Department of Biochemistry

School of Life Sciences

Syllabus for

Integrated M.Sc. Biochemistry

(Academic session 2019-2020)

Central University of Rajasthan NH-8, Bandarsindri, Kishangarh-305817

Dist. Ajmer

Course Structure: Semester I-X

Semester	Course Code	Title	Credits	Total Credits
I	BIO-101	**Biology-I (T) Diversity of Life**	3	**18**
	BIO-102	**Biology Practical-I (P)**	1	
		Chemistry*	3+1=4	
		Mathematics*	4	
		Physics*	4	
		English*	2	
			18	
II	BIO-103	**Biology-II (T) Techniques for Biology**	4	**18**
		Chemistry*	3+1=4	
		Mathematics*	4	
		Physics*	2+2=4	
		English/ICT*	2	
			18	
III	BIO-201	**Biology-III (T) Biochemical Constituents of Life**	4	**18**
		Chemistry*	3+1=4	
		Physics*	4	
		Environmental Science*	3	
		Open Elective II-(offered by the Social Science Department) *	3	
			18	
IV	BIO-202	**Biology-IV (T) Structural Organization of Life**	3	**18**
	BIO-203	**Biology Practical-II (P)**	1	
		Chemistry*	3+1=4	
		One Subject out of Maths/Physics/Statistics/CS/Economics*	4	
	BIO-204	Open Elective-I (offered by the any Science Department) **Ecology and Evolution**	3	
		Open Elective-II (offered by the Social Science Department) *	3	
			18	
V	BIO-301	**Biology-V (T) Functional Organization of Life**	3	
	BIO-302	**Biology-VI (T) Reproductive Biology**	3	
	BIO-303	**Biology-VII (T) Genetics**	3	**18**
	BIO-304	**Biology Practical-III (P)**	3	
	BIO-305	Open Elective-I (offered by the Science Department) **Laboratory safety, Ethics in Bio-Sciences and Intellectual Property Right**	3	
		Open Elective-II (offered by other than Science Department) *	3	
			18	
VI	BIO-306	**Biology-VIII (T) Interactive Biology**	3	**18**
	BIO-307	**Biology-IX (T) Introduction to Gene Technology**	3	
	BIO-308	**Biology-X (T) Trends in Biology**	3	
	BIO-309	**Biology Practical-IV (P)**	3	
		Open Elective I- (offered by the any Science Department) Current Trends in Environmental Sciences	3	
		Open Elective II- (offered by other than Science Department) *	3	
			18	

Semester VII

Code	Title of the course	Type of Course	Credits
BCH-401	Fundamentals of Biochemistry	Core	3
BCH-402	Molecular Genetics	Core	3
BCH-403	Cell Biology	Core	3
BCH-404	Microbiology	Core	3
BCH-405	Bioenergetics	Core	3
BCH-406	Human Physiology	Core	3
BCH-407	Biochemistry Practical	Core	3
BCH-408	Microbiology Practical	Core	3
	Course offered by other departments	Open elective*	#

Total credits: 24

Semester – VIII

Code	Title of the course	Type of Course	Credits
BCH-409	Immunology	Core	3
BCH-410	Developmental Biology	Core	3
BCH-411	Plant Biochemistry	Core	3
BCH-412	Enzymology and Protein Engineering	Core	3
BCH-413	Elective I A. Cancer biology B. Neurobiochemistry C. Pharmaceutical Biochemistry	Elective	3
BCH-414	Elective II A. Molecular Medicine B. Infection Biology		
BCH-415	Immunology Practical	Core	3
BCH-416	Enzymology and Plant Biochemistry Practical	Core	3
BCH-417	Health Awareness	Open elective*	#

Total credits: 24

Semester – IX

Code	Title of the course	Type of Course	Credits
BCH-501	Clinical Biochemistry	Core	3
BCH-502	Genetic Engineering	Core	3
BCH-503	Biophysics and Bioinformatics	Core	3
BCH-504	Bioanalytical Methods	Core	3
BCH-505	Biosafety, Laboratory safety and IPR	Core	3
BCH-506	Elective III A. Environmental Biochemistry B. Evolutionary Biology	Elective	3
BCH-507	Molecular Biology Practical	Core	3
BCH-508	Clinical Biochemistry Practical	Core	3
BCH-509	Fundamental of Research Methodology	Open elective*	#

Total credits: 24

Semester – X

Code	Title of the course	Type of Course	Credits
BCH-510	Journal Club Presentation	Tutorial/Presentation	3
BCH-511	Review of Literature and Project Proposal	Tutorial/Presentation	3
BCH-512	Major Project (Research Dissertation)	Tutorial/Laboratory	15
BCH-513	Research Dissertation Presentation	Tutorial/Presentation	3

******* *Open electives are not compulsory and will not be considered for course requirement*

 # Credits may vary for open elective offered by other departments as per their syllabus.

Semester I

BIO-101 **Biology-I (T) Diversity of Life** **Credits 3**

Course Structure

Unit I: Microbial Diversity and Diversity in Lower Plants
Bacteria: General characteristics, cell structure of bacteria and their components, mycoplasma, archaebacteria, cyanobacteria, microbes in extreme environments. Fungi: General characteristics and classification Viruses: General characteristics and classification.
Diversity in Lower Plants: General characteristics, reproduction, classification and economic importance of algae, lichens, bryophytes and pteridophytes, alternation and generation in bryophytes and pteridophytes, vascular system in pteridophytes, economic importance of bryophytes and pteridophytes.

Unit II: Diversity in Higher Plants and Diversity in Lower Animals
Diversity in Higher Plants: General characteristics, reproduction, classification of gymnosperms, life cycle of gymnosperms and angiosperms, salient features of botanical nomenclature, economic importance of gymnosperms and angiosperms.
Diversity in Lower Animals: General characteristics, classification of various groups of protozoans, porifera, coelenterate, helminthes, annelida, arthropoda, mollusc, and echinodermata. Canal system in sponges, polymorphism of sponges, different larvaes, classification, mechanism of formation, and significance of coral reefs.

Unit III: Diversity of Higher Animals
General features of hemichordates, cephalochardates & urochardates. General characters and classification of pisces, amphibia, reptilia, aves, and mammalia, parental care in fishes and amphibia, poison apparatus and biting mechanism of poisonous snakes, identification of poisonous and non-poisonous snakes, flight adaptation of birds, dentition in mammals, connecting links, flying and aquatic mammals.

Suggested Readings

1. Ananthanarayan and Paniker (2017) A text book of Microbiology, :10th Edition. Orient Blackswan Publisher, Delhi
2. Nigam HC. (2017) Biology of Chordates, 25th Edition Vishal Publishing Co.
3. Cambell and Reece: Biology (2016) Biology 11th Edition, Pearson
4. Kotpal, R.L. (2016) Modern Textbook of Zoology - Invertebrates Rastogi Publications, Meerut.
5. Willey, J. Sherwood L, Woolverton C, (2016), Prescott Microbiology. 10th Edition, McGraw-Hill Publisher, Columbus, OH
6. Kotpal RL. (2015) Modern Textbook Of Zoology Vertebrates. Rastogi Publications
7. Singh, Pandey, Jain. (2011). A Text Book of Botany- Rastogi Publication.
8. Ganguly, Das & Dutta. College Botany. (2011) New Central Book Agency.
9. Pelczar Mi J., Chan, E.C.S., Krieg, NR, (2009). Microbiology, McGraw-Hill publication

BIO-102 **Biology Practical-1** **Credit 1**

Course Structure

List of laboratory practical
1. Specimen observation of Bacteria and viruses.
2. Microscopic observation of algae and cyanobacteria/

3. Specimen observation of bryophytes and pteridophytes.
4. Study of transverse sections/chart of the following: Sycon (as an example of Parazoa to show its structure, spicules and canal system), Hydra (as an example of diploblastic animal), Fasciola (as an example of triploblastic acoelomate animal), Ascaris (as an example of triploblastic pseudocoelomate animal), Hirudinaria (as an example of triploblastic schizocoelomate animal), Frog (as an example of triploblastic enterocoelomate animal)
5. Study of salient features and classification up to classes of the non-chordates with special emphasis on their adaptive characters using museum specimen.
6. Study of salient features and classification up to classes of the chordates using museum specimens.

