(Batch: 2018-2023)
Revised Structure with New Code Number
Department of Molecular Biology and Biotechnology
Integrated MSc in Bioscience and Bioinformatics

Minimum credit requirement : 214
Minimum duration : 5 years (10 semesters)
Maximum duration : 7 years (14 semesters)

REVISED COURSE STRUCTURE

Open Elective for UG

Course code	Course Name	L-T-P	CH	CR	Remark
BI 109	Basic in Bioinformatics	3-0-0	3	3	Spring Semester
BI 111	Health and Hygiene	3-0-0	3	3	Autumn Semester

Semester I

Course code	Course Name	L-T-P	CH	CR	Remark
BI 103	Biology I (Major)	2-1-0	3	3	Core
BI 105	Biology I Lab (Major)	0-0-3	6	3	Core
PI	Physics I	2-1-0	3	3	GE
CI	Chemistry I	2-1-0	3	3	GE
MI	Mathematics I	2-1-0	3	3	GE
	Physics I Lab	0-0-3	6	3	GE
EG 101	Communicative English	2-0-0	2	3	AECC
	Total		**27**	**21**	
BI 101	Biology I	2-1-0	3	3	GE for Non-Bio
BI 107	Biology I Lab	0-0-3	6	3	

Semester II

Course Code	Course Name	L-T-P	CH	CR	Remark
BI 104	Biology Major II	2-1-0	3	3	Core
BI 108	Biology Major II Lab	0-0-3	6	3	Core
PI	Physics II	2-1-0	3	3	GE
CI	Chemistry II	2-1-0	3	3	GE
MI	Mathematics II	2-1-0	3	3	GE
	Chemistry I Lab	0-0-3	6	3	GE
ES 102	Elementary Environment Science	3-0-0	3	3	AECC
	Total		**27**	**21**	
BI 106	Biology II	2-1-0	3	3	GE for Non-Bio

Semester III

Course code	Course Name	L-T-P	CH	CR	Remark
BI 233	Cell Biology	2-1-0	3	3	Core
BI 235	Genetics	2-1-0	3	3	Core
BI 237	Introduction to Bioinformatics	2-1-0	3	3	Core
BI 239	Biology Major III Lab	0-0-3	6	3	Core
	Physics III	3-0-0	3	3	GE
	Chemistry III	2-1-0	3	3	GE
CS 101	Introduction to Scientific Computing	2-0-1	4	3	AECC
NS 102	NSS	0-0-2	2	2	SEC
	Total		**26**	**23**	

Semester IV

Course Code	Course Name	L-T-P	CH	CR	Remark
BI 222	Microbiology	2-1-0	3	3	Core
BI 238	Basics in Biocomputing	2-0-1	4	3	Core
BI 232	Plant Physiology	2-1-0	3	3	Core
BI 234	Animal Physiology	2-1-0	3	3	Core
BI 236	Biochemistry I	2-1-0	3	3	Core
BI 242	Biology Lab-IV (Physiology & Biochemistry)	0-0-3	6	3	Core
BI 228	Biology lab V(Microbiology)	0-0-2	4	2	Core
	Disaster Management	3-0-0	3	3	SEC
		Total	**29**	**23**	

Semester V

Course Code	Course Name	L-T-P	CH	CR	Remark
BI 321	Molecular Biology - I	2-1-0	3	3	Core
BI 337	Developmental Biology	3-1-0	4	4	Core
BI 339	Bioprogramming and Biostatistics	2-0-1	4	3	DCE
BI 341	Immunology-I	2-1-0	3	3	Core
BI 343	Computational Biology	2-1-0	3	3	Core
BI 345	Biology lab -VI. (Molecular Biology)	0-0-3	6	3	Core
BI 347	Biology lab-VII. (Immunology)	0-0-3	6	3	Core
	Total		**29**	**22**	

Semester VI

Course Code	Course Name	L-T-P	CH	CR	Remark
BI 340	Molecular Genetics	2-1-0	3	3	Core
BI 342	Advance Programming I	2-0-1	4	3	Core
BI 346	Bioinformatics Software and Algorithms	2-1-0	3	3	DCE
BI 348	Analytical Techniques	2-1-0	3	3	DCE
BI 338	Seminar - I	0-1-0	1	1	Core
BI 350	Mini Project	0-0-8	16	8	Dissertation /Project
Total			**30**	**21**	

