(Batch: 2017-2022 & 2016-221)
Department of Molecular Biology and Biotechnology

Course Structure and Syllabus of Integrated M.Sc. in Bioscience and Bioinformatics

Minimum credit requirement : 196
Minimum duration : 5 years (10 semesters)
Maximum duration : 7 years (14 semesters)

COURSE STRUCTURE

Semester I

Course Code	Course Name	L-T-P	CH	CR	Remark
PI 101	Physics-I	2-0-1	4	3	
CI 101	Chemistry-I	2-0-2	6	4	
BI 101	Biology-I	2-0-1	4	3	
MI 101	Mathematics-I	2-1-0	3	3	
CS 101	Introduction to Scientific Computing	2-0-1	4	3	CBCT
EG 101	Communicative English	2-0-0	2	3	CBCT
Total credits				**19**	

Semester II

Course Code	Course Name	L-T-P	CH	CR	Remark
PI 102	Physics-II	2-0-2	6	4	
CI 102	Chemistry-II	2-0-1	4	3	
BI 102	Biology-II	2-0-1	4	3	
MI 102	Mathematics-II	2-1-0	3	3	
ES 102	Elementary Environmental Science	3-0-0	3	3	CBCT
EG102/ SC102	Communicative English-II/ Basic Sociology	3-0-0/ 3-0-0	3/ 3	3/ 3	CBCT
NS 102	National Service Scheme	0-0-2	2	2	
Total credits				**21**	

Semester III

Course Code	Course Name	L-T-P	CH	CR	Remark
MI 211	Numerical Methods and Integrals	2-1-0	3	3	
BI 231	Biochemistry -I	2-1-0	3	3	
BI 223	Cell Biology	2-1-0	3	3	
BI 227	Lab for Biochemistry and Cell Biology	2-1-0	3	2	
BI 229	Animal Physiology	0-0-2	4	3	
CI 201	Chemistry-III	2-1-0	3	3	
/ / CL121/ FL101/ GL101	Laboratory Guidance and Safety/ Economics/ Basic Chinese-I/ Basic French-I/ Basic German-I	2-1-0/ 2-1-0/ 2-1-0/ 2-1-0/ 2-1-0	3/ 3/ 3/ 3/ 3	3/ 3/ 3/ 3/ 3	CBCT
Total credits				**20**	

Semester IV

Course Code	Course Name	L-T-P	CH	CR	Remark
MI 212	Introductory Statistics	2-1-0	3	3	
BI 222	Microbiology	2-1-0	3	3	
BI 226	Basic in Biocomputing	2-1-0	3	3	
BI 228	Laboratory in Microbiology	2-1-0	3	2	
BI 230	Plant Physiology	0-0-2	4	3	
CI 202	Chemistry-IV	2-1-0	3	3	
DM301/ SC102/ CL122/ FL102/ GL102	Disaster Management/ Basic Sociology/ Basic Chinese- I/ Basic French-I/ Basic German-II	2-1-0/ 2-1-0/ 2-1-0/ 2-1-0/ 2-1-0	3/ 3/ 3/ 3/ 3	3/ 3/ 3/ 3/ 3	CBCT
Total credits				**20**	

Semester V

Course Code	Course Name	L-T-P	CH	CR	Remark
BI 321	Molecular Biology	2-1-0	3	3	
BI 323	Developmental Biology	2-1-0	3	3	
BI 325	Analytical Techniques	2-1-0	3	3	
BI 327	Bioprogramming and Biostatistics	2-1-0	3	3	
BI 335	Biochemistry -II	2-0-0	2	2	
BI 331	Lab. on Enzymology	0-0-2	4	2	
BI 333	Lab. on Molecular Biology	0-0-2	4	2	

Total credits			**18**	

Semester VI

Course Code	Course Name	L-T-P	CH	CR	Remark
BI 322	Molecular Genetics	2-1-0	3	3	
BI 324	Genetic Engineering	2-1-0	3	3	
BI 326	Immunology	2-1-0	3	3	
BI 328	Biological Database Management	2-0-0	2	2	
BI 330	Computational Biology	2-1-0	3	3	
BI 338	Seminar -I	0-1-0	1	1	
BI 334	Lab. on Immunology	0-0-2	4	2	
BI 336	Lab. on Genetic Engineering	0-0-2	4	2	
Total credits				**19**	

Semester VII

Course Code	Course Name	L-T-P	CH	CR	Remark
BI 421	Structural Bioinformatics	2-1-0	3	3	
BI 423	Cell and Tissue Culture	2-1-0	3	3	
BI 425	Bioinformatics Software and Algorithms	2-0-0	2	2	
BI 427/429/ 431/ 433	Elective – I : Animal Biotechnology / Microbial Biotechnology/ Plant Biotechnology/ Nano Biotechnology	2-1-0	3	3	
BI 435	Fermentation and Bioprocess Engineering	2-0-0	2	2	
BI 437	Lab. on Cell and Tissue Culture	0-0-2	4	2	
BI 439	Lab. on Bioprocess Engineering	0-0-2	4	2	
	CBCT Elective			3	CBCT
Total credits				**20**	

Semester VIII

Course Code	Course Name	L-T-P	CH	CR	Remark
BI 422	Genomics and Proteomics	2-1-0	3	3	
BI 424	Bioethics, Biosafety and IPR	2-0-0	2	2	
BI 426	Elective – II : Metagenomics/ Toxinology/ Pharamcogenomics/ Evolutionary Genomics	2-1-0	3	3	
BI 434	Virology	2-0-0	2	2	
BI 442	Seminar - II	0-2-0	2	2	
BI 438	Lab. on Applied Bioinformatics	0-0-3	6	3	
BI 440	Lab. on Genomics and Proteomics	0-0-3	6	3	
	CBCT Elective			3	CBCT
Total credits				**21**	

Semester IX

Course Code	Course Name	L-T-P	CH	CR	Remark
BI-521	Project - I	0-0-16	32	16	
BI-525	Seminar -III	0-1-0	1	1	
	CBCT Elective			3	CBCT
Total credits				**20**	

Semester X

Course Code	Course Name	L-T-P	CH	CR	Remark
BI-522	Project - II	0-0-16	32	16	
BI-526	Seminar – IV (Project outcome)	0-2-0	2	2	
Total credits				**18**	

+ *Course for which there is a separate practical unit assigned as Computer Laboratory*
L: Lectures T: Tutorials P: Practical CH: Contact Hours (all per week) CR: Credit
MI: Courses offer by the Department of Mathematical Sciences
PI: Courses offer by the Department of Physics
CI: Courses offer by the Department of Chemical Sciences
BI: Courses offer by the Department of Molecular Biology and Biotechnology

Total Credit	: (19+21+20+20+18+18+21+21+20+18)	= **196**
Total Credit in Lab & Project	: (4+6+2+2+4+4+4+6+16+16)	= **64**
Total Credit excluding Lab & Project	:	= **132**
Total Credit in CBCT	: (6+6+3+3+3+3+3)	= **27**

Note: 1. CBCT **(Choice Based Credit Transfer)** Electives are to be chosen from the general list of CBCT courses available for that particular semester.

Biology – I (BI-101) **L2-T0-P1-CH4-CR3**

Unit-I: Diversity in living world
Introduction, difference between living and non-living, unicellular, colonial and multicellular forms.

Unit-II: Microbial world
Characteristics with examples of archae, eubacteria, viruses, viroids and prions.

Unit-III: Plant Kingdom
A general description on lower and higher groups of plants; Specific studies on each of the following groups of plants with description of a typical example from (i) Thallophyta, (ii) Bryophyta, (iii) Pteridophyta, (iv) Gymnosperm, and (v) Angiosperm.

Unit-IV: Animal Kingdom
Nonchrodates and chordates-definition, classification with examples.

Unit-V: Fundamentals of genetics
Mendelian laws of inheritance, and non-Mendelian inheritance, chromosome theory of inheritance, mutation and mutagens.

Unit-VI: Basic concept of evolution
Theories of evolution: Lamarckism; Darwinism and Neo-Darwinism; Evolution and human health.

Unit-VII: Conservation biology
Level of biodiversity; global biodiversity and hot spots, tropical biodiversity, economics of biodiversity, threatened and endangered species, conservation of forest and wild life, social forestry, deforestation and consequences, joint forest management. Indian case studies on conservation/management strategy (project tiger, biosphere reserve).

Practical
(i) Specimen observation.
(ii) Permanent slide observation.
(iii) Observation of bacteria, fungi on plate.
(iv) Observation of bacteria, fungi under microscope.
(v) Counting bacteria from natural environments.
(vi) Dissection and observation of any flower to study different flower parts.
(vii) Student should take 5 to 10 animal/plant from nature and show their common features and diverse features from evolutionary adaptation point of view.

Few suggested books to read

1. BIOLOGY by Raven, Johnson, Losos, & Singer (2005)
2. ESSENTIAL GENETICS by D. L. Hartl & E. W. Jones (1999)
3. GENETICS: the continuity of life by D. J. Fairbank & W. R. Andersons (1999)

Biology – II (BI-102) **L2-T0-P1-CH4-CR3**

Unit-I: Chemical basis of life
Origin of life, biological forms and functions and bases of their study in molecular terms Role of water molecule, buffer solution, Thermodynamics of biological systems.

Unit-II: Elements of Biochemistry
Basic structure and physiological functions of carbohydrates, protein, lipids and nucleic acids. Role of minerals and vitamins in growth and development. Thermodynamics of biological system. Metabolism and energy interconversion.

Unit-III: Anatomy and Physiology – Basic concepts
Anatomy of root, stem and leaf of monocotyledous and dicotyledous plants. Plant physiology: Absorption and transpiration in plants, photosynthesis, nitrogen metabolism, Structural Organization of tissues, organs and organ systems. Anatomy and physiology of Human: digestive system, vascular, respiratory, excretory system.

Unit-IV: Basics of cell and Molecular Biology
Cell structure and division, cancer, the central dogma of molecular biology.

Unit-V: Outlines of immunology
Type of immunity: cell mediated immunity, description of various types of T-cells and their functions, innate immunity (specific and non specific) acquired: active and passive immunity, humoral and cell mediated immunity, immune system- lymphocytes. Immunoglobulins- structure and function.

Unit-VI: Human welfare and biology
Introduction to Genetic Engineering, Microbial Biotechnology, Environmental Biotechnology, Transgenic plants and animals, cloning whole organ, stem cell.

Practical
(i) Preparation of Buffer and Solution.
(ii) Validation of Beer and Lambert Law.
(iii) Anthrone method of carbohydrate estimation.
(iv) Estimation of total Protein.
(v) Spectrophotometric estimation of DNA.
(vi) Lipid estimation by thin layer chromatography.
(vii) Counting RBCs and WBC/Demonstration.
(viii) Blood group determination/Demonstration.

