ISBN-13: 978-0124260139

BCH-DE-13 Nanobioscience Credit 3

Learning objectives: The course is designed for mastersstudents to acquire the specific knowledge of basic sciences in the fundamentals of Nanomaterials and its application in Agriculture and medical field.

Learning outcomes: At the completion of this course, the students will be able:

To understand the application of Nanomaterials in biology and acquire the knowledge about the DNA, proteins, amino acids, drug delivery, biomedicine, etc., To provide the knowledge in basics of nanotechnology in biosciences. To make the students understand about the functional principles of nanoparticles. To provide the international/national visibilities of nano-science developments and their relevance in multi-functionalities.

Unit I

Definition of Nanomaterials, recent advances in nanomaterials.Nanoscale Science and Technology-Implications for chemistry, physics and biology. Classifications of nanomaterials-Zeolites, mesoporous materials, nanomembranes - Carbon nanotubes and graphene - Core shell and hybrid nanocomposites.Quantum Dots. Theory of advanced drug delivery: Fundamentals of Nanocarriers - Size, Surface, Magnetic and Optical Properties, Pharmacokinetics and Pharmacodynamics of Nano drug carriers. Critical Factors in drug delivery.

Unit II

Top down and bottom up approaches: Chemical approaches: Sol gel processing-Solvothermal, hydrothermal, precipitation, Spray pyrolysis, Electro spraying and spin coating routes, Self-assembly, Vapour phase deposition, self-assembled monolayers (SAMs).Preparation and Characterization of Bionanomaterials- Dendrimers, Gene transfection.pH based targeted delivery- chitosan and alginate. Copolymers in targeted drug delivery- PCL,PLA, PLGA.Magnetic nanoparticles, liposomes, niosomes, exsosomes and solid lipid nanoparticles (SLNs). Natural polymers assisted for the synthesis of the nanomaterials. Synthesis of nanoparticles usingPlants bacteria and Fungi.

Unit III

Physiochemical characterization of Nanomaterials:Basicprinciplesof UV Visible spectroscopy, Electron Spin Resonance, NMR Spectroscopy, FTIR, Zeta potential, Dynamic light scattering (DLS),Differential Scanning Calorimetry (DSC), Scanning Electron Microscopy(SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), Thermogravimetric Analysis, X-RayDiffraction.Nanotechnology in gene therapy.Nanoprobes-Nanoimmunoassay and nano-immunosensors- Immunodiagnostics for cancer and other non-communicable diseases.Diagnosis by in vivo imaging- detection of tumors, cancer and genetic defects.Nanobot medical devices. Nano-bioconjugates and their significance.Nanoscaffolds.Multifunctional Inorganic and organic nanoparticles and their biomedical applications.Nanotoxicology- Societal and Ethical Implications-Environmental Regulation. Recent trends in nanobioscienceresearch and techniques.

Books recommended:

1. K.W. Kolasinski, ―Surface Science: Foundations of Catalysis and Nanoscience‖, Wiley, 2002.
2. Nanotechnology in Biology and Medicine: Methods, Devices and Application by Tuan Vo-Dinh .CRC press, 2007.
3. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties &Applications ,Imperial College Press, 2004.
4. A. S. Edelstein and R. C. Cammarata, ―Nanomaterials: Synthesis, Properties and Applications‖, Institute of Physics Pub., 1998.
5. G.A. Ozin and A.C. Arsenault, ―Nanochemistry : A chemical approach to nanomaterials‖, Royal Society of Chemistry, 2005. 8. Physical Chemistry – Atkins Peter, Paula Julio.
6. W.Gaddand, D.Brenner, S.Lysherski and G.J.Infrate(Eds.), Handbook of NanoScience, Engg. and Technology, CRC Press, 2002.
7. Chemistry of nanomaterials : Synthesis, properties and applications by CNR Rao et.al.
8. Nanoparticles: From theory to applications – G. Schmidt, Wiley Weinheim 2004.
9. Processing & properties of structural naonmaterials- Leon L. Shaw Nanochemistry: A Chemical Approach to Nanomaterials, Royal Society of Chemistry, Cambridge UK 2005.

BCH-DE-14 Plant Functional Genomics Credit 3

Learning objectives: The objective of the course is to introduce the knowledge about complete genome information of species. The comparative genomics will predict the function of unknown gene.

Learning outcomes: At the end of the study, student will be benefitted as

- Plant functional genomics will give exposure to cutting edge biology to students.
- Structural, Comparative and Functional genomics of plants gives genome wide high throughput data information and its function.
- Proteomics, Metabolomics and System biology details global and targeted approaches, gene expression networks etc to answer the biological question.