Semester II

BIO-103 **Biology-II (T) Techniques for Biology** **Credits 4**

Course Structure

Unit I: Chromatography and Centrifugation
Introduction to chromatography, paper chromatography, gel filtration, ion-exchange chromatography, affinity chromatography, hydroxyapatite chromatography, introduction to centrifugation techniques, differential and density gradient centrifugation, separation of different organelles

Unit II: Analysis of Biomolecules
Characterization of proteins and nucleic acids; different electrophoresis like AGE, PAGE, different gel staining methods, auto-radiography, electrophoretic mobility shift assay, chromatin immuno-precipitation.

Unit III: Microscopy
Principles and application of light microscope and electron microscope, magnification and resolution power, An introduction to advance microscopies like fluorescence, confocal, AFM, and cryo-electron microscopy.

Unit IV: Spectrophotometry
Principle and applications of UV-Vis Spectroscopy, An introduction to advance spectrometry like fluorescence, circular dichroism, NMR and mass spectrometry.

Suggested Readings

1. Wilson K, Goulding KH. (2018) Principles and Techniques of Biochemistry and Molecular Biology, Eight Edition , Edited by Hofmann A, Clokie S. Cambridge University Press
2. Plummer DT. (2017) An Introduction to Practical Biochemistry. 3rd Edition McGraw Hill Education
3. Philips, R. Kondev J, Theriot J, Garcia H. (2012). Physical Biology of the Cell. 2nd Edition Garland Science.

Semester III

BIO-201 **Biology-III (T) Biochemical Constituents of Life** **Credits 4**

Course Structure

Unit I: Basics of Biochemical Reactions

Concept of different chemical interactions: covalent and non-covalent interactions and their importance in biological system, physical properties of water, concept of acid and bases, pH and buffer, definition of enzymes, co-enzymes, an introduction to kinetic parameters.

Unit II: Carbohydrate and Lipids Chemistry
Structure of classification of monosaccharides, disaccharides, and polysaccharides, reducing and non-reducing sugars, classification of lipids, fatty acids, triglycerides, phospholipids, water and fat-soluble vitamins.

Unit III: Protein and Nucleic acid Chemistry
Structural features of amino acids, classification of amino acids, peptide, structure of polypeptide, Ramachandran plot, protein folding, Structure of purine, pyrimidine, nucleoside & nucleotides, different types of DNA and RNA.

Unit IV: Organization of DNA into chromosomes and its function
Structure of chromatin and chromosomes, DNA replication of prokaryotes and eukaryotes, transcription, translation, regulation of gene expression: transcriptional, translational and post-translational.

Suggested Readings

1. Nelson DL, Cox MM (2017) Lehninger Principles of Biochemistry, 7th Edition. W. H. Freeman
2. Stryer L, Berg JM, Tymoczko JL. Gatto GJ. (2015) Biochemistry, 8th Edition. W. H. Freeman
3. Satyanarayana U, (2013), Biochemistry Elsevier
4. Voet DV, Voet JG. (2011) Biochemistry, Wiley
5. Karp G. (2015) Cell and Molecular Biology: Concepts and Experiments.5th Edition. John Wiley Publication.

Semester IV

BIO-202 Biology-IV (T) Structural Organization of Life Credits 4

Course Structure

Unit I: Cell Organization, cell cycle and signaling
Eukaryotic sub-cellular components: Nucleus, chromosomes, plasma membrane, endoplasmic reticulum, lysosomes, peroxisomes, Golgi apparatus, mitochondria, chloroplast, cytoskeleton.Mitosis and meiosis, cell cycle, cell-cell adhesion, extracellular matrix, interaction and communication between the cells (animal, plant and bacteria), cell signaling, differentiation and organogenesis.

Unit II: Plant Anatomy
Plant cell wall and membranes; plant structure organization, anatomy of root, stem and leaves, floral parts, embryo and young seedlings, meristems, vascular system in plants, life cycle of an angiosperm, pollination, fertilization, embryogenesis, seed formation, cellular totipotency, clonal propagation, organogenesis and somatic embryogenesis, in-vitro fertilization.

Unit III: Animal Anatomy-I
Organizational level of animal body structure and function: tissue, body cavities, anatomy of integumentary, skeletal (articulations), muscular (skeletal, smooth & cardiac muscles), nervous (CNS and PNS; cranial nerves), sensory (eye, ear, nose, tongue).

Unit IV: Animal Anatomy-II

Cardiovascular (heart and blood vessels), blood circulation, lymphatic, Respiratory (structure of organs of respiration), digestive, urinary, male and female reproductive systems.

Suggested Readings

1. Nelson DL, Cox MM (2017) Lehninger Principles of Biochemistry, 7th Edition. W. H. Freeman
2. Stryer L, Berg JM, Tymoczko JL. Gatto GJ. (2015) Biochemistry, 8th Edition. W. H. Freeman
3. Grisham CM, Garrett RH. (2012) Biochemistry. 6th Edition. Brooks Cole
4. Voet DV, Voet JG. (2011) Biochemistry, Wiley
5. K.L. Moore, A.R. Delley. A. M. Abgur. (2017) Clinical Oriented Anatory. Lippincott Williams and Wilkins; Eighth, North American Edition.
6. Koelling C. (2016) Plant Anatomy, Morphology and Physiology. Syrawood Publishing House
7. Tortora GJ, Derrickson BH. (2013) Principles of Anatomy and Physiology. John Wiley & Sons.
8. David F. Cutler, Ted Botha, Dennis Wm. Stevenson. (2009) Plant Anatomy; An applied approach. Wiley –Blackwell Publication.
9. Pelczar Mi J., Chan, E.C.S., Krieg, NR, (2009). Microbiology, McGraw-Hill publisher
10. W. C. Dickson. (2000). Integrative Plant Anatomy. Academic Press

BIO-203 **Biology Practical-II (P)** **Credits 3**

Course Structure

List of laboratory practical

1. Study of Floral characters and Floral diagram of representative member of some families: Malvaceae, Brassicaceae, Asclepiadaceae, Solanaceae, Euphorbiaceae, Poaceae
2. Study of type of ovary, ovules, placentation types, types of pollen grains and stages of dicot embryo.
3. Transverse section of leaf, stem and root for different plants in University campus.
4. Demonstration of phenomenon of osmosis and diffusion.
5. Demonstration of functioning of heart using model.
6. Counting of red blood corpuscles and white blood corpuscles
7. Determination of hemoglobin content.
8. Demonstration of blood grouping.
9. Identification of amino acids in the mixture using paper chromatography
10. Principle & operation of Spectrophotometer, Verification of Beer's Law Spectrophotometrically and Qualitative tests for identification of sugars
11. Estimation of protein by Biuret method and Folin Lowry method
12. Observation of permanent slides of mitosis and meiosis.

Open Elective I

BIO-204 **Ecology &Evolution** **Credits 3**

Course Structure

Unit-I: Ecological Factors, Population and Community

Ecological factors, Laws of limiting factors- Liebig's law of minimum, Shelford's law of tolerance. Structure and composition of atmosphere, hydrosphere, lithosphere and biosphere, Levels of organization- species, population characteristics, species interactions: predation, herbivory, competition, parasitism, mutualism and commensalism. Population regulation, community characteristics, ecotone, edge effect & ecological Successions.

Unit-II: Ecosystem Ecology
Ecosystem - concept, structure (biotic and abiotic), food chain, food web, ecological efficiency, energy flow and production. Fixation of solar energy and sustenance of trophic levels, measurement and efficiency of primary production and secondary production, biogeochemical cycles, succession, homeostasis and stability of ecosystem. Microbial community in biosphere, biofilm and its ecological implication, microbial diversity, extremophiles.

Unit-III: Evolution and Conservation Biology
Concept of evolution and theories- Lamarckism, Darwinism, Neo Darwinism, isolation, mutation, speciation, germplasm and genetic drifts, Geographical range of species and range extensions, Concepts of neutral evolution, molecular divergence and molecular clocks; Molecular tools in phylogeny, classification and identification; Gene duplication and divergence. Biodiversity and conservation: hotspots, causes of depletion, conservation methods and endangered species, wild life of India and its conservation.

Suggested Readings

1. Botkin, Daniel B. and Keller, Edward A. (2014). Environmental Science: Earth as a Living Planet. 6th ed. John Wiley & Sons.
2. Krebs, C. (2008) The Ecological World View. CISIRO Publishing
3. McArthur, (2006) Microbial Ecology, Elsevier.
4. Odum, E.P. (2005) Fundamentals of Ecology. Cengage.