Text cum reference books

1. BIOLOGY by Raven, Johnson, Losos, & Singer (2005)
2. BIOCHEMISTRY by J. M. Berg, J. L. Tymoczko, & Lubert Stryer (2011)

Semester III

BI 221: Biochemistry **L2- T1-P0 CH3-CR3**

Unit I: Introduction to Biochemistry
Chemical basis of life; Composition of living matter; Water –role of water in life, properties, pH, ionization and Hydrophobicity, Four families of biological macromolecules, importance of studying biochemistry.

Unit II: Proteins
Amino acids structure and functional group properties; Peptides and covalent structure of proteins; Classification of proteins; Protein configuration-primary, secondary, tertiary and quaternary structures ; Evolution of protein structure; Structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin etc; biological functions of proteins; protein and unfolding

Unit III: Carbohydrates
Source and biological functions of carbohydrates; Sugars - mono, di, and polysaccharides; Mutarotation, anomers, epimers etc; classification of carbohydrates with examples of each class, glycoproteins and glycolipids.

Unit IV: Lipids
Lipids structure, biological functions and properties of lipids, classification of lipids; important members of storage and membrane lipids; lipoproteins.

Unit V: Nucleic acids
Nucleosides: DNA, RNA; nucleotides, nucleic acids - structure, sugar puckering; diversity and function; sequencing; Brief overview of central dogma.

Unit VI: Bioenergetics
Bioenergetics-basic principles; Equilibria and concept of free energy; Coupled processes; Thermodynamic principles-first and second laws of thermodynamics; ATP as universal currency of energy in biological system.

Text books

1. Voet D, Pratt CW,Voet JG. Principles of Biochemistry, 4th edition, Wiley, John & Sons. 2012.
2. Nelson DL, Cox MM. Lehninger Principles of Biochemistry, 6th edition, Macmilan. 2013.

Reference books

1. Berg JM, Tymoczko JL, Stryer L. Biochemistry: International Edition, 7th edition, W.H. Freeman and Macmilan. 2011.

BI 223: Cell Biology **L2-T1-P0-CH3-CR3**

Unit I: Introduction to cell and Microscopy
The Cell - dimensions and classifications with reference to plant and animal cells. Microscopy and imaging cellular molecules: Light (Phase contrast and DIC), confocal and atomic force microscopes. Staining and sample preparation for light and electron microscopy.

Unit II: Cell division
Cell division in microbes plant and animal. Cell cycle and regulation of cell division.

Unit III: Interaction of the cell with its environment
Plasma membrane: Chemical nature, structure and functions; Extracellular Space, Cell junction, cell-cell communications, adhesion, and the extracellular matrix cell wall.

Unit IV: Endomembrane system
Endoplasmic reticulum, Golgi body, lysosomes. Mitochondria: Structure, function and its role in aerobic respiration. Chloroplast: Structure and role in photosynthetic reaction. Cell nucleus: nuclear membrane, structure and organization.

Unit V: Transport of macromolecules and particles
Eendocytosis and exocytosis, regulated and constitutive secretion of macromolecules, protein sorting to different localization.

Unit VI: Cell signaling
G-protein mediated signaling, RTK signaling, Ca^{++} signaling, Ras-MAPK signaling, Wnt signalling. Apoptotic signaling pathways.

Textbooks:

1. Karp G., Cell and Molecular Biology: Concepts and Experiments, 3rd Edition (John Wiley & Sons, Inc., 2002).
2. Scott, M. P. et al, Molecular Cell Biology, 5th Edition (W. H. Freeman, 2004).
3. Alberts, B. et al., Molecular Biology of the Cell, 4th Edition(Garland Publishing, 2004).
4. Becker, W. M. et al., The World of Cell, 5th Edition (Benjamin Cummings, 2002).

Reference books:

1. Cooper, G. M. and Hausman, R. E., The Cell: a Molecular Approach, 5th Edition (ASM Press and Sinauer Associates, Inc., 2009).

BI 225: Plant and Animal Physiology L2-T1-P0-CH3-CR3

Unit I: Plant nutrition
Essential nutrients, deficiencies and plant disorders; heavy metal stress and homeostasis; molecular mechanism of mineral uptake by plants. Water relations in plants: polarity; water potential in plants; movement of water in plants; soil-plant-atmosphere continuum.

Unit II: **Photoperiodism and photosynthesis**
Photoperiodic response, site of perception and florigen concept; Senescence and its molecular aspects; Dormancy regulation. Photosynthesis: Photophosphorylation, C3, C4 and CAM pathways, photorespiration.

Unit III: Plant growth regulators
Auxins, gibberellins, cytokinins, ethylene, abscissic acid - Physiological effects and mechanism of action; Brassinosteroids as growth regulators; salicylic acid, jasmonic acid.

Unit IV: Digestive system
Anatomy of alimentary canal in mammals, Exocrine glands of digestive system; Structure and function of liver; Digestive enzymes; Mechanism of digestion and absorption of carbohydrate, proteins and lipids in mammal.

Unit V: Circulatory and respiratory systems
Composition of and circulation of blood, structure and function of heart in vertebrates. Anatomy and histology of lungs in mammal; Gas exchange in lungs & peripheral tissues; Structures and function of excretory organ in vertebrates.

Unit VI: Muscular and Nervous systems
Types of muscles; Molecular mechanism of muscle contraction; neuromuscular junction.Type and structure of neuron; Nerve impulse Electrical activity of axons, synapse and neuromuscular junction; Neurotransmitters.

Unit VII: Reproductive system and Endocrinology
Structure and function of reproductive system in mammals; Endocrine glands and hormones in vertebrates. Mechanism of hormone action.

Textbooks

1. Lambers, H. and Chapin, F. S., Plant Physiological Ecology (Springer, 2000).
2. Mukherji, S. and Ghosh, A.K., Plant Physiology, 1st edition (New Central Book Agency Private Ltd. Kolkata, 2009).
3. Guyton, C. and Hall, E., Text book of Medical Physiology, 10th edition (W.B. Saunders Company, 2001).
4. Hill, R.W., Wyse, G. A. and Anderson, M., Animal Physiology, 2nd edition (Cambridge University Press, 2008).

Reference Books

- Taiz, L. and Zeiger, E., Plant Physiology, 4th edition (Sinauer Associates, 2006).
- Sherwood, Klendorf and Yancy, Animal Physiology: From Genes to Organisms (Thomson Brooks/Cole Publishers, 2005).

BI227: Lab for Biochemistry and cell biology **L0-T0-P2-CH4-CR2**

1. Introduction to pH and buffers.
2. Quantitative estimation of protein, DNA and RNA.
3. Quantitative estimation of carbohydrates by anthrone method.
4. Isolation of DNA from organisms.
5. Spectrophotometric analysis of DNA.
6. Gel electrophoresis and DNA restriction digestion.
7. Identification of stages from permanent slides showing Mitosis and Meiosis.
8. Methods of cell disintegration.
9. Lymphocyte culture and isolation of sub-cellular fractions.

Reference books

1. An introduction to practical biochemistry, 3rd edition by David T Plummer
2. Microbiology Laboratory Manual, 5th Edition, James G. Cappucciino and Natalie Sherman
3. Molecular Cloning A Laboratory Manual 1 2nd Edition, J. Sambrook, E.F Fristsch and T. Maniatis
4. Molecular Cloning A Laboratory Manual 2 2nd Edition, J. Sambrook, E.F Fristsch and T. Maniatis

Semester IV

BI 222: Microbiology **L2-T1-P0-CH3-CR3**

Unit I: Brief history and development of microbiology
Introduction to study of Microbiology, conflict over spontaneous generation, role of microorganisms in disease, development of Koch's postulate.

Unit II: Microbial Taxonomy
Classification system- phenetic, phylogenetic, numerical, morphological and biochemical characteristics; nucleic acid sequencing, Novel genomic tools including signatures, restriction digestion patterns, unculturable micoebes, Metagenomics,

Unit III: Microbial diversity
Bacterial cell wall, cytoplasmic structure and inclusions bodies, sporulation and spore, diversity in bacterial structure actinomycetes, rickettsias, mycoplasma; archaea, eukaryotic microorganisms: protozoa, algae, yeast and fungi,

Unit IV: Viruses
Basic structure, classification, double stranded and single stranded DNA and RNA viruses, replication of DNA and RNA viruses; viroids and prions; bacteriphages with suitable examples.

Unit V: Microbial growth and Nutrition
Culture media, microbial growth curve, influence of environmental factors on growth; quorum sensing, Common nutrient requirements, introduction to nutritional types in microorganisms, uptake of nutrient by the cell, energetic of biosynthetic reactions; photosynthesis (oxygenic an anaoxygenic), autotrophs, heterotrophs. assimilation of inorganic phosphorous, sulphur and nitrogen.

Unit VI: Horizontal gene transfer
Transformation, conjugation, transductions. synthetic biology

Unit VII: Microbial diseases and their control
Host-pathogen relationship, mechanisms of virulence, pathogenesis in plants and animals. Antimicrobial chemotherapy, quorum sensing and quorum sensing inhibitors,

Textbooks

1. Willey, J., Sherwood, L. and Woolverton C., *Microbiology*, 7th edition (McGraw-Hill Science,
2. 2008).
3. Pelczar, M.J., Chan, E.C.S. and Kreig, N.R., *Microbiology*, (Mc. Graw Hill., 1993).
4. Brock, T.D., Smith, D.W. and Madigam, M.T., *Biology of Microorganisms, 4th* Edition
5. (Prentice Hall International, 1993).
6. Tortora, G.J., Fernke, B.R. and Case, C.L., *Microbiology – An Introduction,* 9th Edition
7. (Benjamin Cummings, 2009).

BI 224: Ecology and Environmental Biology L2-T1-P0-CH3-CR3

Unit I: Introduction to Ecology and Environment
Definition, principle and scope of Environmental Science; Concept of Environmental factor: Abiotic and Biotic factors. Ecosystem: Definition, types, structure and function of different ecosystems, energy flow; Examples of some ecosystems: Terrestrial (forest, grassland) and aquatic (fresh water, marine, estuarine) ecosystem. Ecological succession: Types and general process of succession; Concept of climax; resource competition; Primary and secondary succession; influence of animal on vegetational succession; community evolution.

Unit II: Biogeochemical cycling
Concept of biogeochemical cycle, types; water cycle; gaseous cycle-Carbon, nitrogen, iron; sedimentary cycles- phosphorous, sulfur.

Unit III: Habitat and niche
Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.

Unit IV: Biotic Community
Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.

Unit V: Population ecology
Population dynamics; species boarders; predator-prey systems; population growth curves age distribution, population regulation; concept of metapopulation – demes and dispersal, interdemic extinctions. Types of interactions, interspecific competition, herbivory, carnivory, commensalism, symbiosis, direct and indirect mutualism.

Unit VI: Environmental monitoring
Effect of pollution, Monitoring techniques and methodology, pH, Dissolved Oxygen (DO); Chemical oxygen demand (COD); Biological Oxygen Demand (BOD). Bioremediation; adverse effect of recombinant technology on environment.