Unit-I

Introduction to Genomics, Sequencing of Complex Genomes,Studies on model plant genomes, Sequencing generations, methods and technologies. Annotation of genomes and predictions of genes, Comparative Genomics, Small RNA world, Deep sequencing, metagenomcis

Unit-II

Introduction to Proteomics, Extraction and purification of proteins from biological samples, SDS-PAGE, 2D- Gel Electrophoresis & DIGE, NMR and LC-MS/MS Specroscopy for protein/peptide characterization, Gel based and gel free proteomics, Functional Proteomics, Organellar Proteomics

Unit-III

Metabolomics, Isolation and characterization of metabolites for Global and targeted metabolome, Introduction to systems Biology, system biology tools and modelling of biological pathways, Gene expression/Co- expression networks. Recent trends in Plant Functional Genomics research and techniques.

Books recommended:

1. Plant Genomics: Methods and Protocols, Editors: DJ Somers, P.Langridge, JP Gustafson
2. Functional Plant Genomics- J F Morot-Gaudry, P Lea, J F Briat
3. The Proteomics Protocols Handbook, by John M. Walker (Editor), Humana Press, 2005.
4. Introduction to Genomics, 2 editions. by Arthur M. Lesk, Oxford University Press,

5. Plant Systems Biology, D A Belostotsky, Springer,2009

BCH-DE-15 Plant Genetic Engineering & genome Editing Credit 3

Learning objectives: The objective of the course is to introduce the knowledge about plant genetic modification by different approaches and its biosafetyregulation.

Learning outcomes: The students will achieve

- Detailed understanding of Recombinant DNA technology and Genetic engineering principles.
- Pros and cons of Genetically modified (GM) technology and crop biotechnology.
- Concepts of genome editing in plants application and regulations.

Unit-I

Introduction to Genes and Genomes, Molecular scissors, Recombinant DNA technology, Molecular Cloning, cDNA and genomic Libraries, DNA sequencing

Unit-II

Genetic Transformation in Plants, Physical DNA delivery and Agrobacterium mediated transformation, Overexpression and antisense/RNAi technologies, Transgenic Plants, screening, Gene Integration, Molecular and Physiological characterization of transgenics, GM Plants, controversies, Regulations, Biosafety guidelines for GM Plants, Gene expression, Application of Genetic Engineering

Unit-III

Introduction to Genome Editing, Tools, TALENS, ZFN, CRISPR- CAS, Genome edited Plants, Regulations and Future of Genome Editing in Crop Biotechnology. Recent trends in plant genetic engineering & genome editing research and techniques.

Books recommended:

1. Techniques for Engineering Genes; Curell BR et al;2004
2. Recombinant DNA and Biotechnology; 2nd Ed ; Kreuzer H and Massey A ;ASM;2006
3. Plant Genetic Engineering- J H Dodds,2012
4. Genome Editing and Engineering: From TALENs, ZFNs and CRISPRs to Molecular Surgery- K. Appasani,2018
5. Molecular Cloning; 3rd Ed; Sambrook & Russel : Cold Spring Harbour Laboratory press,

NY ; 2001

BCH-DE-16 Plant Stress Biology Credit 3

Learning Objective: The objective of the course is to introduce the knowledge about plant stress and regulation under environmental stress.

Learning Outcome: At the end of the course, the students will be able to

- accumulate knowledge of biotic, abiotic stress and nutritional deficiency stress
- understand the defence mechanism in response to various stress
- acquire knowledge about miscellaneous transcriptional regulation, signalling, redox metabolism, programmed cell death and systemic acquired response in response to stress.

Unit I:

Abiotic Stress: Plant response to abiotic stress; drought and salt stress, osmotic adjustment and its role, acid soil stress, metal stress, waterlogging, light, cold and heat stress, stress-inducible proteins and genes. The role of plant growth regulators in stress tolerance mechanisms and nutrient deficiency stress and disorders in plants.

Unit II:

Biotic Stress: Plant pathology; its scope and relationships to other sciences, concept of plant diseases, pathogenicity, pathogen penetration and entry, colonization in the host, factors affecting infection. Enzymes in plant diseases; cell wall degrading enzyme, toxins in relation to plant diseases, defense mechanism. Genetics of plant-pathogen interaction; effect of environment on diseases development, epidemiology, forms of epidemics and conditions governing some of the important crop diseases.

Unit III:

Plant Stress Molecular Biology: Stress sensors; signal transduction, MAPK pathway, CDPK, and other pathways. Transcriptional regulation of stress tolerance, MYB, WRKY, NAC, bZIP and other factors. Stress responsive gene expression and phenotypic responses; Hyper sensitive response (HR), systemic acquired response, ROS generation, programmed cell death.Recent trends in Plant stress biology research and techniques.