Semester V

BIO-301 Biology-V (T) Functional organization of Life-Physiology Credits 3

Course Structure

Unit I: Microbial Physiology
Common nutrient requirements and nutrient uptake in microbes, microbial growths- measurement, growth curve, effect of environmental factor on growth. An introduction to metabolism of carbohydrates, nucleic acid, lipids and proteins, microbial electron transport system

Unit II: Plant Physiology
Water movement in plant, transpiration, photosynthesis, respiration and photorespiration, nitrogen metabolism, physiological effects and mechanisms of action of plant hormones, photoreceptors- phytochromes, cryptochromes and phototropins, photoperiodism

Unit III: Animal Physiology
Exchange and transport of gases, regulation of respiration, physiology of circulatory system, physiology of execratory system, organization of nervous system, synapses and synaptic transmission, endocrine and exocrine glands, hormones, regulation of hormone secretion, mode of action, effects of abnormal secretions of hormones and placental hormones.

Suggested Readings

1. K.L. Moore, A.R. Delley. A. M. Abgur. (2017) Clinical Oriented Anatory. Lippincott Williams and Wilkins; Eighth, North American Edition.
2. Koelling C. (2016) Plant Anatomy, Morphology and Physiology. Syrawood Publishing House
3. Willey, J. Sherwood L, Woolverton C, (2016), Prescott Microbiology. 10th Edition, McGraw-Hill Publisher, Columbus, OH
4. Barrett K, Brooks H, Boitano S, Barman S. (2015) Ganong's Review of Medical Physiology, Twenty-Fifth Edition (Lange Medical Book)
5. Hall JE. (2015). Guyton and Hall Textbook of Medical Physiology, 13th Edition. Elsevier.
6. Tortora GJ, Derrickson BH. (2013) Principles of Anatomy and Physiology. John Wiley & Sons.
7. Taiz L, Zeiger E. (2010). Plant Physiology Fifth Edition, Sinauer Associates, Inc

8. Reddy, Rao, Reddy, Reddy, Chary. (2007). University Botany III (Plant Taxonomy, Plant Embryology, Plant Physiology), New Age International.
9. Trivedi PC. (2006) Advances in Plant Physiology; I. K. International Publishing House.

BIO-302 Biology-VI(T) Reproductive Biology Credits 3

Course Structure

Unit I: Microbial Reproduction
Basic of microbial reproduction, Bacterial- Conjugation, transformation and transduction and Fungal reproduction- vegetative, asexual, and sexual, Algal Reproduction: vegetative, asexual and sexual. Viral reproduction: lytic and lysogenic cycle, reproduction of phages, Protozoan Reproduction (Amoeba, Paramecium and Plasmodium).

Unit II: Plant Reproductive and Developmental Biology
Reproductive development, induction of flowering, flower as a modified determinate shoot. flower development, genetic and molecular aspects, anther and pollen biology, pollination and fertilization, seed and fruit development, seed structure, types and their dispersal mechanisms.

Unit III: Animal Reproductive and Developmental Biology
Reproductive strategies and reproductive cycles in vertebrates, spermatogenesis, oogenesis, hormonal regulation in gametogenesis in male and female, physiology of male and female reproduction, mechanism of fertilization, types of eggs and pattern of cleavage, gastrulation and fate map, comparison of cleavage and gastrulation in sea urchin, frog and chick embryos, In-vitro fertilization, embryo transfer technology.

Suggested Readings

1. Gilbert SF, Barresi MJF, (2016), Developmental Biology 11th Edition Sinauer Associates
2. Albertis B, Jhonson A, Lewis L, Morgan D, Raff M, Roberts K, Emeritus, Walter P, (2014) Molecular Biology of the Cell. 6th Edition, Garland Science
3. Bhojwani, S.S. and Bhatnagar, S.P. (2014). The Embryology of Angiosperms, Vikas Publishing House. Delhi.
4. Karp G. (2007) Cell and Molecular Biology. John Wiley Publication.
5. Shivanna, K.R. (2003). Pollen Biology and Biotechnology. Oxford and IBH Publishing Co. Pvt. Ltd. Delhi.
6. Raghavan, V. (2000). Developmental Biology of Flowering plants, Springer, Netherlands.

BIO-303 Biology-VII(T) Genetics Credits 3

Course Structure

Unit I: Basic of Genetics
Introduction to genetics, pre-Mendelian, Mendelian and non-Mendelian inheritance, genetic linkage, recombination and crossing over, chromosomal basis of inheritance, mutations and mutagenesis, genetic basis of sex determination, extra-nuclear inheritance, exchange of genetic material.

Unit II: Molecular Genetics
Plasmid replication, copy number control, incompatibility, maintenance, curing & function, distribution & importance. Composite transposons, replicative and non-replicative transposons, Tn-transposons and

evolution, mobile genetic elements, methods of genetic transfer: Transformation, Conjugation, Transduction and sexduction, mapping genes by interrupted mating, fine structure analysis of genes.

Unit III: Human Genetics and Population Genetics

Chromosomal abnormalities: aneuploidy, translocation and deletion. Genetic counseling. Hardy-Weinberg principle, evolutionary agents, selection, fitness, migration and random drift, modes of speciation (allopatric and sympatric).

Suggested Readings

1. Snustad DP, Simmons MJ. (2015) Principles of Genetics, 7th Edition , Wiley.
2. Albertis B, Jhonson A, Lewis L, Morgan D, Raff M, Roberts K, Emeritus, Walter P (2014) Molecular Biology of the Cell. 6th Edition, Garland Science
3. Anthony J.F. Griffiths, Susan R. Wessler, Sean B. Carroll and John Doebley. (2011) Introduction to Genetic Analysis: International Edition.
4. Brown TA. (2011) Introduction to Genetics: A Molecular Approach. Garland Science
5. Karp G. (2007) Cell and Molecular Biology. John Wiley Publication.

BIO-304 Biology Practical- III Credits 3

Course Structure

List of laboratory practical

1. Study of cross-section of reproductive structure of flowering plants.
2. Preparation of different media for bacterial and fungal isolation.
3. Demonstration of Autoclave, laminar air flow, hot air oven, centrifuge and pH meter: principle and its working
4. Demonstration of serial dilution, pouring, plating and streaking.
5. Identification of micro-organisms: simple staining, differential staining, acid fast staining, capsule staining, spore staining and motility
6. Demonstration of microbial reproduction, Bacterial- Conjugation, transformation and transduction.
7. Demonstration of mendalian genetics using pea plant and drosophila
8. Qualitative and Quantitative studies of Plant communities.
9. Demonstration of food web from the given set of data, (Representative of a natural ecosystem).
10. Field activity for construction of ecological pyramids of number, biomass, energy from the given set of data (Representative of a natural ecosystem).

BIO-305 Open Elective I: Laboratory safety, Ethics in Bio-Sciences and Intellectual Property Rights Credits 3

Course Structure

Unit I. Laboratory Safety

Laboratory safety guidelines and regulations, standard operating protocols (SOP),use of Genetically Modified Organisms (GMOs) and their release in the environment. Laboratory safety measures for production of transgenic organisms. Hazardous Materials used in Bio-sciences, their Handling and Disposal. Good Laboratory Practice (GLP) and Good Manufacturing Practice (GMP).