Unit VII: Conservation biology and Management
Natural resources and their conservation; wildlife in India and conservation.

Textbooks:

1. Odum, E. , Brewer, R., and Barrett, G. W., Fundamentals of Ecology , 5th Edition (Thomson
   Brooks/Cole, 2004).
2. Kormondy, E. J., Concepts of Ecology, (Prentice-Hall, Englewood Cliffs, N. J, 1969).
3. Verma, P.S. and Agarwal, V.K. Environmental Biology: Principles of Ecology (S. Chand Limited, published 2000)

Reference books

1. Golley, F. B., A History of the Ecosystem Concept in Ecology: More Than the Sum of the Parts, (Yale University Press, 1996).
2. Wainwright, M., An Introduction to Environmental Biotechnology, (Kluwer Academic Publishers, 1999).
3. Rittman B. and McCarty, P.L., Environmental Biotechnology: Principles and Applications, 2nd Edition (McGraw-Hill, 2000).

BI 226: Basics in Bio-computing **L2-T1-P0-CH3-CR3**

Unit I: Basic Concepts
Basic computer organization, Processor and memory, secondary storage devices, Input-Output devices, Computer software, planning the computer program, Computer languages, Operating system: MS DOS, Unix (some basic commands), Data communication and computer network.

Unit II: Programming Basics
Elements of programming in C: Variables, Constants, Keywords, Input/output, Control Statements, Functions, Structures (Basic Ideas with illustrations only).

Unit III: Internet Technology
Internet and world wide web, Client- server organization, FTP, HTTP, Telnet, Browsers: Netscape and Internet explorer, Searching the web, Search engines, Intelligent use of a search engine, html, Scripting, Basic ideas of CGI and perl (only the working principles).

Unit IV: Word Processing and Documentation
Basic word processing in Microsoft word, Power Point and Excel, Preparing and processing text documents, MS-Acess.

Unit V: Bioinformatics and Information Technology
What is Bioinformatics, Use of information technology for studying Biosciences, Emerging areas in Bioinformatics, Future prospects of Bioinformatics.

Unit VI: Bioinformatics Basics
Introduction to Genomics, Proteomics, Human Genome Project, Biological Software, Public Database, Gene Bank, Using Public Database.

Text Books

1. Rastogi, B.C., Bioinformatics, Concept, Skills & Applications, 2nd Edition (CBS Publications, 2009).
2. Sinha, P.K., Computer Fundamentals, (BPB Publications, 2002).

Reference Books

1. Kanitkar Y., Programming in C, (BPB Publications, 2008).
2. Mount, D. W., Bioinformatics, Sequence & Genome Analysis, 2nd Edition (CBS, 2005).

BI 228: laboratory in microbiology **L0-T0-P2-CH4-CR2**

1. Isolation of pure culture and Gram staining.
2. Use of differential and selective media for bacterial culture.
3. Spore and capsule staining and biochemical activities of microorganism.
4. Study of microbial growth kinetics.
5. Screening of bacteria for production of extracellular enzymes.
6. Sampling techniques; waste water analysis for physiochemical characteristics such as pH conductivity, TDS, DO, BOD, COD.

Reference books

1. An introduction to practical biochemistry, 3rd edition by David T Plummer
2. Microbiology Laboratory Manual, 5th Edition, James G. Cappucciino and Natalie Sherman
3. Molecular Cloning A Laboratory Manual 1 3rd Edition, J. Sambrook, E.F Fristsch and T. Maniatis
4. Molecular Cloning A Laboratory Manual 2 2nd Edition, J. Sambrook, E.F Fristsch and T. Maniatis

Semester V

BI 321: Molecular Biology **L2-T1-P0-CH3-CR3**

Unit I: Genome organization
Structure and organization of chromosome in prokaryotes and eukaryotes: packaging of DNA into chromosomes, DNase I sensitive regions, heterochromatin and euchromatin, DNA methylation (e.g. X chromosome inactivation). Genome complexity: DNA reassociation kinetics, Cot curve, C-value paradox, repetitive and unique sequences.

Unit II: DNA structure
DNA double helix: Base-pairing in DNA (incl. Non-Watson-Crick), DNA as a Helix, processes that affect helical nature, A- B- and Z- DNA. DNA supercoiling: Linking number, twist, super-helical density, topoisomerases.

Unit III: Replication, repair and recombination
Replication in prokaryotes and eukaryotes: chemistry of replication, DNA polymerases, mechanism of replication- initiation, elongation and termination. DNA repair: Base mis-pairing, insertion/deletion, DNA lesions- pyrimidine dimer and AP sites, photolyase, mismatch, base-excision and nucleotide-excision repair mechanisms, SOS regulation, specialized DNA polymerases for DNA lesions, double-strand break repair and non-homologous end-joining. Homologous recombination: mechanism of homologous recombination-holiday model, double-strand break repair model, Chi sequences and role of different proteins. Non-homologous recombination: conservative site-specific recombination, FLP/FRT and Cre-Lox recombination, transposition- DNA transposons and retroposons and mechanism.

Unit IV: Transcription
Prokaryotic transcription: RNA polymerase, promoters, sigma factors, initiation, elongation and termination (Rho-dependent and independent), anti-termination. Eukaryotic transcription: Types of RNA polymerase and structure-assembly, promoters and enhancers, transcription factors, TBP and TAFs, post-transcriptional modifications (capping, poly-A tail, splicing).

Unit V: Translation
Prokaryotic translation: Ribosome, tRNA, amino-acyl tRNA synthetases, genetic code, translation-initiation, elongation, termination and ribosome recycling, codon-anticodon pairing Eukaryotic translation: Ribosome, tRNA, translation-initiation, elongation, termination and ribosome recycling, post-translational modifications.

Unit VI: Regulation of gene expression
Prokaryotes: Transcriptional regulation: activators and repressors, Operons-Lac, Trp and Ara, regulation by sigma factors, Post-transcriptional and post-translational regulation: anti-sense RNA, riboswitch, anti-sigma factors, two-component regulatory system, Tm RNA. Eukaryotes: Transcriptional regulation: DNA methylation, Histone modification, transcription factors, enhancersPost-transcriptional regulation: Alternative splicing, RNA editing, non-stop and non-sense mediated decay of mRNA, microRNA, siRNA, mRNA transport Translational regulation and Post-translational regulation: UTR-mediated regulation, phosphorylation.

Text books

1. Benjamin, L. Gene IX (Jones and Barlett Publishers, 2007)
2. Watson, et al Molecular Biology of the Gene (Benjamin Cummings Publishing Company Inc, 007)
3. Alberts, B. Molecular Biology of the Cell (Garland Publishing, 2007)

Reference books

1. Allison, L.A. Fundamental Molecular Biology (Blackwell Publishers, 2007)
2. John Wilson, J. & Hunt, T. Molecular Biology of the Cell, Fifth Edition: The Problems Book (Garland Publishing, 2007)
3. Tropp, B. E. Molecular Biology: Genes To Proteins (Jones & Bartlett Publishers, 2007)

BI323: Developmental Biology L2–T1–P0-CH 3-CR 3

Unit I: History of developmental biology
Historical perspective and different techniques in developmental biology. An overview of model organisms.

Unit II: Developmental genetics
Developmental events and genetics, Genes in early development, control of gene expression and cell signaling. Early embryonic development: Gametogenesis, Fertilization, Cleavage I, Cleavage II, Gastrulation I, Gastrulation II.

Unit III: Embryogenesis
Embryogenesis in plant: Embryogenesis and early pattern formation in plants , cell lineages and developmental control genes in a model plant
Embryogenesis in animals: Embryogenesis and early pattern formation in animal, cell lineages and developmental control genes in *C. elegans*.

Unit IV: Patterning of body plan
Laying of body axis planes, Axis formation and anterior/posterior patterning in amphibians/ C. elegans/ mouse, Axis formation and anterior/posterior- dorsal/ventral patterning in Drosophila (maternal effect genes, segmentation, zygotic genes, Hox genes), Sex determination in Drosophila.

Unit V: Cell differentiation
Differentiation of Specialized Cells: Stem cell differentiation and cell fate determination, cell adhesion and migration and morphogenesis; Blood cell formation; Differentiation of cancerous cells and role of protooncogenes.

Unit VI: Plant meristem organization and differentiation
Plant meristem organization Organization of Shoot Apical Meristem (SAM); Organization of Root Apical Meristem(RAM); Plant Meristem Differentiation: Pollen germination and pollen tube guidance; Phloem differentiation; Self-incompatibility and its genetic control; Embryo and endosperm development; Heterosis and apomixes.

Text books

1. Scott F. Gilbert. Developmental Biology, (Sinauer Associates, Inc., 9th edition, 2010)
2. Lewis Wolpert. Principles of Development, (Oxford University Press, 5th edition, 2010)

Reference books

1. Bruce Alberts et al, Molecular Biology of the Cell, (Garland Science; 5th edition, 2007).
2. Benjamin Lewin, Gene IX (Jones & Bartlett Learning, 9th edition, 2007).
3. James D. Watson et al., Molecular Biology of the gene (Pearson Prentice Hall, 5th edition, 2003).
4. B. M. Turner, Chromatin & Gene regulation: Molecular Mechanisms in Epigenetics (Wiley-Blackwell, 2002).

BI 325: Analytical Techniques

L2–T1–P0-CH3-CR3

Unit I: Microscopy techniques
Principles and application of electron microscopy, optical microscopy, phase contrast and fluorescence microscopy. Confocal microscopy, FRET, FRAP, TIRF.

Unit II: Spectroscopy techniques
Photoluminescence; UV, Visible and Raman Spectroscopy; Theory and application of Circular Dichroism; FTIR, MS, NMR, PMR, ESR and Plasma Emission spectroscopy.

Unit III: Chromatography Techniques
Principles of chromatography; TLC and Paper chromatography; Chromatographic methods for macromolecule separation – Gel permeation, Ion exchange, Hydrophobic, Reverse-phase and Affinity chromatography; HPLC and FPLC; Criteria of protein purity, Ultrafiltration and other membrane techniques, dialysis.

Unit IV: Electrophoretic techniques
Theory and application of Polyacrylamide and Agarose gel electrophoresis; Capillary gel electrophoresis; 2D-gel Electrophoresis; Disc gel electrophoresis; Gradient electrophoresis; Pulsed field gel electrophoresis.

Unit III: Centrifugation
Basic principles; Mathematics & theory (RCF, Sedimentation coefficient etc); Types of centrifuge - icrocentrifuge, High speed & Ultracentrifuges; Preparative centrifugation; Differential & density gradient centrifugation; Applications (Isolation of cell components); Analytical centrifugation; Determination of molecular weight by sedimentation velocity & sedimentation equilibrium methods.