Semester VII

Course Code	Course Name	L-T-P	CH	CR	Remark
BI 441	Biochemistry – II	2-1-0	3	3	Core
BI 443	Molecular Biology-II	2-1-0	3	3	Core
BI 445	Immunology II	2-1-0	3	3	Core
BI 447	Biological Database Management System	2-0-1	4	3	Core
BI 449	Advance Programming II	2-0-1	4	3	Core
BI 451	Biology Lab VIII (Biochemistry)	0-0-3	6	3	Core
BI 453	Biology Lab –IX (Immunology)	0-0-2	4	2	Core
Total			**30**	**20**	

Semester VIII

Course Code	Course Name	L-T-P	CH	CR	Remark
BI 442	Structural Bioinformatics	2-0-1	4	3	Core
BI 444	Cell Biology II	2-1-0	3	3	Core
BI 446	Genetic Engineering	2-1-0	3	3	Core
BI 448	Genomics and Proteomics	2-1-0	3	3	Core
BI 450	Applied Microbiology and Bioprocess engineering	2-1-0	3	3	Core
BI 452	System Biology	2-0-1	4	3	Core
BI 454	Biology Laboratory -X (Genetic Engineering)	0-0-3	6	3	Core
BI 456	Biology Laboratory -XI (Applied Microbiology)	0-0-2	4	2	Core
Total			**30**	**23**	

Semester IX

Course Code	Course Name	L-T-P	CH	CR	Remark
BI 527/ BI 529/ BI 531	Animal Biotechnology / Microbial Biotechnology/ Plant Biotechnology	2-1-0	3	3	DCE
BI 533	Bioethics, Biosafety and IPR	2-0-0	2	2	Core
BI-535	Project – I	0-0-15	30	15	Dissertation/ Project
	Total		**35**	**20**	

Semester X

Course Code	Course Name	L-T-P	CH	CR	Remark
BI 528 BI 530	Elective-II Bioinformatics (Molecular Modelling and drug design)/ Evolutionary Genomics	2-1-0	3	3	DCE
	Audit Lecture course Compulsory for all the students				
BI 532	Project – II	0-0-17	35	17	Dissertation/ Project
	Total		**38**	**20**	

Revised Course

GE: Generic Elective; DCE: Discipline Centric Elective; AECC: Ability Enhancement Compulsory Course; SEC: Skill Enhancement Courses

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

SEMESTER I

BI-103 Biology I (Major) L3-T0-P0-CH3-CR3

Unit-I: Introduction to the living world:
Description of living and non-living with comparison of differences; unicellular, colonial and multicellular organisms and their living behaviors.

Unit-II: Microorganisms:
Types of microorganism and their characteristics; characteristics of archaea, eubacteria, green algae, blue-green algae, red algae, lichen, microalgae, diatom, amoeba, protozoa, fungus, bacteria and viruses-viroids and prions.

Unit-III: Plant Kingdom:
Description on lower and higher groups of plants; characteristics of (i) Thallophyta, (ii) Bryophyta, (iii) Pteridophyta, (iv) Gymnosperm, and (v) Angiosperm.

Unit-IV: Animal Kingdom:
Nonchrodates and chordates-description and classification with examples. Description of domestic and wild animals; animals in different ecosystems and their migratory behavior.

Unit-V: Cell, genes and genetics:
Fundamentals of genetics, Mendelian and non-Mendelian inheritance, Chromosome types, chromosome theory of inheritance and mutation.

Unit-VI: Evolution of living world:
Theories of evolution: Lamarckism; Darwinism and Neo-Darwinism; evolution, extinction, and human health.

Unit-VII: Forestry:
Direct and indirect benefits from forests, forest dwellers and their responsibilities, and sustainable forest management.

Unit IX: Conservation biology:
Presence of biodiversity; biodiversity scenario and hot spots, sub-tropical, temperate and tropical biodiversity, economics of biodiversity, threatened and endangered species, conservation of wild life both plant and animal types; conservation and maintenance of crop plants; deforestation and consequences, social forestry, forest management, Indian case studies on conservation and management strategies (Lions of Gir forest, Rhinos of Kaziranga, Swamp deer of Manipur, Project Tiger, Biosphere reserve).

Suggested books

1. BIOLOGY by Raven, Johnson, Losos, & Singer (2013), 10th Edition, McGraw-Hill Education.
2. Principles of Genetics by Robert H. Tamarin. TATA McGRAW-HILL Edition
3. ESSENTIAL GENETICS: : A Genomics Perspective by D. L. Hartl & E. W. Jones (2012), 6th Edition, Jones & Bartlett Learning.
4. GENETICS: the continuity of life by D. J. Fairbank & W. R. Andersons (1999)
5. Molecular and Cell Biology (Schaum's Outlines series special Indian edition) by W. D. Stansfield, J. S.C. Colome, R. J. Cano and R. N. Sharan (2010), McGraw Hill Education.