Unit II. Bioethics

Introduction to bioethics, ethical Issues in Genetic Manipulations and Genetically Modified Organisms: foods and crops, GMO labeling, Ethical issues involved in stem cell research and use. Use of animals in research and testing and alternatives for animals in research. Animal cloning, human cloning and their ethical Aspects. Testing of drugs on human volunteers. Organ transplantation and ethical issues. Ethical, legal and social implications of Human Genome Project

Unit III Intellectual Property Right

Intellectual Property Rights. Introduction to Patent and Process Involved in Patenting. Patenting Living Organisms, Patent of agricultural technology, and their implications for India and other developing countries. Copyright, trademark, trade secret, Traditional Knowledge and Geographical indication. Commercial Exploitation, and Protection of IPR. Participation in Biosafety and Protection of Biodiversity. Indian Biodiversity Act

Suggested Readings

1. Singh. B.D. 2010 Biotechnology Expanding Horizons, Third Edition, Kalyani Publishers
2. Bioethics and Biosafety in Biotechnology by Sree Krishna V., New Age International (P) Ltd., Publ., Mumbai. 2007
3. Intellectual Property Rights by Deborah E. Bouchoux., Delmar Cenage Learning. 2005
4. Biodiversity and Conservation by G. Melchias, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 2001
5. An Advanced textbook on Biodiversity: Principles and Practice by K.V. Krishnamurthy, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 2003.
6. The Indian Environmental Protection Act (EPA), 1986
7. Rules for manufacture, use/import/export and storage of hazardous microorganisms or cells Act, 1989
8. Food Safety and Standards act (Government of India), 2006
9. Intellectual Property Rights on Biotechnology by Singh, KC, BCIL, New Delhi

Semester VI

BIO-306 **Biology-VIII (T) Interactive Biology** **Credits 4**

Course Structure

Unit I: Plant-Microbe Interaction

Basic concepts of plant pathology and phytobacteriology, mutualism, commensalism, parasitism, Plant microbe symbiotic interactions. Plant pathogen interactions**,** Bacterial plant diseases, their symptoms, and control, general concepts of plant immunity, Virulence determinants of plant pathogenic bacteria, plant immunity, application of plant-microbe interaction in genetic engineering.

Unit II: Animal- Microbe Interaction

Interaction of host and microbes process of recognition and entry in host cells by different pathogens, human microbiome and their symbiotic relation, rumen ectosymbiosis, Host parasite relationship, microbial diseases in animals, alteration of host cell behavior by pathogens.

Unit III: Human Immunity

Introduction to immune system, innate and acquired immunity, antibody, major histocompatibility complex, complement systems, T and B-cell maturation and differentiation, antigen processing and presentation, hypersensitive reaction and autoimmune disease.

Unit IV: Microbial Response to antimicrobial therapeutics

History of antimicrobial discovery, antibiotics used to control animal and plant pathogens, mode of action of antimicrobial molecules and response of pathogen, modulation of the host immune response, evolution of virulence and resistance of bacteria, virus and other pathogens.

Suggested Readings

1. Willey, J. Sherwood L, Woolverton C, (2016), Prescott Microbiology. 10th Edition, McGraw-Hill Publisher, Columbus, OH
2. Pelczar Mi J., Chan, E.C.S., Krieg, NR, (2009). Microbiology, McGraw-Hill publisher
3. Kuby, J. (2006) Immunology 6th Edition W.H. Freeman and Company, New York

BIO-307 Biology-IX (T) Introduction to Gene Technology Credits 4

Course Structure

Unit I: Cloning and Expression Vehicles
Enzymes in DNA manipulation, restriction digestion, ligation (adapters, linkers etc.) and transformation (chemical, physical and biological; transformation efficiency, competence), vectors & hosts of RDT: plasmid, phage, cosmid, phagemid, YAC, BAC, Ti plasmid vectors, cloning and expression, vector for bacterial, plant and animal systems.

Unit II: **Tools for Gene Technology**
Polymerase Chain Reaction: general concept, primer designing, PCR efficiency, various types (Gradient, Inverse, Multiplex, Reverse Transcriptase PCR, real time PCR), PCR product cloning, 5' and 3' RACE, molecular cloning of DNA or RNA fragment in bacterial and eukaryotic (plant & animal) systems.

Unit III: **Protein Expression in Bacteria, Animal and Plants**
Expression of recombinant proteins using bacterial, animal and plant vectors. Over expression of proteins in bacteria, plant and animal-general idea, basic idea of protein engineering, protein array & their applications.

Unit IV: Genetically Engineered Organism and Gene Therapy.
Strategies for gene transfer to plant cells, generation and significance of transgenic plants, production of transgenic mice, ES cells can be used for gene targeting in mice, transgenic animals, basic introduction to knocked down, knocked-out, gene editing and gene therapy.

Suggested Readings

1. Nelson DL, Cox MM (2017) Lehninger Principles of Biochemistry, 7th Edition. W. H. Freeman
2. Karp G. (2015) Cell and Molecular Biology: Concepts and Experiments.5th Edition. John Wiley Publication.
3. S. B. Primrose & R. M. Twyman (2007) Principles of Gene Manipulation and Genomics (Seventh Edition);. Blackwell Publishing.
4. Lewin B (2007) Genes IX , 9th Revised Edition, Jones and Bartlett Publishers
5. Christopler H. (1995) Gene cloning and Manipulating, Cambridge Universoty Press
6. Nicholl, D.S.T (1994) An Introduction of Genetic Engineering, Cambridge University Press.

BIO-308 Biology-X (T) Trends in Biology Credits 4

Course Structure

Unit I: Trends in Microbial Biotechnology

Microbial fermentation and production of small and macro molecules, Application of production of therapeutics, and diagnostics, Bioresource and uses of biodiversity, metagenome analysis, molecular approaches to microbial strain identifications

Unit II: Trends in Plant Biotechnology
Tissue culture methods for plants, transgenic plants, Omics methods and their application to agriculture, breeding in plants, Bioremediation and phytoremediation, Biosensors, basic of molecular marker-RFLP, AFLP, SNPs, SSCP, QTL analysis.

Unit III: Trends in Animal Biotechnology
Animal cell culture methods and its application, breeding in animals, transgenic knockdown and knockout animals, Omics approaches and its application to health and gene therapy, various methods of gene editing and changes like CRISPR-Cas technology, Cre-Lox technology etc.

Unit IV: Trends in Computational Biology
Introduction to genomics, proteomics, transcriptomics, DNA, RNA, protein and genome sequence databases, searching for sequence database, an introduction to computational modeling of biological systems

Suggested Readings

1. Freshney RJ, (2016) Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, Wiley Blackwell
2. Reinert J, Bajaj YS (2013) Applied and fundamental Aspects of Plant Cell, Tissue, and Organ Culture, Narosa Publishning House.
3. Xiong J (2006) Essential Bioinformatics, Cambridge University Press
4. Mount DW (2001) Bioinformatics: Sequence and Genome Analysis, University of Arizona, Tucson
5. Crueger W, Crueger A, (2000) A text of Industrial Microbiology, 2nd Edition, Panima Publishing Corp.
6. Stanbury PF, Ehitaker H, Hall SJ (1997) Principles of Fermentation Technology., Aditya Books (P) Ltd.

BIO-309 **Biology Practical-IV (P)** **Credits 3**

Course Structure
List of laboratory practical

1. Isolation of DNA and RNA from bacteria.
2. SDS Page for given protein sample.
3. Primer designing
4. Polymerase chain reaction.
5. Isolation of Plasmid.
6. Restriction digestion and ligation
7. Preparation of competent cell
8. Demonstration of antibiotic resistance in different microbes.
9. Downloading various sequences from GenBank in FAST format,
10. Demonstration of BLASTn, BLASTp and phylogentic tree preparation using MEGA software.

Semester VII

BCH-401 Fundamentals of Biochemistry Credit 3

Unit I

Structure of monosaccharides, oligosaccharides and polysaccharides, glycoproteins, glycolipids, proteoglycans, mutarotation, annomerisation, epimerization, stability of polysaccharides.

Glycolytic pathway; 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, metabolism of Fructose and Galactose

Unit II

Structure and properties of fatty acids, storage and membrane lipids, phospholipids and cholesterol, Composition and synthesis of lipoproteins and their transport in the body, oxidation of fatty acids (beta & alpha), oxidation of long chain fatty acids, Synthesis of lipids, elongation of fatty acids, desaturation of fatty acids, regulation of fatty acid synthesis, cholesterol metabolism, regulation of cholesterol metabolism.

Structure, composition and properties of nucleic acids, *De-Novo* synthesis of purine and pyrimidine nucleotides and its regulation. Synthesis of nucleoside di- and triphosphates, deoxynucleotides and TMP and degradation of purine and pyrimidine nucleotides, salvage pathways of nucleotides synthesis.

Unit III

Structure and properties of amino acids, Structure of protein (Primary, Secondary, Tertiary and Quaternary), essential and non-essential amino acids, general reactions of amino acid metabolism, urea cycle, synthesis of various molecules via amino acid metabolism intermediates, non-standard Amino Acids.

Structure and properties of vitamins, co-enzymes, biochemical action of vitamin and water-soluble vitamins, Biosynthesis of vitamins, role of vitamins in the metabolism.