Unit IV: Radioactivity
Radioactive & stable isotopes; Pattern and rate of radioactive decay; Units of radioactivity; Measurement of radioactivity; Geiger-Muller counter; Solid & Liquid scintillation counters (Basic principle, instrumentation & technique); Autoradiography; Measurement of stable isotopes. Use of radioactivity in biochemistry.

Unit V: Advanced Techniques
Protein crystallization; Theory and methods; API-electrospray and MALDI-TOF; Mass spectrometry; Enzyme and cell immobilization techniques; DNA & Peptide Synthesis, FACS.

Text books

1. Freifelder D., Physical Biochemistry, Application to Biochemistry and Molecular Biology,
1. 2nd Edition, W.H. Freeman & Company, San Fransisco, 1982.
2. Keith Wilson and John Walker, Principles and Techniques of Practical Biochemistry, 5th
3. Edition, Cambridge University Press, 2000.
4. D. Holme & H. Peck, Analytical Biochemistry, 3rd Edition, Longman, 1998.

Reference books

1. R. Scopes, Protein Purification - Principles & Practices, 3rd Edition, Springer Verlag, 1994.

BI 327: Bio-programming and Biostatistics L2–T1–P0-CH3-CR 3

Unit I: Basics of biostatistics
Frequency Distributions and Statistical Measures: mean, mode, median, variance, standard deviation, coefficient of variation, measures of skewness and kurtosis

Unit II: Probability
Introduction to theory of Probability, Conditional Probability, Bayesian Rules, Random variable, Distributions of random variables, Binomial, Poisson Fundamental concepts in applied probability, Probability and analysis of one and two way samples' discrete and continuous probability models, Expectation and variance; Central limit theorem.

Unit III: Data analysis
Exploratory data analysis and statistical inference, Chi-square test for independence, P-value and z-score of the statistic.

Unit IV: Bio-programming
Concepts of flowcharting, algorithm development, pseudo codes, program compilation etc.

Unit V: Programming languages
(1) C: File handling in C, Modes for files, Functions used in files.
(2) C++: Introduction and application of Object Oriented programming languages, Differences between C and C++, Different properties of C++, Inheritance, Polymorphism, Virtual Functions, Decision and Loops, Array, Functions.
(3) Perl: Introduction and application of Perl, Bio-perl (Transcription, Reverse compliment and reading PDB files).
(4) JAVA: Object Orientation and Introduction to JAVA, Importance and features of java.

Text Books
1. Arora P.N. Biostatistics
2. Kanetkar. Y. P. Let us C++
3. Kanetkar. Y. P. Let us C
4. E. Balagurusamy: Programming in ANSI C
5. O'Reilly: Beginning Perl for **Bioinformatics**.
6. E Balaguruswamy: Programming with java: a primer.

Reference Books
1) E. Balagurusamy: Object Oriented Programming with C++
2) Liang Y Daniel: An introduction to Java programming
3) Bernard Rosner: Fundamentals of biostatistics

BI 329: Advanced Biochemistry **L3–T0–P 0-CH 3-CR3**

Unit I: Metabolism
Basic concept and function of metabolism, metabolic pathways, regulation of metabolism.

Unit II: Enzyme
Enzyme nomenclature, unique features of enzyme catalysis, concept of enzyme –substrate complex,thermodynamic principles – effect of catalyst on activation energy; enzyme kinetics, significance of Km/Kcat, allosteric enzymes, enzyme regulation-feed back regulation, covalent and non-covalent mechanisms of enzyme regulation; coenzymes.

Unit III: Isolation and purification of enzymes
Methods of enzyme isolation and purification, determination of molecular mass and purity of enzymes.

Unit IV: Carbohydrate metabolism and biological oxidation
Glycolysis and citric acid cycle, glyoxalate cycle, gluconeogenesis, pentose phosphate pathway and glycogen metabolism; oxidoreductases, redox potential, electron transport chain, oxidative phosphorylation and mechanism of ATP synthesis.

Unit V: Lipid metabolism
Metabolism of fatty acids, ketone bodies – formation and utilization, biosynthesis of cholesterol.

Unit VI: Protein metabolism
Pathways of amino acid metabolism, transamination, transdeamination and deamination.

Unit VII: Nucleic acid metabolism
Synthesis and degradation of nucleotides; metabolism of purines and pyrimidines.

Text books

1. Stryer, L. Biochemistry (Freeman Company, 2002).
2. Voet D and Voet J.G.,.Fundamentals of Biochemistry (John Wiley and Sons, 2004).
3. Nelson, D.L and Cox M MLehninger Principles of Biochemistry (Freeman. 2009).

Reference books

1. Zubey, G.L. Parson., W W and Vance, D.E., Principles of Biochemistry (Brown Publishers 1995).
2. Devlin, T.M., Text book of Biochemistry (John. Wiley and Sons. 2002).
3. Goodwin, T. W and Mercer E.I., Introduction to Plant Biochemistry (CBS Publishers and distributors 1998).

BI 331: Lab on Enzymology **L0-T0-P2-CH4-CR2**

1. Isolation of extracellular enzymes like amylase/protease/cellulose.
2. Assay of enzymatic activity of amylase/protease/cellulose.
3. Separation of proteins by polyacrylamide gel-electrophoresis.
4. Purification of enzyme by chromatography.
5. Assessment of purity and determination of molecular weight of protein using electrophoresis and chromatographic techniques.
6. Determination of activity, specific activity and kinetics (Km and Vmax values) of enzyme (cellulose/protease/amylase).

Practical books

1. David T. Plummer. An Introduction To Practical Biochemistry (Mcgraw-hill 1987).
2. Microbiology Laboratory Manual, 5th Edition, James G. Cappucciino and Natalie Sherman.
3. Molecular Cloning A Laboratory Manual 1 3rd Edition, J. Sambrook, E.F Fristsch and T. Maniatis.
4. Molecular Cloning A Laboratory Manual 2 2nd Edition, J. Sambrook, E.F Fristsch and T. Maniatis.

BI 333: Lab on Molecular Biology **L0-T0-P2-CH4-CR2**

1. Study of hyperchromic and hypochromic effect in DNA by spectrophotometry
2. Study of chromatin organization
3. Plasmid DNA isolation and agarose gel electrophoresis
4. Restriction mapping of plasmid DNA
5. Competent cell preparation
6. Transformation of plasmid to competent cells
7. Blue-white screening of transformed cells.

Practical books

1. Microbiology Laboratory Manual, 5th Edition, James G. Cappucciino and Natalie Sherman
2. Molecular Cloning A Laboratory Manual 1 3rd Edition, J. Sambrook, E.F Fristsch and T. Maniatis
3. Molecular Cloning A Laboratory Manual 2 2nd Edition, J. Sambrook, E.F Fristsch and T. Maniatis

Semester VI

BI 322: Genetics **L2-T1-P0-CH3-CR3**

Unit I: Genetics
Introduction to Genetics: Mendelian and non-mendelian inheritance, linkage and crossing over, molecular markers.

Unit II: Mutations
Nomenclature, Isolation, Mutation rate, Types of mutations, Reversion, Mutagens, Mechanisms of mutagenesis, Assay of mutagens.

Unit III: Microbial Genomes and genetic mechanisms
Plasmids, Transposable genetic elements, Bacteriophages, Gene transfer in bacteria: Conjugation, Transformation and Transduction, Gene mapping. Antibiotic resistance markers on plasmids (mechanism of action and resistance). Size, Number and geometry of chromosomes, Genome composition, Evolution.

Unit IV: Human genetics
Introduction to human genetics, Human mutations and their nomenclatures, Types of genetic diseases; Role of human genetics in medicine. Human Genome analysis: Human Genome Project, SNPs and their role in medicine.

Unit V: Chromosomal Aberrations
Disorders of sex chromosomes and autosomes. Human pedigrees and their analysis: Patterns of single gene inheritance-autosomal recessive; Autosomal dominant; X linked dominant and recessive.

Unit VI: Mitochondrial genetics
Mitochondrial inheritance; Genomic imprinting; Lyon hypothesis; isodisomy, Role of Y chromosome.

Unit VII: Molecular cytogenetics
Fluorescence In Situ Hybridization (FISH); Comparative Genomic Hybridization (CGH).

Unit VIII: Population Genetics
Hardy Weinberg equilibrium, Mutation, selection, Migration, Gene flow; Genetic drift.

Texts books

1. Strachan T and Read A P, Human molecular genetics, 3rd Edition, Garland Publishing, 2004.
2. Gupta P K, Genetics, 4th Edition, Rastogi Publications, 2011.
3. Maloy SR, Cronan J E, Freifelder D. Microbial Genetics, 2nd Edition, Narosa Publishing House, 2009.
4. Tamarin RH, Principles of genetics, TATA McGraw-Hill Edition. 2002 and latest editions

Reference books

1. Hartl DL and Jones E W.Genetics: Analysis of Genes and Genomes, 6th Edition, Jones & Bartlett Publishers, 2005.
2. Snyder L and Champness W. Molecular Genetics of bacteria, 3rd Edition, ASM Press, 2007.
3. Gangane SD. Human Genetics, 3rd Edition, Elsevier, 2008.

BI 324: Genetic Engineering **L2–T1–P0-CH3-CR3**

Unit I: Introduction to Genetic Engineering
Recombinant DNA technology, Restriction enzymes, T4 DNA ligase, DNA ligation (cohesive and blunt end), modification of DNA ends (terminal transferases, linkers and adaptors), Homopolymeric tailing, T4 kinase, alakaline phosphatase, klenow fragment, DNase I, single strand specific nucleases, RNase H.

Unit II: Molecular techniques
Hybridization techniques: Southern, Northern, Colony hybridization, Southwestern and Far-western cloning, Fluorescence in situ hybridization; Radioactive and non-radioactive probes, Chromatin Immunoprecipitation, DNA-Protein interaction-electromobility shift assay, Gene silencing techniques, siRNA technology, DNaseI footprinting; (PCR is treated as a separate unit), Yeast two hybrid system.

Unit III: PCR and its application
Principles of PCR, Primer design; Fidelity of thermostable enzymes; DNA polymerases; Types of PCR – multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, cloning of PCR products; Proof reading enzymes; PCR in gene recombination; Deletion; addition; overlap extension; and SOEing; PCR in molecular diagnostics; Viral and bacterial detection; PCR based mutagenesis, Mutation detection: SSCP, DGGE, RFLP, Oligo Ligation Assay (OLA), MCC (Mismatch Chemical Cleavage, ASA (Allele-Specific Amplification), PTT (Protein Truncation Test) Diagnostic application of PCR and differential gene expression; PCR application in molecular markers (RAPD, AFLP, microsatellite).

Unit IV: Cloning vector
Plasmids, Phagemids; Lambda vectors, Cosmids; Artificial chromosome vectors (YACs; BACs); Animal Virus derived vectors; Ti and Ri as vectors. Construction of Genomic DNA and cDNA library, Screening of library (complementation and nucleic acid hybridization); immunological recognition, confirmation of clone identity.