BI 101: Biology I (Minor) **L3-T0-P0-CH3-CR3**

Unit-I: Introduction to the living world:
Description of living and non-living with comparison of differences; unicellular, colonial and multicellular organisms and their living behaviors.

Unit-II: Microorganisms:
Types of microorganism and their characteristics; characteristics of archaea, eubacteria, green algae, blue-green algae, red algae, lichen, microalgae, diatom, amoeba, protozoa, fungus, bacteria and viruses-viroids and prions.

Unit-III: Plant Kingdom:
Description on lower and higher groups of plants; characteristics of (i) Thallophyta, (ii) Bryophyta, (iii) Pteridophyta, (iv) Gymnosperm, and (v) Angiosperm.

Unit-IV: Animal Kingdom:
Nonchrodates and chordates-description and classification with examples. Description of domestic and wild animals; animals in different ecosystems and their migratory behavior.

Unit-V: Cell, genes and genetics:
Fundamentals of genetics, Mendelian and non-Mendelian inheritance, Chromosome types, chromosome theory of inheritance and mutation.

Unit-VI: Evolution of living world:
Theories of evolution: Lamarckism; Darwinism and Neo-Darwinism; evolution, extinction, and human health.

Unit-VII: Forestry:
Direct and indirect benefits from forests, forest dwellers and their responsibilities, and sustainable forest management.

Unit IX: Conservation biology:
Presence of biodiversity; biodiversity scenario and hot spots, sub-tropical, temperate and tropical biodiversity, economics of biodiversity, threatened and endangered species, conservation of wild life both plant and animal types; conservation and maintenance of crop plants; deforestation and consequences, social forestry, forest management, Indian case studies on conservation and management strategies (Lions of Gir forest, Rhinos of Kaziranga, Swamp deer of Manipur, Project Tiger, Biosphere reserve).

Suggested books

1. BIOLOGY by Raven, Johnson, Losos, & Singer (2013), 10th Edition, McGraw-Hill Education.
2. Principles of Genetics by Robert H. Tamarin. TATA McGRAW-HILL Edition
3. ESSENTIAL GENETICS: : A Genomics Perspective by D. L. Hartl & E. W. Jones (2012), 6th Edition, Jones & Bartlett Learning.
4. GENETICS: the continuity of life by D. J. Fairbank & W. R. Andersons (1999)
5. Molecular and Cell Biology (Schaum's Outlines series special Indian edition) by W. D. Stansfield, J. S.C. Colome, R. J. Cano and R. N. Sharan (2010), McGraw Hill Education.

BI 105 Biology I Lab (Major) **L-0 T-0 P-3 CH 6 Cr 3**

1. Observation of animals/plants from nature and preparation of herbarium.
2. Observation and identification of permanent slide/specimens of different species.
3. Dissection and construction of floral diagram belonging to different families.
4. Observation of microorganisms by microscope
5. Preparation of buffers routinely used in biological experiments
6. Culture of bacteria through serial dilution of samples

BI 107: Biology I Lab (Minor) **L-0 T-0 P-3 CH 6 Cr 3**
(for Physics and Math Major students only)

1. Observation of animals/plants from nature and preparation of herbarium.
2. Observation and identification of permanent slide/specimens of different species.
3. Dissection and construction of floral diagram belonging to different families.
4. Observation of microorganisms by microscope
5. Preparation of buffers routinely used in biological experiments
6. Culture of bacteria through serial dilution of samples

SEMESTER II

BI-104 Biology -II (Major) **L3-T0-P0-CH3-CR3**

Unit-I: Chemical basis of life:
Origin of life, role of water molecule, introduction to buffers, biological structures and functions.

Unit-II: Elements of Biochemistry:
Structure and functions of carbohydrates, protein, lipids and nucleic acids; role of minerals and vitamins in growth and development; thermodynamics of biological system; metabolism and energy conversion.

Unit-III: Basics of cell and Molecular Biology:
Cell structure and division, cancer, DNA to RNA to Protein: the central dogma of molecular biology, Retroviruses

Unit-IV: Anatomy and physiology:
Concepts of anatomy of root, stem and leaf of monocotyledous and dicotyledous plants;

Unit V: Plant physiology:
Absorption and transpiration in plants, photosynthesis, nitrogen metabolism; structural organization of tissues, organs and organ systems; plant-microorganism interaction, symbiotic associations.