Suggested readings

1. Buchanan, B., Gruissem, W. and Jones, R. (2000) Biochemistry & Molecular Biology of Plants. American Society of Plant Physiologists, USA.

2. Dey, P. M. and Harborne, J. B. (1997) Plant Biochemistry. Academic Press, USA.
3. Metzler, D. E. (2007) Biochemistry. Academic Press, USA.
4. Nelson D. L. and Cox, M. M. (2008) Principles of Biochemistry. W H Freeman & Co., USA.
5. Stryer L., Berg, J. M. and Tymoczko, J. L. (2006) Biochemistry. W.H. Freeman & Co., USA

BCH-DE-17 Protein Engineering Credit 3

Learning Objective: The aim of this course is to introduce methods and strategies commonly used in protein engineering.

Learning Outcome:

At the end of the course,

- Students should be able to understand and explain differences between rational design and directed evolution.
- Students will acquire knowledge about miscellaneous topics such as searches in bioinformatics databases, isolation, expression and purification of novel proteins.
- Students will also get an overview of several biophysical techniques used for analysis of secondary, tertiary and quaternary structure, as well as of screening methods used for selection of novel protein variants with improved properties.

Unit-I:

Protein structural families Introduction; Basic structural principles: amino acids and their conformational accessibilities, Ramachandran Plot; Motifs of protein structures and their packing; Schematic and topology diagrams; Families of protein structures: alpha, alpha/beta,beta, small etc, Protein folding and assembly, Protein folding pathways in prokaryotes and eukaryotes; Single and multiple folding pathways; Protein folding of single domain and multi-domain proteins; Inclusion bodies and recovery of active proteins; Osmolyte assisted protein folding; Structure of chaperones and role of chaperones in protein folding

Unit-II

Protein engineering Strategies for protein engineering; Random and sitedirected mutagenesis; Various PCR based strategies; Role of low-fidelity enzymes in protein engineering; Gene shuffling and Directed evolution of proteins; Protein backbone changes; Antibody engineering; All topics will deal with case studies.

Unit-III

Prediction and design of protein structures, Similar structure and function of homologous proteins; Role of multiple alignment; Homology and ab-initio method for protein structure prediction; Phage display systems; Yeast surface display system, Structure based drug design and case studies, Rational protein design. All topics will deal with case studies.Recent trends in Protein Engineering research and techniques.Recent trends in protein engineeringresearch and techniques.

Books recommended:

1. Introduction to Protein structure, 2nd Ed by Carl Branden and John Tooze, Garland Press, 1999.
2. Structure and Mechanism in Protein Science, Alan Fersht, Freeman, 1999.
3. Protein engineering handbook. Edited by Stefan Lutz - Uwe Bornscheuer. Weinheim: Wiley-VCH, 2009. xli, 409-9. ISBN 9783527318506.
4. Protein engineering in Industrial biotechnology, Ed. Lilia Alberghina, Harwood Academic Publishers, 2002.

BCH-DE-18 Small RNA in Health and disease Credit 3

Learning Objectives: To provide students with the basic knowledge of the functions of different small RNAs. To make them understand the importance of non-coding RNA in cellular homeostasis, prevention of diseases and crop improvement.

Learning Outcomes: At the completion of the course students will be able to

- Understand the mechanism of RNA interference
- Learn the functions of different non-coding RNAs and their relevance in physiology
- Learn siRNA vector design, siRNA delivery and genome editing
- Know about role of non-coding RNAs in different diseases including cancer, cardiovascular disease and neurodegeneration
- Understand the uses of RNAi in disease prevention and crop improvement

Unit I:

Discovery of RNA interference (RNAi): PTGS, RNAi and related phenomena. Detection of small RNAs. Mechanism of RNAi: Different components of RNAi pathway and their evolutionary conservation and role in gene silencing, RNAi-like pathway in bacteria, Molecular basis of RNAi /siRNA /miRNA mediated gene silencing. RNAi in defense and the regulation of chromatin structure and gene expression; RNAi suppressors. Computational tools for miRNA discovery, siRNA and miRNA design. Large-scale genetic analysis using RNAi: Genome-wide RNAi screens in C. elegans, and other systems, High-throughput small RNA profiling, RNAi microarrays.