Unit V: Recombinant protein expression
Bacterial expression host, bacterial expression; expression and purification of recombinant protein; limitations of bacterial expression system; Yeast expression system; introduction of DNA into yeast cells, expression and purification of recombinant proteins from yeast; Baculovirus expression system, bac to bac baculovirus system. Expression in other cell lines.

Unit VI: Transgenic animals
Methods of producing transgenic animals (microinjection, retrovirus and embryonic stem cells), expression of foreign DNA in transgenic mice, gene knock-in and knock-outs in transgenic mice. Gene therapy.

Text books

1. Primrose B. and Twyman R., Principles of Gene Manipulation and Genomics (7th Edition, Blackwell, 2006).
2. Howe C. J., Gene Cloning and Manipulation (2nd Edition, Cambridge, 2007)
3. John R., Analysis of Genes and Genomes (Wiley and Sons. 2004).

Reference books

1. Brown T.A., Gene cloning and DNA Analysis (6th Edition, Willey-Blackwell, 2010)
2. Nicholl D.S.T., An Introduction to Genetic Engineering (3rd Edition, Cambridge, 2008)

BI 326: Immunology **L2–T1–P0-CH3-CR3**

Unit I: Introduction
Basics of an immune response, discrimination between self and non-self, innate and acquired immune response, comparative immunity and evolution of immune system.

Unit II: Innate Immunity
Anatomic and Physiological Barriers, Inflammation, Toll receptors and PAMPs, DAMPs , Defensisns, and Complement system, NK Cells.

Unit III Cells, tissues and organs of the immune system
Haematopoeisis, cells of innate and adaptive immune system, organs of the immune system.

Unit IV: Antigenicity vs immunogenicity
Antigen, factors that influence immunogenicty, B and T cell epitopes, haptens. Immunoglobulins: basic structure, Ig fold and domains, classes and subclasses of Ig, biological activities of Igs, B cell receptor, antigenic determinants on immunoglobulin, Ig diversity -multigene organization of Ig genes, variable region gene rearrangements, mechanism of variable region DNA rearrangements in generation of antibody diversity, class switching, affinity maturation and somatic hypermutation, monoclonal antibodies.

Unit IV: MHC
General organisation and inheritance of the MHC, MHC molecules and genes, cellular distribution of MHC genes molecules, MHC and immune responsiveness and genetic susceptibility to diseases, Antigen processing and presentation: intracellular and extracellular antigen processing pathways.

Unit V: T and B cell maturation and activation
Basics of T and B maturation, selection of T-cell and of B cell repertoire, self-MHC restriction of T and of B cells, T helper cell activation and differentiation, B-cell differentiation and affinity maturation. Effector T cells, cytotoxic T cells, NK cells, ADCC, and hypersensitivity.

Unit VI: Cytokines and cytokine receptors
Properties of cytokines, cytokine receptors, cytokine signal transduction, cytokines secretion by Th1 and Th2 subsets and cross regulation.

Textbooks

1. Basic Immunology: Functions and Disorders of the Immune System, Abul K. Abbas, Andrew H. Lichtman, Shiv Pillai (Elseviers Saunders 4 th Edition).
2. Kuby Immunology, Thomas J. Kindt, Barbara A. Osborne, Richard A . Goldsby (W.H. Freeman Publishers, Sixth Edition).

Reference books

1. Delves, P., Martin, S., Burton, D., Roitt, I. Roitt's Essential Immunology(Wiley-Blackwell, 11th Edition).

BI 328: Biological Databases Management System L2–T0–P0-CH2-CR2

Unit I: Database Concepts
Introduction, History of Databases, Types of Databases.

Unit II: Database Management Systems
Codd Rule, Data Normalization. Introduction to SQL, Structured Query Language, Constraints, Types of SQL Commands, Data Correlation, Introduction to Index, Types of Index.

Unit III: Biological Databases
Introduction, Biological Databases and its importance, Biological databases and their functioning, Types of Biological Databases, Microbiological Databases, Virological Databases, Organism Databases, Primary Sequence Databases, Carbohydrate Databases, RNA databases, Biodiversity, Sequence Database (Nucleotide and Protein Sequence DB), Structural Databases, Gen bank sequence database, submitting sequences to database: NCBI, EMBL, PDB etc.

Textbooks

1. Elmasr, R. and Navathe S. B. Fundamentals of Database Systems (4th Edition , Pearson Education).
2. Korth, H. F., Sudarshan S. Database System Concepts, Abraham Silberschatz,, (McGraw-Hill Publication).

Reference books

1. Bosu O. and Kaur S. T. Bioinformatics Databases, Tools and Algorithms, l, (Oxford University Press).
2. Gautham, N Bioinformatics Databases and Algorithms, (Narosa Publication, Delhi).

BI 330: Bioinformatics Software and Applications L2–T0–P0-CH2-CR2

Unit I: Data search and Pair-wise Alignments
Dynamic Programming BLAST, FASTA, Algorithms for Multiple sequence alignments (CLUSTALW). Substitution Patterns: Jukes Cantor Model, Kimura's model etc. Phylogenetic Analysis: Distance based methods and character based methods and soft-wares.

Unit II: Structure prediction
Statistical approaches to Gene Prediction. Structural prediction of biomolecules (Protein/nucleic acid).

Unit III: 3D structure
Methods for comparison of 3D structure of proteins. (Swiss-PdbViewer- A program to display, analyse and superimpose protein 3D structures, MOLMOL - a molecular graphics program for display, analysis, and manipulation of three-dimensional structures of biological macromolecules, TopMatch-web – For protein structure comparison).

Unit IV: Molecular interactions
Protein-protein, protein-DNA, protein-carbohydrate, DNA small molecules etc.

Unit V: Computational methods
Docking of molecules: Drug designing. Calculation of conformational energy for biomolecules. Molecular, Mechanics, Monte Carlo, Molecular dynamics and quantum mechanics, Molecular modeling.

Text books

1. Brown, T. A. Genomes II (2nd Edition, Wiley – Liss2002).
2. Primrose. Principles of Genome Analysis and Genomics (3rd Edition,Blackwell2003).
3. Baxevanis A. D Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, (Wiley-Interscience.2001).

Reference books

1. Krane, D. E., Raymen, M. L. Fundamental Concepts of Bioinformatics (2002 Benjamin Cummings).
2. Mount, D. W. Bioinformatics: Sequence and genome Analysis (CHSL Press. 2001).
3. Bourne P. E. and Weissig, H. Structural Bioinformatics (2003, WILEY).
4. Ghosh Z. and Mallick B. Bioinformatics Principles and Applications, (Oxford University Press, 2010).

BI 332: Credit seminar **L0–T1–P0-CH1-CR1**

BI 334: Lab on Immunology **L0–T0–P2-CH4-CR2**

1. Blood film preparation and identification of leucocytes by Giemsa stain.
2. Antibody titre by ELISA method.
3. Double diffusion, immunoelctrophoresis and radial immune diffusion.
4. SDS-PAGE and immune blotting.
5. Immunodiagnostics using commercial kits.

Practical books

1. Practical Immunology, 4th Edition Frank C. Hay, Olwyn M. R. Westwood Wiley-Blackwell, ISBN: 978-0-86542-961-1.
2. Molecular Cloning A Laboratory Manual 1 3rd Edition, J. Sambrook, E.F Fristsch and T. Maniatis.
3. Molecular Cloning A Laboratory Manual 2 2nd Edition, J. Sambrook, E.F Fristsch and T. Maniatis.

BI 336: Lab on genetic engineering **L0–T0–P2-CH4-CR2**

1. Amplification of gene and gel electrophoresis.
2. Restriction digestion of PCR product and expression vector.
3. Cloning of PCR product/gene of interest into expression vector .
4. Preparation of competent cell and transformation using ligation mixture.
5. Screening of recombinant clones.
6. Expression of recombinant protein using IPTG.
7. Purification of recombinant protein by Ni-NTA column.

Practical books

1. Microbiology Laboratory Manual, 5th Edition, James G. Cappucciino and Natalie Sherman.
2. Molecular Cloning A Laboratory Manual 1 3rd Edition, J. Sambrook, E.F Fristsch and T. Maniatis.
3. Molecular Cloning A Laboratory Manual 2 2nd Edition, J. Sambrook, E.F Fristsch and T. Maniatis.

Semester - VII

BI 421: Structural Bioinformatics L2-T1-P0-CH3-CR3

Unit-I: Introduction to Macromolecular Structure;
Proteins: Primary Structure, Secondary Structure, Tertiary Structure, Quaternary Structure; Nucleic Acids: DNA – A, B, Z forms, RNA; Viewing Tools: Rasmol, DeepView, GRASP; Graphics Tools: Molscript, Raster3D.

Unit-II: Introduction to Force Fields and Modeling: Introduction to Force Fields, Building small molecules, Building small peptides/nucleic acids, Energy Minimization.

Unit-III: Molecular Dynamics: Basic Theory, Introduction to the AMBER & GROMACS software packages, Applications of Molecular Dynamics in Protein folding, Protein unfolding, Stability of drug/receptor complexes, NMR structure refinement.

Unit-IV: Homology Modeling: Sequence Alignment (Multiple Sequence Alignments, BLAST, FASTA, PAM, GCG, SeqLab (Unix GUI), SeqWeb, Databases), Homology Model Programs (SwissProt (submission to a web resource), InsightII Homology, Look, Model Refinement).

Unit-V: Docking: Simulated Annealing, Genetic Algorithms, Other Methods like TABU, DOCK (spheres vs grids), FTDOCK (Docking small/medium sized polypeptides to proteins), FRED.

Unit-VI: Scoring Methods: Simple Interaction Energies, GB/SA scoring (implicitsolvation), CScore (consensus scoring algorithms**).**

Unit-VII: Structure-Based Drug Design Strategies: Simple Structure Activity Relationships, Drug action and interactions with receptors.

Textbooks

1. Polanski A. *Bioinformatics*, (Springer, 2007).
2. Mount D. *Bioinformatics Sequence and Genome Analysis*, (2nd Edition, Cold Spring Harbor Laboratory Press, New York, 2004)
3. Chorghade M.S. *Drug Discovery and Development*, Vol: 1, (Wiley Interscience, New Jersey, 2006).

Reference Books

1. Bransdan B.H., *Quantum Mechanics*, 2nd Edition, Pearson Education, Delhi, (2007).
2. Voet, D., *Fundamentals of Biochemistry*, (2nd John Wiley and sons, 2006).

BI 423: Cell and Tissue Culture L2-T1-P0-CH3-CR3

Unit-I: Introduction to animal and plant tissue culture: historical background, advantages and limitations of tissue culture, major differences in *in vitro* culture and types of tissue culture and the terminology, finite/infinite cell lines, immortalization of cells, genetic transitions in primary culture, monolayer cultures, immobilized cultures and suspension cultures.