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 Molecular Genetics Credit 3

Unit-I

Basic principles of Mendelian genetics- Segregation and Independent assortment, alleles and multiple alleles; human pedigrees and inheritance; Chromosomal basis of inheritance; Gene interactions; Chromosome and its structure; sex determination and sex-linked inheritance; Dosage compensation,

Mitochondrial and chloroplast inheritance, Hardy-Weinberg equilibrium; Calculation of allele frequency, Genes in early development; Maternal effect genes; Pattern formation genes; Homeotic genes.

Unit-II

Spontaneous and induced; Mechanisms of mutagenesis; Assay of mutagenic agents (Ames test); Chromosomal mutations- numerical (trisomy, polyploidy and aneuploidy) and structural changes and detection methods, somatic and germ line mutations, transposable elements, DNA repair, recombination error, SOS response and mutagenic repair.
Prokaryotic DNA Polymerase I, II and III, Eukaryotic DNA Polymerases, Fidelity and Catalytic Efficiency of DNA Polymerases, Okazaki Fragments, Replication Origin, Primosomes, Concurrent Replication Mechanism Involving Leading and Lagging Strands of DNA; Problems associated with linear replicons. Molecular basis of Recombination, Mutations and Repair.

Unit-III

Prokaryotic RNA polymerase and sigma factors, Prokaryotic and eukaryotic promoters, Eukaryotic RNA Polymerases, Class I, II and III gene promoters, Enhancers and control regions of genes; mechanism of transcription- Prokaryotic and eukaryotic, Chromatin remodeling, Histone code and histone modifications, RNA processing and splicing
Genetic Code, Ribosome Structure, tRNAs, Aminoacyl tRNA synthetase, Initiation, Elongation, Termination, Translational Control, Operon Concept, Riboswitches, gene regulation in prokaryotes and eukaryotes.

Books recommended

- Molecular biology by Robert F. Weaver McGraw-Hill 4 edition (2007)
- Advanced molecular biology by R. M. Twyman, (1998)
- Genes VII by B. Lewin Oxford University Press, Cell Press, London (2000)
- Cell and molecular biology by G. Karp, John Wiley & Sons Inc (2002)

BCH-403 Cell Biology Credit 3

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.

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-404 Microbiology Credit 3

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, bacterial identification, general characteristics of archaea, eubacteria, acellular life forms
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: *Entamoeba*, *Plasmodium*.

Applied Microbiology- Overview of applications of microorganisms in Agriculture, Environment, Food, Industry and Medical Sciences.

Books recommended

- Michael J Pelczar, Microbiology, Tata McGraw, India.
- Microbiology by Stuart Walker, W B Saunders
- 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-405 Bioenergetics Credit 3

Unit-I

Bioenergetics-basic principles; enthalpy, entropy, spontaneous and non-spontaneous thermodynamic reaction, equilibrium constant and concept of free energy, standard reduction potential and its calculations, relation of Gibbs free energy and standard reduction potential, Nernst equation, principles of metabolic regulation, thermodynamic consideration of committed steps in metabolic reactions.

High-energy compounds, energy charge, ATP as energy currency, ATP hydrolysis, coupled reaction, Group transfer energy, Inorganic phosphate as potential phosphoryl donor, pH, and buffer, Henderson-Hasselbatch equation, super acid, buffers and its mechanism, biological buffers, molarity and normality, effect on temperature on buffer properties.

Unit-II

Energy transducing membrane, Oxidation and reduction reaction, Ubiquinone, Iron-sulphur center, co-enzyme and proteins as universal electron carrier, electron transport system in mitochondria, structure of different electron carrier, chemiosmotic theory of Peter Mitchell, oxidative phosphorylation, Proton Motive force, P/O ratio, uncouplers, thermodynamics of electron transport system in mitochondria.

Thermodynamics of protein folding, Biogenetics of amyloidogenesis, Stability of extreme proteins (thermophile and cryophile), stability of intrinsically disordered proteins, thermodynamic based regulation of metabolic pathways, bacterial photosynthesis, thermodynamic consideration of light harvesting complex in plants and ATP synthesis in thylakoid membrane.

Unit-III

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.

Methods used to calculate thermodynamic parameters, Principle and application of Differential Scanning Calorimetry (DSC), Isothermal Titration Calorimetry (ITC) and Surface Plasmon Resonance (SPR), Spectroscopic methods used for calculating of enthalpy, entropy and Gibbs free energy.

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, 5th Edition,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-406 Human Physiology Credit 3

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 O_2 and CO_2 in blood, O_2 and CO_2, 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.

Books Recommended

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

BCH-407 Biochemistry Practical Credit 3

- Prepration of Acetate and phosphate buffer system and validate the Henderson-Hasselbach equation.
- To determine concentration of an unknown protein by UV-Vis Spectrophotometer.
- Determination of Molar extinction coefficient of protein.
- Protein purification by gel filtration, ion-exchange chromatography
- Determine pKa and pI of amino acids
- Protein separation by SDS-PAGE
- Qualitative and Quantitative Analysis of Carbohydrates, Amino acids and proteins, lipid and nucleic acid.
- Separation of amino acids and sugars by TLC
- Extraction of proteins, RNA and DNA from cultured cells.

BCH-408 Microbiology Practical Credit 3

- Sterilization, disinfection, safety in microbiological laboratory
- Preparation of media (plates, broth and slants) for growth of various microorganisms.
- Identification and culturing of various microorganisms. Spreading and streaking plating techniques.
- Staining of bacteria – Simple staining, differential staining, staining of spores and capsules
- Enumeration of microorganisms from water by viable plate counting
- Determination of growth curve of bacteria and calculation of bacterial population by turbidometry
- Effect of pH, temperature and UV irradiation in bacterial growth
- Determination of Minimal Inhibitory concentrations (MIC) for kanamycin and ampicillin against Bacteria.

BCH-409 Immunology Credit 3

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.

Books recommended

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

BCH-410 Developmental Biology Credit 3

Unit-I

Basic concept of development: Basic features of development in animals, gametogenesis, types of eggs, fertilization, cleavage, and blastula, modification of development in evolution, generation of multicellular embryo, formation of germ layers, patterning of vertebrate body plan, Hormonal regulation of gametogenesis in male and female of mammals.

Morphogenesis and organogenesis in animals and plants: *C. elegans*: Study of cell lineage, mosaic development and organogenesis. **Drosophila**: Pattern formation, polarity determination of embryo, formation of body segments, Homeotic genes. **Mouse**: Vertebrate development, determining function of genes during development by generation of knockout and knock-in models. **Arabidopsis:** Organization of shoot and root apical meristem; shoot and root development.

Unit-II

Stem cells in development: Properties of stem cells, embryonic stem cells, mesenchymal stem cells, hematopoietic stem cells, inducible pluripotent stem cells, epithelial to mesenchymal transition, cancer stem cells, embryonic signature in cancer stem cells, stem cell markers and factors.

Differential gene expression in development: Differential gene transcription, differential RNA processing, DNA methylation and control of gene transcription, control of gene expression at the level of translation.

Unit-III

Cell culture: Primary cells, cell lines, immortalization of cells, basic steps of cell culture, isolation of primary cells and stem cells, cryopreservation of cell lines, Cell culture assays (cell viability and cytotoxicity tests, migration and invasion assays), applications of animal cell culture in testing of drugs and production of pharmaceutical proteins.

Medical implications of developmental biology: Medical embryology and teratology, Genetic errors of human development, in-vitro fertilization, environmental assaults on human development, design of future medicines like gene therapy, therapeutic cloning and regeneration therapy.

Books recommended

- Developmental Biology by Scott F. Gilbert, Sinauer Associates, Inc, MA, USA, 10th Edition, 2013.
- CaenorhabditisElegans: Molecular Genetics and Development, second edition, By Joel H. Rothman Academic Press, 2011
- A. Nagy, M. Gertsenstein, K Vintersten, R. Behringer. 2003. Manipulating the mouse embryo: a laboratory manual, Cold spring Harbor Press, New York, USA.
- Stem cell biology edited by Daniel R. Marshak, Richard L. Gardner, David Gottlieb,2001 Cold Spring Harbor Laboratory Press.
- Essentials of Stem Cell Biology, 3rd Edition, edited by Lonza and Atla, Academic Press, 2013

BCH-411 Plant Biochemistry Credit 3

Unit-I

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

Photosynthesis: 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).