Unit II:

Non-coding RNAs. Categories of non-coding RNAs: dsRNAs, siRNAs, shRNAs, piRNAs and miRNAs, Long non-coding RNA, XIST, lincRNA. miRNAs and siRNAs: Pathways, expression and functions of microRNAs, High-throughput analysis of miRNA gene expression; siRNA vectors, siRNA delivery in vitro and in vivo; RNA informatics RNA biology including RNA silencing, RNA-guided transcriptional regulation, CRISPR/Cas immunity and genome editing, telomerase biogenesis, riboswitches, exosome and editosome. Nonsense Mediated RNA Decay. RNA Editing. Alternative Splicing. RNA Secondary Structure. Bacterial ncRNAs and Riboswitches.

Unit III:

OncomiRs and Tumor Suppressor miRNAs. Expression of dsRNA in animals and plants, and its applications: RNAi vectors and generation of transgenic animals and plants, Analysis of expression of dsRNA and gene silencing. Circulating non-coding RNA in extra-cellular vesicles. Role of Long-non coding RNA in cancer, cardiovascular disease. Neurodegenerative disease. The use of RNAi in the prevention of diseases in animal models and crop improvement; RNAi therapy; Future prospects of RNAi in biology, medicine and agriculture. Breakthroughs of RNA biology in medicine and biotechnology.Recent trends in small RNA in health and disease research and techniques.

Suggested readings:

1. The RNA World TEds. TGesteland et al. CSHL Press
2. RNA Interference Technology: From Basic Science to Drug Development. Eds. Fire et al. Cambridge University Press
3. RNAi: A Guide to Gene Silencing. Ed. Gregory J.Hannon CSHL Press
4. RNA Silencing: Methods and Protocols Ed. Gordon G. Carmichael CSHL Press

5. RNA Interference in Practice Ed. Ute Schepers, Wiley-VCH GmbH & Co. KGaA.
6. Genes IX. Lewin B Jones and Barlet

BCH-DE-19 **Virology and Vaccinology** **Credit 3**

Learning objectives: This course will provide the basic and advance concepts of viral infections, outbreak of viral diseases, spread of infection to become epidemic and pandemic etc. This course will also be helpful to understand the vaccinology and its associated immunology concept.

Learning outcomes: At the completion of this course, the students will be able to:

- Understand the history and recent infections developed by the virus to the human beings.
- Identify and classify different members of human infecting viruses.
- Recognize the relationship between a virus and human disease and its mechanism.
- Predict how virus and microorganisms interact with host cells and the way in which diseases arise
- History and the future of human vaccines
- Understand how to develop different generations of vaccines to a number of viral infections.

Unit-I

Virus classifications, types of viruses, virus infection mechanism to animal cells, Development of HIV virus, HIV infection to humans, Structure of HIV virus, mechanism of HIV infection, role of T cells in infection development, development of therapy against HIV, anti-retroviral therapy, HAART, economic loss by HIV at national & international level. HIV-tuberculosis co-infection, Hepatitis virus, types of hepatitis infection, viral outbreaks such as Ebolla, H1N1, and Zika virus, emerging viral infections

Unit- II

Historical background of vaccination, Life expectancy and vaccine, vaccine preventable infectious diseases, Evolution of human infectious diseases and vaccine, Mechanism behind vaccine immunity,

mucosal immune responses to vaccines**,** Vaccines and immunological memory**,**antigens and antigenicity, Omics & databases of vaccine, Vaccine Engineering, Epitope and paratope mapping, IEDB, screening of epitope and paratope and identification of potential epitope for vaccine designing, BCL, CTL and HTL epitopes, MHC and HLA, selection of HLA/MHC for vaccine, population coverage analysis, Adjuvants, types and adjuvanticity, mechanism of adjuvant, antibody and monoclonal antibody, antibody engineering application for monoclonal antibody affinity and its mutations.

Unit-III

Integrated networking of vaccine response, Infection, immunity and vaccine, vaccine clinical trial, phase-I, phase-II, phase-III and phase-IV**,** Defining sample size, How to design, recruit volunteers for, and analyse the results of selected phase trials,vaccine manufacturing, vaccine administration, neoantigens, HIV vaccine, malaria vaccine, tuberculosis vaccine, cancer and vaccines, monoclonal antibody immunotherapy, development of new viruses (eg. Ebola, corona etc.) and role of vaccines in society, Impact of vaccines and immunization in the control of new and emerging infectious diseases, venoms and toxoid in vaccination. Recent trends in virology and vaccinology research and techniques.

Books recommended:

1. Vaccinology: Principles and Practice, by W. John W. Morrow, Nadeem A. Sheikh, Clint S. Schmidt, D. Huw Davies
2. Introduction To Molecular Vaccinology by GIESE M, SPRINGER
3. Modern Vaccinology by EdouradKurstak

BCH-DE-20 **MOOC** **Credit 3**

A suitable MOOC course can be opted by students.