Unit-II:Requirements and techniques of plant tissue culture: media compositions, growth hormones and other organic compounds; gelling agents, culture environment, behavior of cells in culture conditions: division and growth pattern.

Unit-III: Requirements and techniques of animal cell culture: Aseptic techniques, cell type, choice of materials - substrates-culture vessel/ treated surfaces, Development of media, physiochemical properties, complete media, serum, chemically defined basal and minimal essential media, serum and protein free media;

Unit-IV: Behaviour of animal cells in culture: cell adhesion, cell proliferation, differentiation, energy metabolism. Initiation of culture, evolution of cell lines, development of continuous cell line and stem cells

Unit-V: Characterization, cell separation and maintenance of animal cell lines: Cryopreservation, physical methods of cell separation, antibody based techniques, magnetic sorting, cell counting and cell proliferation. Common cell culture contaminants.

Unit-VI: Animal cell culture applications and products: Cell products - antibodies and immuno-regulators, recombinant products, viral vaccines, cell and tissue therapy.

Unit-VII: Micro-propagation: Techniques; multiplication by axillary buds and apical shoot; meristem, shoot tip and bud cultures; factors affecting micro-propagation; organogenesis- direct and indirect; somatic embryogenesis; elimination of viruses and other pathogen in plants. Somaclonal variation and production of disease free plants.

Unit-VIII: Haploid production: Androgenesis; anther and pollen culture; factors affecting androgenesis; gynogenesis - ovary and ovule cultures; embryo culture and rescue.

Unit-IX: Protoplast culture and somatic hybridization: Isolation, regeneration of protoplast; culture media and methods; cell wall formation, division and growth. Fusion of protoplasts and their culture; selection of hybrid cells and generation of hybrid plants and their characterization; symmetric and asymmetric hybrids; cybrids; applications and limitations of somatic hybridizations.

Unit-X: Hardening, acclimatization and cultivation of tissue culture-derived plants: Exposure of tissue culture-derived plants to normal environment and their gradual acclimatization. Cultivation of the acclimatized plants in pots and filed.

Text books

1. Freshney R. I., *Culture of Animal Cells*, (5th Edition, Wiley-Liss, 2005).
2. Neumann K. H., Kumar A. , Imani J. *Plant Cell and Tissue Culture - A Tool in Biotechnology: Basics and Application (Principles and Practice),* (Springer; 1st edition 2009).
3. Satyanarayana U. *Biotechnology*, Books and Allied (P) Ltd.Kolkata

Reference books

1. John R.W. Masters, *Animal Cell Culture: Practical Approach*, (3rd Edition, Oxford, 2000).
2. Clynes, M*., Animal Cell Culture Techniques*, 1st Edition, Springer, 1998.
3. Dixon R A. Plant Cell Culture, IRL Press, Oxford – Washingto DC, 1987

BI 425: Computational Biology L2-T1-P0-CH3-CR3

Unit-I: Data search and Pair-wise Alignments: Dynamic Programming BLAST, FASTA.

Unit-II: Algorithms: for Multiple sequence alignments (CLUSTALW).

Unit-III: Substitution Patterns: Jukes Cantor Model, Kimura's model etc.

Unit-IV: Phylo-genetic Analysis: Distance based methods and character based methods and soft-wares.

Unit-V: Statistical approaches to Gene Prediction.

Unit-VI: Structural prediction of biomolecules (Protein/nucleic acid)

Unit-VII: Methods for comparison of 3D structure of proteins. (**Swiss-PdbViewer**- A program to display, analyse and superimpose protein 3D structures, ***MOLMOL*** - a molecular graphics program for display, analysis, and manipulation of three-dimensional structures of biological macromolecules, **TopMatch-web** – For protein structure comparison)

Unit-VIII: Molecular interactions: protein-protein, protein-DNA, protein-carbohydrate, DNA small molecules etc.

Unit-IX: Docking of molecules: Drug designing.

Unit-X: Computational methods: Calculation of conformational energy for biomolecules. Molecular Mechanics, Monte Carlo, Molecular dynamics and quantum mechanics,

Unit-XI: Molecular modelling.

Text books

1. Brown, T. A. *Genomes II* (2nd Edition, Wiley – Liss2002).
2. Primrose. *Principles of Genome Analysis and Genomics* (3rd Edition, Blackwell2003).
3. Baxevanis A. D *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins*, (Wiley-Interscience.2001).

Reference books

1. Krane, D. E,. Raymen, M. L. *Fundamental Concepts of Bioinformatics* (2002 Benjamin Cummings).
2. Mount, D. W. *Bioinformatics: Sequence and genome Analysis* (CHSL Press. 2001).
3. Bourne P. E. and Weissig, H. *Structural Bioinformatics* (2003, WILEY).
4. Ghosh Z. and Mallick B. *Bioinformatics Principles and Applications*, (Oxford University Press, 2010)

BI 427: Animal Biotechnology **L2-T1-P0-CH3-CR3**

Unit-I: Animal Cell Culture

Structure of Animal Cell; History of animal cell culture; Basic requirement for animal cell culture; Cell culture media and reagents; Animal cell; Tissue and organ cultures; Primary culture secondary cell culture; Continuous cell lines; Suspension culture somatic cell cloning and hybridization; Transfection and transformation of cells; Commercial scale production of animal cells; Stem cells and their application; Application of animal cell culture for in vitro testing of drugs; Testing of toxicity for environmental pollutants in cell culture; Application of cell culture technology in production of human and animal plant vaccines and pharmaceutical proteins.

Unit-II: Animal health Biotechnology

Introduction to immune systems; Cellular and Humoral immune response; History of development of vaccines; Introduction to the concept of vaccines; Conventional methods of vaccine production; Recombinant approaches to vaccine production; Hybridoma technology; Phage display technology for production of antibodies; Antigen antibody based diagnostic assays including radio immunoassays and enzyme immunoassays; Immunoblotting; nuclei acid based diagnostic methods including nucleic acid probe hybridization; restriction endo-nuclease analysis; PCR, Real time PCR; Nucleic acid sequencing; commercial scale production of diagnostic antigens and anti-sera; animal disease diagnostic kits; probiotics; Structure of sperms and ovum; cryopreservation of sperms and ova of live stocks; artificial insemination; super ovulation; in-vitro fertilization; culture of embryos; cryopreservation of embryos; embryo transfer; embryo splitting; embryo sexing.

Unit-III:Animal genomics

Different methods of characterization of animal genomes; SNP; STR; QTLs, RFLP; RAPD; Proteomics; Metabolomics; Genetic basis for disease resistance; gene knock out technology and animal models for human genetic disorders.

Unit-IV:DNA Forensics

Immunological and nucleic acid based methods for identification of animal species; detection of adulteration in meat using DNA based methods; detection of food/ feed adulteration with animal protein; identification of wild animal species using DNA based methods using different parts including bones, hair, blood, skin and other parts of the confiscated by anti poaching agencies; Human forensics; microbial forensics; bio-terror agents; Bio-crimes and Bio-terrorism.

Text books

1. Animal cell biotechnology Portner, 2nd edition, Humana Press, 2007.
2. Pinkert, Transgenic animal technology, Academic Press 2006.

Reference books

1. Ed. John R.W. Masters, Animal cell culture- Practical approach, 3rd edition , Oxford University Press, 2000.
2.Gordon, Reproductive technologies in farm animals, CAB Intl, 2005.

BI-429: Microbial Biotechnology L2-T1-P0-CH3-CR3

Unit I: Isolation and Screening of industrially important Microbes; Large scale cultivation of industrial microbes; improvement to improve yield of selected compounds for eg. antibiotics, enzymes or recombinant proteins, novel antimicrobials

Unit II: Basic Principles of bioprocess as applied to selected microbes; Process optimization of selected products.

Unit III: Recombinant Protein production in microbes; Commercial issues pertaining to the production of recombinant products from microbes; down stream processing approaches; Industrial Microbes as cloning hosts (Streptomyces/Yeast).

Unit IV: Environmental Application of microbes; Ore leaching; Toxic waste removal; Soil remediation. Biohydrogen and bioplastics, Environmental Microbiology and Genomics, Bioremediation, Bioaugmentaion, including Ecobiotechnological approaches.

Unit V: Microbial application in food and health care industries; Food Processing and food preservation; Antibiotics and enzymes of pharmaceutical use.

Text books

1. Glazer and Nikaids, Microbial Biotechnology, 2nd Edition, Cambridge University Press 2007.
2. Peter F Stanbury, A Whitaker and S J Hall, Principles of fermentation technology, 2nd Edition (Paper back), BH, Elsevier Science Ltd.2003.

References/ suggested readings:

1. Murray Moo- Young, H. W. Blanch Comprehensive Biotechnology: V:3, Pergamon Press.
2. Journals: (A) Nature Biotechnology (B) Trends in Microbiology (C) Current opinion in Microbiology.

BI-431: Plant Biotechnology L2-T1-P0-CH3-CR3

Unit I: Marker Assisted Cloning in Plants; Traits: (I) Functional: Biochemical/ Developmental /Environmental; (II). Inheritance: Dominant/Recessive/Quantitative Mapping: (I) Markers: Phenotype/Molecular, (II) Mapping: Genetic/Physical, (III) Genomic/cDNA library, (IV) Gene identification: complementation/sequencing.

Unit II: Plant functional genomics, Plant genomics: genome sequence/hypothetical genes/comparative genomics/functional genomics; Forward and Reverse Genetic Strategies, Gene and Enhancer Traps for Gene Discovery.

Unit III: Selectable markers and reporter genes for plants; Neomycin phosphotransferase II (NPTII), Hygromycin phosphotransferase Gentamicin acetyltransferase β-glucuronidase (GUS), Luciferase, Green fluorescent protein (GFP) Elimination of selection markers from transgenic plants.

Unit IV: Vectors for plant transformation; Agrobacterium based vectors (Ti and Ri), Binary vectors, Multi gene vectors and Gateway approach, Viral vectors.

Unit V: Transgenic plants; (I) Approaches: Overexpression, VIGS and RNAi; (II). Applications: Insect and pest resistance, Nutritional enhancements, abiotic stress mitigation.

Unit VI: Biocontainment strategies; Terminator technology, Gene Use Restriction Technologies (GURTs), Parthenocarpy Technology, Chloroplast Transformation, Gene Deletor Technology.

Unit VII: Plant immune and signaling system; Hormonal modulation, R proteins, sugar induced, fatty acid, innate immunity in plants, photoreceptor signaling, plant microbe interaction, molecular diagnosis of plant disease.