Books recommended

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

BCH-412 Enzymology and Protein Engineering Credit 3

Unit-I

Enzyme definition and characteristics, mechanism of enzyme action, activation energy, collision & transition state theories, lock and key model, induced fit hypotheses, active site - structure, substrate binding, role of catalytic amino acid residues, nomenclature and classification of enzyme, type of enzymatic catalysis; acid-base, nucleophilic-electrophilic covalent catalysis, mechanisms of action of chymotrypsin, ribonuclease, lysozyme; ribozymes, synthetic artificial enzymes (e.g., β-benzyme)

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.

Unit-II

Enzyme Inhibition, irreversible 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, Hill's coefficients, cooperativity, positive and negative, hemoglobin as a model for cooperativity.

Enzyme regulation and feedback control, phosphorylation, enzyme regulation of aspartic

transcarbamylase and metalloenzymes, carboxypeptidase A, isozymes and their significances.

Unit-III

Protein engineering strategies to improve enzyme stability, specificity and activity, engineering disulphide bonds, engineering thermostable and cryostable enzymes.
Engineered chimeric antibody, protein engineering of antibody, combining sites, replacement of FC domains, catalytic antibodies (abzymes), Engineering of peptide based therapeutics or antibiotics against diseases associated enzymes.
Strategies for the discovery of improved and novel enzymes for industrial applications (homology and structure based approaches, screening methods, use of mutants), Optimization of industrial enzymes by mutagenesis, Enzyme immobilization techniques, use of isolated enzymes in industrial processes, engineering industrial important enzyme, Application of enzymes: cosmetic benefits, enzyme-based biosensors, enzyme replacement therapy

Books recommended

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

BCH-413 Elective I Credit 3

A. Cancer Biology

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.

Books recommended

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

B. Neurobiochemistry

Unit-I

Developmental Neurobiology: Organogenesis and neuronal multiplication, axonal and dendritic growth, glial multiplication and myelination, growth in size, regeneration and repair mechanisms, plasticity.
Neuromorphology and neurocellular anatomy: Central nervous system (CNS) and peripheral nervous system (PNS), autonomous nervous system, somatic nervous system, dendritis and axons, neurofilaments. Sensory receptor and effector endings; peripheral nerves, spinal and cranial nerves: Plexuses ganglia, afferent pathways and sense organs. Spinal cord: Topographical anatomy, spinal nerves, grey and white matter of spinal cord.

Unit-II

Neurotransmitters: Acetylcholine, dopamine, norepinephrine, etc., chemistry, synthesis, storage and release of neurotransmitters, transmission, synaptic modulation, receptors involved and mechanism of neuronal integration. Electrical and chemical synapses, temporal and spatial summation, voltage dependent calcium channel and their blockers, EPSP and IPSP, receptor agonists and antagonists.
Secondary Messengers: Importance of cyclic nucleotides and protein phosphorylation in nervous system. Involvement of protein kinases and calcium in neuronal metabolism. Neuropeptides: classes of neuropeptides, mode of action, role of neuropeptides in obesity and pain neuropeptide receptors.

Unit-III

Learning and Memory: Correlation of behavioral and biochemical events, measurement of learning and memory, agents affecting learning and memory, biochemical correlates of excitation, learning and behavior.
Neurodegenerative diseases: Parkinson's, alzheimar's disease, amyotrophic lateral sclerosis, senile dementia. Biochemical theories of mental disorder: chemistry of neuroleptics and anxiolytics and Schizophrenia.

Books recommended

- Siegel et al., Basic Neurochemistry, 6th Edition, Lippincott -Williams-Wilkins, 1999
- Kandel et al., Principles of Neural science, 4 Edition, McGraw-Hill Medical, 2000.
- Zegmond, Fundamentals of Neuroscience, 1st Edition, Academic Press, 1999
- Bear: Neuroscience: Exploring the Brain, 2nd edition, Lippincott Williams & Wilkins, 2001

C. Pharmaceutical Biochemistry

Unit-I

Bioinformatics approached for drug development: Identification of potential molecules, chemical compound library preparation, Identification of target in pathogen, Ligand & protein preparation, Molecular docking, Binding free energy estimation, High throughput virtual screening, Docking protocol validation and enrichment analysis, Single point energy calculation, Pharmacokinetics and Pharmacodynamics, ADME & toxicity prediction, Molecular dynamic simulation, Rule of three and five, Lipinsky rule, Pharmacophore development, Quantitative structure activity relationship, 3D-QSAR, Techniques of developing a pharmacophore map covering both ligand based and receptor based approaches.

Unit-II

Drug metabolism & interactions: Drug-receptor interactions, receptor theories and drug action, Xenobiotics, xenobiotics phases (Phase-I, Phase-II and Phase-III), role of cytochrome P450 oxidases and glutathione S-transferases in drug metabolism, factors affecting drug metabolism, Enzymes as a drug target, Kinase inhibitors, ATPase inhibitors, drug protein interaction, Drug-DNA interaction.

Basic ligand concepts-agonist, antagonist, partial agonist, inverse agonist, efficiency and potency. Forces involved in drug-receptor complexes. Receptor classification – the four super families. Receptor binding assays- measurement of K_d, B_{max} and $IC_{50.}$

Unit-III

Drug delivery & trials: General principles of screening, correlations between various animal models and human situations, Correlation between in-vitro and in-vivo screens; Special emphasis on cell-based assay, biochemical assay, radiological binding assay, Pharmacological assay, In vitro, In vivo & Ex-vivo experiments, Preclinical and clinical trials (Phase-I, Phase-II, Phase-III and Phase-IV clinical trial).

Main features of clinical trials, including methodological and organizational considerations and the principles of trial conduct and reporting. Key designs surrounding design, sample size, delivery and assessment of clinical trials.

Books recommended

- Practical Application of Computer-Aided Drug Design, Ed. Charifson P., Marcel Dekker Inc.
- 3D QSAR in Drug Design: Theory, Methods and Applications, Ed. Kubinyi H., Ledien ESCOM.
- Pharmaceutical Profiling in Drug Discovery for Lead Selection, Borchardt RT, Kerns EH, Lipinski CA, Thakker DR and Wang B, AAPS Press, 2004

BCH-414 Elective II Credit 3

A. Molecular Medicine

Unit-I

Current topics in fungal, parasitic, bacterial and viral genetics (with the emerging knowledge of sequence databases available and ongoing projects). Understanding the mechanisms available for genetic variability in different pathogens to defy host immune system. Host signalling in response to infections. Bacterial two component signalling systems. Bacterial adhesins, virulence factors. Protein and DNA secreting systems and pathogenicity island. Molecular basis of antimicrobial resistance and its detection. Molecular approaches in clinical microbiology.

Unit-II

Molecular and cellular basis of viral pathogenesis such as tumor viruses, hepatitis virus, HIV, Ebolla, H1N1, and Zika virus etc, phage tolerance and resistance, microbiome of human health, distribution of microbiota of the human body, molecular basis of metabolic disorders in human and therapy, metabolic profiling, Genetics and epigenetics in metabolic disorders, molecular basis of human diseases like Parkinson, Alzheimar

Unit III

Molecular targets of therapeutics such as microbial targets, signal transduction pathways, autoimmune disease targets, cancer targets, epigenetic modifications and emerging targets; molecular biomarkers, receptors specificity, agonists and antagonists, therapeutics drugs and classes, Peptide therapeutics, monoclonal antibodies, pharmacodynamics of different classes of drugs, Mechanisms of toxicity, therapeutic index, mechanisms of detoxification, mechanisms of medicinal plant products or secondary metabolites, evolution of drug tolerance mechanism in bacteria, virus, and humans, Surveillance model for prediction of antimicrobial susceptibility.

Books recommended

- Virology: Principles and Applications John Carter, Venetia Saunders.
- 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.
- Michael J Pelczar, Microbiology, Tata McGraw, India.
- Ross Dennis W., Introduction to Molecular Medicine, Springer-Verlag New York Inc
- R.J. Trent, Molecular Medicine, Academic Press

B. Infection Biology

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.