Textbooks

1. Adrian, S. *Plant Biotechnology: The Genetic Manipulation Of Plants* (Oxford University Press, 2008)
2. Razdan, M.K. *Introduction to Plant Tissue Culture* (Oxford & Ibh Publishing Co. Pvt. Ltd, 2006)
3. Agrios G.N. *Plant Pathology* (Elsevier, 2008)

Reference Books

1. Philip M. Gilmartin, P.M. & Bowler, C. *Molecular Plant Biology (Vol. 1)* (Oxford University Press, USA, 2002)
2.Philip M. Gilmartin, P.M. & Bowler, C. *Molecular Plant Biology (Vol. 2)* (Oxford University Press, USA, 2002)

BI-433: Nano Biotechnology **L2-T1-P0-CH3-CR3**

Unit I: Introduction to Nano-Biotechnolgy; Nano technology-Definition and concepts; cellular nanostructures; Nanopores; Bio-molecular motors; criteria for suitability of nanostructures for biological applications.

Unit II: Basic characterization techniques; Electron microscopy; Atomic Force microscopy; Photon correlation spectroscopy.

Unit III: Thin films; Colloidal nanostructures; Nano vesicles; Nanospheres; Nano Capsules.

Unit IV: Nanostructures for drug delivery, Concepts, Targeting, Routes of delivery and advantages.

Unit V: Nanostructures for diagnostics and biosensors; Nanoparticles for diagnostics and imaging; nanodevices for sensor development.

Text books

1. Biomedical nanotrechnology editor: Neelina H.Malsch Publisher: CRC Press. ISBN: 0-8247-2579-4.
2. Bionaotechnology: Lessons from Nature Author: David S. Goodsell publisher; Wiley-Liss ISBN: 047141719X

Reference books

1. Multilayer thin films, Editor(s): Gero Decher, Joseph B Schlenoff Publisher; Wiley-VCH Verlag GmbH & Co. KGaA ISBN: 3527304401

BI 435: Fermentation and Bioprocess Engineering L2-T0-P0-CH2-CR2

Unit I: Basic principle of Biochemical engineering: Basic Principles in bioprocess technology
Isolation, screening and maintenance of industrially important microbes; Microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); Strain improvement for increased yield and other desirable characteristics.

Unit II: Concepts of basic mode of fermentation processes
Bioreactor designs; Types of fermentation and fermenters; Concepts of basic modes of fermentation - Batch, fed batch and continuous; Conventional fermentation v/s biotransformation; Solid substrate, surface and submerged fermentation; Fermentation economics; Fermentation media; Fermenter design- mechanically agitated; Pneumatic and hydrodynamic fermenters; Large scale animal and plant cell cultivation and air sterilization; Upstream processing: Media formulation; Sterilization; Aeration and agitation in bioprocess; Measurement and control of bioprocess parameters; Scale up and scale down process.

Unit III: Downstream processing
Bioseparation - filtration, centrifugation, sedimentation, flocculation; Cell disruption; Liquid-liquid extraction; Purification by chromatographic techniques; Reverse osmosis and ultra filtration; Drying; Crystallization; Storage and packaging; Treatment of effluent and its disposal.

Unit IV: Applications of enzymes and microbes
Mechanism of enzyme function and reactions in process techniques; Enzymic bioconversions e.g. starch and sugar conversion processes; High-Fructose Corn Syrup; Interesterified fat; Hydrolyzed protein etc. and their downstream processing; baking by amylases, deoxygenation and desugaring by glucoses oxidase, beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing, bio-sensors, bio-pesticide, bio-fertilizers.

Unit V: Enzyme kinetics
Two-substrate kinetics and pre-steady state kinetics; Allosteric enzymes; Enzyme mechanism; Enzyme inhibitors and active site determination Production, recovery and scaling up of enzymes and their role in food and other industries; Immobilization of enzymes and their industrial applications.

Text books
1. Stanbury RF and Whitaker A., Principles of Fermentation Technology, Pergamon press,Oxford, 1997.
2. Baily JE and Ollis DF., Biochemical Engineering fundamentals, 2nd Edition, McGraw- Hill Book Co., New York, 1986.

Reference books
1. Aiba S, Humphrey AE and Millis NF, Biochemical Engineering, 2nd Edition, University of Tokyo press, Tokyo, 1973.
2. Comprehensive Biotechnology: The Principles, Applications and Regulations of Biotechnology in Industry, Agriculture and Medicine, Vol 1, 2, 3 and 4. Young M.M., Reed Elsevier India Private Ltd, India, 2004.
3. Jackson AT., Bioprocess Engineering in Biotechnology, Prentice Hall, Engelwood Cliffs, 1991.
4. Shuler ML and Kargi F., Bioprocess Engineering: Basic concepts, 2nd Edition, Prentice Hall, Engelwood Cliffs, 2002.
5. Mansi EMTEL, Bryle CFA. Fermentation Microbiology and Biotechnology, 2nd Edition, Taylor & Francis Ltd, UK, 2007.

BI 437: Lab. on Cell and Tissue Culture L0-T0-P2-CH4-CR2

1. Tissue culture media preparation
2. Germination condition optimization of different types of seed under sterile condition.
3. Meristem culture and micropropagation
4. Callus, suspension and single cell culture
5. Primary culture techniques
6. Embryo culture.

Practical books

Roberta H. Smith. Plant Tissue Culture, Second Edition: Techniques and Experiments (Academic Press).

BI 439: Lab. on Bioprocess Engineering L0-T0-P2-CH4-CR2

1. Determination of oxygen transfer rate and volumetric oxygen mass transfer coefficient (KLa) under variety of operating conditions in shake flask and bioreactor.
2. Determination of mixing time and fluid flow behaviour in bioreactor under variety of operating conditions.
3. Rheology of microbial cultures and biopolymers and determination of various rheological constants.
4. Production of microbial products in bioreactors.
5. Studying the kinetics of enzymatic reaction by microorganisms.
6. Production and purification of various enzymes from microbes.
7. Comparative studies of Ethanol production using different substrates.
8. Microbial production and downstream processing of an enzyme, e.g. amylase.
9. Various immobilization techniques of cells/enzymes, use of alginate for cell immobilization.

Semester VIII

BI 422: Genomics and Proteomics **L2-T1-P0-CH3-CR3**

Unit I: Introduction
Structural organization of genome in Prokaryotes and Eukaryotes; Organelle DNA-mitochondrial, chloroplast; DNA sequencing-principles and translation to large scale projects; Recognition of coding and non-coding sequences and gene annotation; Tools for genome analysis-RFLP, DNA fingerprinting, RAPD, PCR, Linkage and Pedigree analysis-physical and genetic mapping.

Unit II: Genome sequencing projects
Microbes, plants and animals; Accessing and retrieving genome project information from web; Comparative genomics, Identification and classification using molecular markers-16S rRNA typing/sequencing, ESTs and SNPs.

Unit III: Proteomics
Protein analysis (includes measurement of concentration, amino-acid composition, N-terminal sequencing); 2-D electrophoresis of proteins; Microscale solution isoelectricfocusing; Peptide fingerprinting; LC/MS-MS for identification of proteins and modified proteins; MALDI-TOF; SAGE and Differential display proteomics, Protein-protein interactions, Yeast two hybrid system.

Unit IV: Pharmacogenetics
High throughput screening in genome for drug discovery-identification of gene targets, Pharmacogenetics and drug development.

Unit V: Functional genomics and proteomics
Analysis of microarray data; Protein and peptide microarray-based technology; PCR-directed protein in situ arrays; Structural proteomics.

Text books
1. Voet D, Voet JG & Pratt CW, Fundamentals of Biochemistry, 2 nd Edition. Wiley 2006.
2. Glick BR & Pasternak JJ, Molecular Biotechnology, 3rd Edition, ASM Press, 1998.
3. Campbell AM & Heyer LJ, Discovering Genomics, Proteomics and Bioinformatics, 2 n d Edition. Benjamin Cummings 2007.

Reference books
1. Brown TA, Genomes, 3rd Edition. Garland Science 2006.
2. Primrose S & Twyman R, Principles of Gene Manipulation and Genomics, 7th Edition, Blackwell, 2006.

BI 424: Bioethics, Biosafety and IPR **L2-T0-P0-CH2-CR2**

Unit-I: Moral and ethical issues in Biotechnology.

Unit-II: Biosafety: Introduction; Historical Backround; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals;

Unit-III: Biosafety guidelines - Government of India; Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs;

Unit-VI: Risk Analysis: Risk Assessment; Risk management and communication;

Unit-V: Regulations: Overview of National Regulations and relevant International Agreements including Cartegana Protocol.

Unit-VI: Intellectual Property: Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of GMOs IP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies

Unit-VII: Agreements and Treaties: History of GATT & TRIPS Agreement; Madrid Agreement; Hague Agreement; WIPO Treaties; Budapest Treaty; PCT; Indian Patent Act 1970 & recent amendments

Unit-VIII: Basics of Patents and Concept of Prior Art: Introduction to Patents; Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; Specifications: Provisional and complete; Forms and fees Invention in context of "prior art";

Unit-IX: Patent databases: Searching International Databases; Country-wise patent searches (USPTO, esp@cenet(EPO), PATENT Scope(WIPO), IPO, etc.)

Unit-X: Patent filing procedures: National & PCT filing procedure; Time frame and cost; Status of the patent applications filed; Precautions while patenting –Financial assistance for patenting - introduction to existing schemes Patent licensing and agreement Patent infringement- meaning, scope, litigation, case studies

Text books

1. BAREACT, *Indian Patent Act 1970 Acts & Rules,* (Universal Law Publishing Co. Pvt.
1. Ltd., 2007).
2. Kankanala C., *Genetic Patent Law & Strategy*, (1st Edition, Manupatra Information
3. Solution Pvt. Ltd., 2007).

Important Links:

1. http://www.w3.org/IPR/
2. http://www.wipo.int/portal/index.html.en
3. http://www.ipr.co.uk/IP_conventions/patent_cooperation_treaty.html
4. www.patentoffice.nic.in
5. www.iprlawindia.org/ - 31k - Cached - Similar page
6. http://www.cbd.int/biosafety/background.shtml

BI 426: Elective -II Metagenomics/ Toxinology/ Pharamcogenomics/ Evolutionary Genomics
L2-T1-P0-CH3-CR3

Metagenomics

Unit I: Introduction
Sample enrichment, Nucleic acid extraction and enrichment technologies, Genome and gene enrichment, Gene targeting, Metagenomic DNA libraries, Metagenomic cDNA (transcriptomic) libraries, Metagenome sequencing, Commercial successes (examples)

Unit III: Identification of viral pathogens
Viral metagenomics as an improved pathogen detection method, Promise of metagenomic viral pathogen detection (Diagnostics, Outbreak response, Viral discovery, Environmental monitoring), Isolation of viral particles, Bioinformatic techniques, Verification, Plant Virus Metagenomics.

Unit IV: Sampling to data analysis
Sampling and processing, Sequencing technology, Assembly, Binning, Annotation, Experimental Design and Statistical Analysis, Sharing and Storage of Data, Single-Cell Analysis.

Unit V: Pyrosequencing and Microbial Identification
Metagenomics and the Human Microbiome, DNA Sequencing and Bacterial Identification, Next-Generation DNA-Sequencing Technologies-Pyrosequencing and 454, Metagenomics: Sequencing of 16S rDNA Amplicons, Whole-Genome Shotgun Sequencing, Next-Generation Microbial-Identification Strategies: Metagenomics and Informatics, Special Challenges: Fungal and Viral Metagenomics.