Books recommended

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

BCH-415 Immunology Practical Credit 3

- Serum separation, Storage.
- Antibody titer by ELISA method.
- Precipitin reaction by double immunodiffusion and radial immunodiffusion (Ouchterlony and Mancini's methods)
- Separation of mononuclear cells by Ficoll-Hypaque
- Immunodiagnostics using commercial kits
- Blood smear identification of leucocytes by Giemsa stain
- Detection of antigens by immunoblotting techniques, western bloting

BCH-416 Enzymology and Plant Biochemistry Practical Credit 3

- Enzymatic Assays
- Effect of substrate concentration on enzyme kinetics
- Determination of optimum pH and temperature for enzymatic activity
- Determination of kinetic parameters
- Determination of dissociation constant of inhibitor
- Determination of Allosterism in enzyme.
- Estimation of total chlorophyll, chlorophyll a and chlorophyll b pigments firm the leaves.
- Estimation of starch content.
- Spectrophotometric estimation of Indole acetic acid in plant tissues.
- Estimation of carotene, ascorbic acid, phenols and tannins in fruits and vegetables.

BCH-417 Health Awareness Credit 3

Unit-I

Introduction to the most common mental disorders, Identifying Risk Factors associated with poor mental health, Defining internalizing and externalizing behaviors, Diagnosing mental health problems, Definition of Personality, Development of Personality, Assessment of Personality, The Power of Personality, Personality Disorders, Personality Traits and Abilities and Seafaring. Definition of Stress: Eustress and Distress, Work related stress factors, Effects

of Stress, Stress Management, Definition of Anger, hostility and Aggression understanding the difference and dealing with anger effectively and productively, Anger as a Social Script. Emotional literacy- Develop Self Awareness, Empathy, Social Awareness, Techniques for mastering emotional literacy: Ability to identify , affirm, value and validate feelings, Reconstructing and Reframing emotions, Waking up techniques for emotional literacy, ABC of emotions, Navigating emotions : Breathe, concentrate, balance, Exercise Optimism – Positive Experience Recall.

Unit-II

Food habits for good health, food and water contamination, Balanced diet, importance of vitamins, home and workplace hygiene, Harmful effects of excessive uses of computer and cellphone, radiation from mobile affecting human health, addiction towards social network, protection from UV rays, protection from sound effects, heat and cold season precautions, pollution affecting human health. Precautions during travelling, good and bad cholesterol, body weight, first aid for home,

Unit-III

Biological clock, importance of sleep, requirement and importance of exercise, Age related disorders, routine body checkup, consultation with physician, medicine/antibiotic courses, healthy maintenance and awareness about each important organ of human body such as eye, ear, mouth, teeth, tongue, heart, lungs, stomach, thyroid, genital organs, blood, awareness to control emerging infectious diseases, vaccination requirement & importance, BMI, BMR, detoxification.

Books recommended:

- Eat to Beat Disease: The New Science of How Your Body Can Heal Itself by William W Li
- A Guide To Mental Health & Psychiatric Nursing by Sreevani R
- Textbook of Nutrition and Dietetics, Sharda Gupta, Santosh Jain Passi, Rama Seth, Ranjana Mahna, Seema Puri and Kumud Khanna

BCH-501 Clinical Biochemistry Credit 3

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.

Books recommended:

- Harpers Illustrated Biochemistry 30th Edition, McGraw-Hill Education, 2015
- Clinical Biochemistry and Metabolic Medicine Eighth Edition by Martin Andrew Crook, CRC Press, 2012
- Textbook of Biochemistry for Medical Students, 7th edition, by D M Vasudevan, Sreekumari S, KannanVaidyanathan, 2010, Jaypee.
- Clinical chemistry: Techniques, Principles, Correlations , 6th Edition, by Bishop, Fody and Schoeff, 2012, Lippincott Williams & Wilkins

BCH-502 Genetic Engineering Credit 3

Unit-I

rDNA Technology: Restriction enzymes, restriction modification system, DNA ligase, *E. coli* DNA polymerase I and Klenow enzyme, T4 DNA polymerase, reverse transcriptase, polynucleotide kinase, alkaline phosphatase.
Cloning Methodologies: Plasmids and plasmid vectors, new generation of plasmid cloning vectors, Lambda vectors - insertion and replacement vectors, cosmids. High capacity cloning vectors – YACs, BACs and PACs. Shuttle vectors. Expression vectors - pMAL, GST, pET-based vectors. Eukaryotic expression vectors. Protein purification: His-tag, GST-tag, MBP-tag etc. Vectors used for cloning in animal cells: SV-40, vaccinia/bacculo and retroviral vectors. Plant based vectors, Ti vectors.

Unit-II

Genomic and cDNA library preparation: Methods for construction of genomic and cDNA libraries – vectors used, generation of cDNAs, preparation of genomic DNA for library construction. Lambda *in vitro* packaging. Methods used in the identification and analyses of

recombinant DNA clones. Protein-protein interaction and yeast two hybrid system. Phage display. Principles of maximizing protein expression

RNA interference &rDNA therapy: Introduction to siRNA, siRNA technology, microRNA, construction of siRNA vectors, principle and application of gene silencing. Production of insulin, drug, vaccines, diagnostic probe of genetic diseases. Gene therapy

Unit-III

Transgenic Technology: Gene knockout and knock-in, Generation of transgenic animals and its application, Cre-loxP recombination technology, Homologus and Non-homologus recombination, Gene isolation, gene transfer systems, Ti plasmid, plant virus vectors, electroporation, microinjection, microprojectile technology, particle bombardment, Generation of transgenic plants and its application, Plant tissue culture, anther and pollen culture, protoplast culture, protoplast fusion, cybrid, somatic hybrid, somatic embryogenesis, embryo rescue, application of recombinant DNA technology in photosynthetic efficacy, nitrogen fixation efficiency and resistance to environmental stresses.

Books recommended:

- T.A. Brown, Gene Cloning and DNA Analysis: An Introduction. Fifth Edition, Wiley-Blackwell, 2006.
- S.B. Primrose, R.M. Twyman and R.W.Old; Principles of Gene Manipulation. 6th Edition, S.B.University Press, 2011.
- J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL, 2001.

BCH-503 Biophysics and Bioinformatics Credit 3

Unit-I

Conformations of peptide and proteins (primary, secondary, tertiary and Quaternary), alpha and Pi helix, Turns (beta, alpha, gamma etc.), Ramachandran plot, protein folds and motifs, domains and domain swapping, protein symmetry, prokaryotes and mammalian molecular chaperons, Structure of globular proteins and 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, PPI, PDI, Receptor agonists and antagonists.

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

Physical properties of membrane, 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 (protein, nucleic acid, Domain), multiple sequence alignment, phylogenetic clustering and analysis, protein modelling (homology modelling, threading and *ab initio* prediction), Identification of drug targets, Molecular docking (Rigid docking, flexible docking), docking based screening, Preparation of ligand and receptor for docking, lead discovery, lead optimization, combinatorial library, force fields, molecular energy minimization, molecular dynamics simulation, Quantitative Structure Activity Relationship (QSAR), ADMET studies, 3D pharmacophore, Pharmacokinetics, pharmacogenomics, chemoinformatics and chemogenomics,

Books recommended:

- Thomas E. Creighton, Proteins: Structure and Molecular Properties, W H Freeman & Co, 2011.
- Alexei V. Finkelstein, Oleg BorisovichPtitsyn, Protein physics: A course of lectures, Academic Press, 2002.
- Carl-IvarBrändén, John Tooze, Introduction to Protein Structure , Garland Pub., 1999.
- Jack Kyte , Structure in Protein Chemistry , Garland Science, 2007.
- David Whitford, Proteins-Structure and function , Wiley, 2005.
- A. Kessel and Nir Ben-Tal, Introduction to Proteins-Structure, function and motion, CRC press, Taylor and Francis, 2011.
- Georg E. Schulz, R. HeinerSchirmer, Principles of protein structure, Springer, 1998.

BCH-504 Bioanalytical Methods Credit 3

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, 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).

Books recommended

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

BCH-505 Biosafety, Laboratory safety and IPR Credit 3

Unit-I

Biosafety: Historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; recommended biosafety levels for infectious agents and infected animals; biosafety guidelines - government of India, roles of IBSC, RCGM, GEAC etc. for GMO applications in food and agriculture; environmental release of GMOs; risk assessment; risk management and communication; national regulations and international agreements.

Bioethics: Introduction to bioethics, human genome project and its ethical issues, genetic manipulations and their ethical issues, ethical issues in GMOs, foods and crops in developed and developing countries, environmental release of GMOs, ethical issues involved in stem cell research and use, use of animals in research experiments, animal cloning, human cloning and their ethical aspects, testing of drugs on human volunteers.

Unit-II

Intellectual Property Rights (IPR): Introduction to patents, types of patents, process involved in patenting in India, trademarks, copyright, industrial design, trade secrets, traditional knowledge, geographical indications, history of national and international treaties and conventions on patents, WTO, GATT, WIPO, Budapest Treaty, Patent Cooperation Treaty (PCT) and TRIPS.

Patent databases: Searching international databases; analysis and report formation. Indian Patent Act 1970; recent amendments; filing of a patent application; precautions before patenting-disclosure/non-disclosure; procedure for filing a PCT application.

Unit-III

Patent filing and infringement: Patent application- forms and guidelines, fee structure, time frames; types of patent applications: provisional and complete specifications; PCT and convention patent applications, International patenting-requirement, financial assistance for patenting-introduction to existing schemes; Publication of patents-gazette of India, status in Europe and US.

Research Patenting: Patenting by researchers and scientists-University/organizational rules in India and abroad. Detailed information on patenting biological products, Case studies on patents (basmati rice, turmeric, neem etc.), and patent infringement.

Books recommended:

- P Ganguly, Intellectual Property Rights, Tata McGraw Hill, 2007.
- Thomas J.A., Fush R.L., (2002), Biotechnology & safety Assessment (3rdEd.), Academic press.
- Fleming D.A., Hunt D.L., (2002), Biological safety Principles &practices(3rd Ed.) ASM Press, Washington.
- Biotechnology- A Comprehensive treatise (Vol 12), Legal economic & ethical Dimensions VCH.
- Sasson A, Biotechnologies & Development, UNESCO Publications.
- Singh K, Intellectual Property Rights on Biotechnology, BCIL, New Delhi.
- Singh BD. 2007. *Biotechnology: Expanding Horizon*. Kalyani.
- Biotechnologies and Development, Sasson A, UNESCO Publications, 1988
- Biotechnologies in developing countries present and future, Sasson A, UNESCO Publications, 1993
- Intellectual property rights on Biotechnology, Singh K, BCIL, New Delhi

BCH-506 Elective III Credit 3

A. Molecular Evolution

Unit – I

Lamarck; Darwin - concepts of variation, adaptation, struggle, fitness and natural selection; Origin of cells and unicellular evolution: Origin of basic biological molecules; abiotic synthesis of organic monomers and polymers; concept of Oparin and Haldane; experiment of Miller (1953); the first cell; evolution of prokaryotes; origin and diversification of eukaryotes; multicellularity and development; diversification of plants and animals; generation of variation by mutation and recombination; random genetic drift; population structure; phenotypic evolution

Unit – II

Molecular evolution, namely; selectionist hypotheses, neutralist hypotheses and mutationist hypotheses, directed evolution, combined computational and *in-vitro* evolution approaches, Thermodynamics of the molecular evolution, Methods for the molecular evolution, Significance of molecular evolution, Protein evolution, Nucleic acid evolution

Unit – III

Physical environment; biotic environment; biotic and abiotic interactions, Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement, Characteristics of a population; population growth curves; population regulation; life history strategies (*r* and *K* selection); concept of metapopulation- demes and dispersal, interdemic extinctions, age structured populations. Types of interactions, Nature of communities; levels of species diversity and its measurement; edges and ecotones, Ecological succession: Ecosystem, structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine).

Books recommended:

- Begon, M., Townsend, C. R., and Harper, J. L.. Ecology from Individuals to Ecosystems. Wiley-Blackwell, USA. 2005.
- Chapman, J. L. and Reiss, M. J. Ecology: Principles and Applications. Cambridge University Press, UK., 1998.
- Roderick D.M. Page, Edward C. Holme, Molecular Evolution: A Phylogenetic Approach, Wiley & Sons

- Barton, N.H., Briggs, D.E.G., Eisen, J.A., Goldstein, D.B., Patel, N.H., Evolution. Cold Spring Harbor Laboratory Press, New York, 2007

B. Environmental Biochemistry

Unit-I

Environmental components: Atmosphere, structure and chemical composition of atmosphere, Internal structure of the Earth, rocks and their classification, minerals and their classification. Weathering and soil formation, soil profile, soil classification, soils of India.
Global Water Balance. Origin and composition of sea water. Hydrological cycle. Classification of trace elements, mobility of trace elements, biogeochemical cycles.

Unit-II

Fundamentals of Ecology: Definition, subdivisions. Ecosystems: concept of ecosystems, aquatic ecosystem, terrestrial ecosystem, energy flow in ecosystems, nutritional flux. Food-chains, Food web, ecotone, edge effects, ecological habitat & niche, ecological pyramids and ecosystem stability, concept of habitat and niche.
Biomes and Habitat Diversity: Classification of biomes, major biotic elements of each biome and their characteristics. Population and community ecology, population growth curves, life history strategies (r &k selection); concept of metapopulation. Ecological succession, primary and secondary, mechanism of succession.

Unit-III

Global environmental issues and International laws: Global warming, Green house effect, ozone depletion, acid rains, hazardous waste, CITES etc. Earth's carbon cycle, carbon sequestration, sustainable development.
Bioremediation: Introduction and types of bioremediation, bioremediation of surface soil and sludge, bioremediation of subsurface material, *In situ* and *Ex-situ* technologies, Phytoremediation.
Chemical toxicology: Biochemical effects of heavy metals (Pb, As, Hg, Cd), pesticides, insecticides, herbicides, weedicides, larvicides.

Books recommended:

- Fundamentals of Ecology 5th Edition by Eugene Odum (Author), Gary W. Barrett (Author)
- Environmental Chemistry Paperback –by V. K. Ahluwalia (Author), Lalita S. Kumar (Author), ANE Books
- Environment and Ecology: Biodiversity, Climate Change and Disaster Management, by Majid Husain (Author), Access Publishing
- Environmental Biology (Principles of Ecology), 4/e DR. P.S. VERMA & DR. V.K. AGARWAL, S. Chand Publishing
- Ecology Environmental Science and Conservation, 1/e, J.S. SINGH, S. R. GUPTA& S P Singh, S. Chand Publishing.
- Textbook of Environmental Chemistry, by Ayodhya Singh, Publisher: Neha Publishers & Distributors.

BCH-507 Molecular Biology Practical Credit 3

- Extraction of plasmid DNA from bacterial cell and electrophoresis in agarose gel.
- Restriction enzyme digestion and electrophoresis.
- Ligation and cloning in a plasmid vector

- Preparation of competent cells followed by transformation and calculation of transformation efficiency.
- PCR and analysis by agarose gel electrophoresis
- Blue white screening, restriction map Analysis.
- Expression and purification of the recombinant protein
- Multiple sequence alignment and Primer designing

BCH-508 Clinical Biochemistry Practical Credit 3

- Blood cell counts
- Determination of blood sugar, urea.
- Determination of blood cholesterol, triglycerides
- Determination of blood uric acid, albumin, creatinine.
- Determination of blood SGPT, SGOT.
- Determination of blood SOD, Catalase, Glutathione peroxidase activity
- Determination of blood alkaline phosphatase, myeloperoxidase activity
- Determination of blood Ca^{2+}, $Na^{+}$and K^{+}.

BCH-509 Fundamental of Research Methodology Credit 3

Unit I:

Research Basics: definition, purpose and types; Process of Research and Dimensions of research, research problem, research questions, Research design, tools of research; methods of research, systematic review of literature, preparation of research proposal/ synopsis, Research Ethics (Issues relating to referencing and documentation, copyrights, plagiarism), Impact Factor, H-Index, Citation Index, references/bibliography, structuring the thesis, use of software in thesis writing.

Unit II:

Data collection, processing and presentation, Measures of central tendency, Regression and Correlation, ANOVA; Errors; Levels of significance; probability distributions; Analysis of variance Hypothesis; Probabilities; t-test, p-value; χ^2test, use of software in statistical analysis

Unit III

Funding Agency (National and International), Fellowships at national and international levels, conferences and symposium, testimonial, reference letter, preparation of manuscript and its submission, writing of innovative project proposal and its submission.

Books recommended:

- John W. Creswell, Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, 4th Edition SAGE
- Sharan B. Merriam & Elizabeth J. Tisdell, Qualitative Research: A Guide to Design and Implementation, 4th Edition, John Wiley & Sons