Unit VI: Metagenomics and Microbial Communities
Microbial Services: Genesis of oxygen, Conversion of nitrogen, Maintenance of human health, Synthesis of antibiotics; Microbial Communities, Metagenomics and symbioses, Metagenomics and geochemical cycles & Bioremediation, Metagenomics and antibiotic resistance, Eukaryotic metagenomics, Plasmidomics

Unit VII: Human Health
Antibiotic Resistance, Oral Microbiome, The Human Gut, IBD and Crohn's Disease, Cystic Fibrosis, Type 1 Diabetes, Other Human Microbiota, Microbial Ecology in States of Health and Disease, Influence of Diet and Dietary Components on the Microbiome.

VIII: Metagenomics of Plant-Microbial Interactions
Plant Virus Metagenomics, siRNA Sequencing, Enriched Virus-Like Particles, Enrichment for dsRNAs, Environmental Plant Viruses from Other Sources, metagenomics of the plant rhizosphere, rhizosphere microbiome and plant health.

Text books

1. Metagenomics (Methods and Protocols), Editors: Streit, Wolfgang, Daniel, Rolf (Eds.), ISBN 978-1-60761-823-2, Springer.

2. Metagenomics Sequences from the Environment, Bethesda (MD): National Center for Biotechnology Information (US); 2006 (URL: http://www.ncbi.nlm.nih.gov/books/NBK6858/)
3. Microbial Metagenomics, Metatranscriptomics, and Metaproteomics, ISBN: 978-0-12-407863-5, Academic Press.
4. Genomics and the Rhizosphere, Tett, Adrian J, Turner, Thomas R, Poole, Philip S, DOI: 10.1002/9780470015902.a0023728, John Wiley & Sons, Ltd.

References:

1. Metagenomics of the Human Body, Editors: Nelson, Karen E. (Ed.), ISBN 978-1-4419-7089-3, Springer.
2. Metagenomics: Current Innovations and Future Trends, Editor: Diana Marco Caister, ISBN: 978-1-904455-87-5, Academic Press.

Toxinology

Unit-I: General Introduction
Definition of toxins, different categories of toxins and venoms, recent trends in venom and toxin research.

Unit-II: Bacterial toxins
Bacterial toxinogenesis, endotoxins, exotoxins, exotoxins, bacterial protein toxins with special reference to cholera, diphtheria and tetanous toxins, molecular mechanism of action of endotoxins, exotoxins, enterotoxins and neurotoxins.

Unit-III: Plant toxins
Natural toxins in plants, Plant toxic proteins, impact of plant toxin on human, natural toxins in food plants, allelopathy.

Unit-IV: Toxins from snake venom
Snakes and Biological significance of their venoms, composition of snake venom, evolution of venom, 3D structure of some important venom constituentsand their mechanism of action (phospholipase A2, cardiotoxin, neurotoxin) three-finger toxins, antivenom and medicinal plants in treatment of snakebite patients.

Unit-V: Venomics
Proteomics approach to study the venom proteomics.

Unit-VI: Tools for isolation and characterization of toxins
Multidimensional chromatographic techniques (gel-filtration, ion-exchange reverse-phase HPLC, SDS-PAGE, 2-dimensional gel electrophoresis), toxin mass fingerprinting, N-terminal peptide sequencing, analysis of protein data by using proteomics softwares.

Unit-VII: Medicinal and industrial applications of venoms and toxins
Use of toxin in neurobiology and muscular research, anticancer drug, diagnosis of hemostatic disorders, antibacterial agents, bioinsecticide and other industrial applications.

Text Books

1. Madagon, Martinks and Parker, Biology of Microorganism,10th edition, Prentice Hall, 2003.
2. A.L. Harvey , Snake toxins, , First edition, Pergamon, 1991.

Reference Books

1. Stephen P. Mackessy, Handbook of Venoms and Toxins of Reptiles, CRC Press,Taylor and Francis Group, 2010.
2. Kurt F. Stocker , Medical Use of Snake Venom Proteins, CRC Press, 1990.

Pharamcogenomics

Unit I:
Pharmacogenomics; Pharmacogenetics; Benefits; Practical applications of pharmacogenomics; The Promise of Pharmacogenomics today leading to personalized medicines; Human genetic variation-examples of CYP gene variation leading to variable metabolism of drugs; Distribution of variation; Mutations & its kind; Natural selection; Variation in ethnic groups, races.

Unit II:
Pharmacology; Clinical pharmacology; Drugs; Drug Legislation & safety; Types of Drugs – examples of latest drugs; Drug potency and Efficacy; ADME of drug – Drug absorption; Drug distribution; Drug metabolism & Drug Excretion; Drug efficacy & toxicity; drug therapeutic leves; Therapeutic Index; Drug abuse; Drug response in patients by correlating gene expression; Regulation of gene expression; polymorphism; Alleles; Single nucleotide polymorphism; Genotyping; example of TPMT and DPD gene mutation and their impact in treatment strategy.

Unit III:
Genetic markers-Biomarkers in early drug development; Biomarkers in Clinical development; Biomarkers for molecular Diagnostics- example of cancer biomarkers; Pharmacogenetics & drug development.

Text Books

1. Wu R and Lin M, Statistical & Computational Pharmacogenomics, CRC Press, 2008.
2. Yan Q, Pharmacogenomics in Drug Discovery and Development, Springer-Verlag New York, LLC, 2008.
3. Meyer UA and Tyndale RF, Pharmacogenomics, 2nd Edition, CRC Press, 2005.

Reference Books

1. Innocenti F, Pharmacogenomics: Methods and Applications, Springer-Verlag New York, LLC, 2005.
2. Rothstein MA and Collins FS, Pharmacogenomics: Social, Ethical and Clinical Dimentions, Wiley John & Sons, Inc., 2003.

Evolutionary Genomics

Unit-I
Molecular evolution theories: selection theory, neutral theory of evolution
Genome G+C% in prokaryotes, Nucleotide composition in DNA, parity rules in DNA, mutation between leading and lagging strand, strand compositional asymmetry in chromosomes, Gene distribution along the chromosomes, role of replication and transcription.

Unit-II
Codon usage bias: mutation theory, regulation theory, selection mutation drift theory.
Selection forces shaping codon usage bias: translational selection, mRNA structure, protein folding.

Unit-III
Genome sequence of prokaryotes, study of molecular evolution, evolutionary significance, minimal genome, synthetic organisms

Unit-IV
Genome sequence of model eukaryotic organisms and its evolutionary implications: *Homo sapiens*, *Arabidopsis thaliana*, *Drosophila melanogaster* etc.

Unit-V
Y chromosome and & mitochondrial DNA markers in genealogical studies; human migration; culture and human evolution

Unit-VI
Shaping of human genome by pathogen/disease pressure and selection

Text Books
1. R. H. Tamarin, Principles of Genetics, 6th edition, William C Brown Pub, 1998.
2. Daniel L. Hartl and Elizabeth W Jones , Genetics: Principles and Analysis, 4th edition, Jones & Bartlett Pub, 1997.
3. Sylvie Lesage , Immunogenetics: Tolerance and Autoimmunity, Nova Science Publishers, 2010.

Reference Books
1. W. H. Li , Molecular Evolution, illustrated edition, Sinauer Associates, Incorporated, 1997 .
2. Motoo Kimura , The neutral theory of molecular evolution, Reprint edition, Cambridge University Press, 1985.

BI 434: Virology **L2-T0-P0-CH2-CR2**

Unit I: Introduction

History and principles of virology; Classification of viruses; Virus structure and morphology; Satellite viruses; Viroids; Prions; Virusoids, etc.

Unit II: Virus Replication

RNA viruses: General strategies, replication of plus stranded RNA virus (polio), negative strand RNA viruses (Influenza); Replication of double stranded RNA virus (rotavirus) and retroviruses (HIV); DNA viruses: Replication of double stranded DNA viruses (SV40/Pox), ssDNA virus (AAV) and Adenoviruses. Replication of DNA and RNA plant viruses.

Unit III: Virus-cell Interaction

Ultrastructural cytopathology; Host cell 'shut off'; mechanism of viral persistence and latency (HSV and HIV); Cellular interactions-clathrin coated pits, endocytosis and virus uncoating mechanisms; IRES; Antivirals: Interferons and its mechanisms of action; Gene silencing technology.

Unit IV: Methods to diagnose virus infections

Electron microscopy, serological ELISA, neutralization assays; haemagglutination and haemagglutination-inhibition tests, complement fixation, Western blot. Molecular methods: PCR, real time PCR, sequencing, and hybridization.

Unit V: Cultivation and purification of viruses

In vivo and *in vitro* systems for tissue culture growth of viruses, estimation of yields, methods for purification of viruses with special emphasis on ultracentrifugation methods. Methods to study plant viruses; Infectivity assays- sap transmission, insect vector transmission, agroinfection (using Agrobacterium).

Unit VI: New and emerging viruses

SARS corona virus, Middle East Respiratory syndrome corona virus, Nipah and Hendra virus, New strains of influenza viruses with novel host range.

Unit VII: Viral vaccines

History of live attenuated vaccines using poxvirus as example, polio and rabies vaccines. Subunit vaccines eg. Hepatitis B vaccine. HIV vaccines and reasons for their failure. New vaccine adjuvant such as GMCSF, Flt-3 ligand, etc. DNA vaccines for viral infections.

Text/Reference books

1. Fundamentals of Molecular Virology (7^{th} edition) by Nicholas H. Acheson.

2. Fields Virology by Lippincott Williams and Wilkins.

3. Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses by S. J. Flint, L. W. Enquist, V. R. Racaniello, and A. M. Skalka.

4. Fundamental Virology by Bernard N. Fields and David Mahan Knipe.

5. Fundamentals of Plant Virology by R. E. Matthews.

BI 436: Seminar and Mini Review **L0-T2-P0-CH2-CR2**

BI 440: Lab. on Genomics and Proteomics **L0-T0-P3-CH6-CR3**

1. Isolation of genomic DNA from *Bacillus subtilis** genome.
2. PCR amplification of *ScoC* gene and analysis by agarose gel electrophoresis
3. Preparation of plasmid, pET-28a from *E.coli* DH5_ and gel analysis.
4. Restriction digestion of vector (gel analysis) and insert with NcoI and XhoI
5. Vector and Insert ligation
6. Transformation in E.coli DH5.
7. Plasmid isolation and confirming recombinant by PCR and RE digestion.
8. Transformation of recombinant plasmid in *E.coli* BL21 (DE3) strain.
9. Induction of ScoC protein with IPTG and analysis on SDS-PAGE
10. Purification of protein on Ni-NTA column and analysis of purification by SDS-PAGE

*Any other bacterial strain can be used.