Unit VI: Animal Physiology:
Anatomy and physiology of digestive system, vascular, respiratory, excretory systems.

Unit-VII: Immunology:
Immune response, immunization and immunology - types of immunity; cell mediated immunity, description of various types of T-cells and their functions, innate and acquired immunity, active and passive immunity, humoral and cell mediated immunity; immune system-lymphocytes; structure and functions of immunoglobulins.

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

Suggested books

1. BIochemistry by J. M. Berg, J. L. Tymoczko, &LubertStryer (2011), 7th Edition, Palgrave MacMillan.
2. BIOLOGY by Raven, Johnson, Losos, & Singer (2013), 10th Edition, McGraw-Hill Education.
3. ESSENTIAL GENETICS: : A Genomics Perspective by D. L. Hartl & E. W. Jones (2012), 6th Edition, Jones & Bartlett Learning.
4. Molecular and Cell Biology (Schaum's Outlines series special Indian edition) by W. D. Stansfield, J. S.C. Colome, R. J. Cano and R. N. Sharan (2010), McGraw Hill Education.

BI-102 Biology - II (Minor) **L3-T0-P0-CH3-CR3**

Unit-I: Chemical basis of life:
Origin of life, role of water molecule, introduction to buffers, biological structures and functions.

Unit-II: Elements of Biochemistry:
Structure and functions of carbohydrates, protein, lipids and nucleic acids; role of minerals and vitamins in growth and development; thermodynamics of biological system; metabolism and energy conversion.

Unit-III: Basics of cell and Molecular Biology:
Cell structure and division, cancer, DNA to RNA to Protein: the central dogma of molecular biology, Retroviruses

Unit-IV: Anatomy and physiology:
Concepts of anatomy of root, stem and leaf of monocotyledous and dicotyledous plants;

Unit V: Plant physiology:
Absorption and transpiration in plants, photosynthesis, nitrogen metabolism; structural organization of tissues, organs and organ systems; plant-microorganism interaction, symbiotic associations.

Unit VI: Animal Physiology:
Anatomy and physiology of digestive system, vascular, respiratory, excretory systems.

Unit-VII: Immunology:
Immune response, immunization and immunology - types of immunity; cell mediated immunity, description of various types of T-cells and their functions, innate and acquired immunity, active and passive immunity, humoral and cell mediated immunity; immune system-lymphocytes; structure and functions of immunoglobulins.

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

Suggested books
1. BIochemistry by J. M. Berg, J. L. Tymoczko, &LubertStryer (2011), 7th Edition, Palgrave MacMillan.
2. BIOLOGY by Raven, Johnson, Losos, & Singer (2013), 10th Edition, McGraw-Hill Education.
3. ESSENTIAL GENETICS: : A Genomics Perspective by D. L. Hartl & E. W. Jones (2012), 6th Edition, Jones & Bartlett Learning.
4. Molecular and Cell Biology (Schaum's Outlines series special Indian edition) by W. D. Stansfield, J. S.C. Colome, R. J. Cano and R. N. Sharan (2010), McGraw Hill Education.

BI 108 Biology II Lab (Major) **L-0 T-0 P-3 CH 6 Cr 3**

1. Microscopic identification of different stages of cell division (mitosis and meiosis) from permanent cells.
2. Preparation of onion root tip and study of cell divisions.
3. Tissue organization in root and shoot apices using permanent slides
4. Preparation of blood smear. Blood grouping (ABO and Rh).
5. Validation of Beer and Lambert Law
6. Estimation of carbohydrates, proteins, nucleic acids

BI 107: Biology I Lab (Minor) **L-0 T-0 P-3 CH 6 Cr 3**
(for Chemistry major students only)

1. Observation of animals/plants from nature and preparation of herbarium.
2. Observation and identification of permanent slide/specimens of different species.
3. Dissection and construction of floral diagram belonging to different families.
4. Observation of microorganisms by microscope
5. Preparation of buffers routinely used in biological experiments
6. Culture of bacteria through serial dilution of samples

SEMESTER III

BI 233 Cell Biology I **L2-T1-P0-CH3-CR3**

Unit I: Introduction to Cell Biology

The Cell – introduction to Prokaryotes and Eukaryotes. Difference between normal cell and cancer cell. Evolutionary link between prokaryotes and eukaryotes (recent molecular evidences). Microscopy: Light microscopy (Bright field, Phase contrast and DIC).

Unit II: Cell division

Cell division in Microbes, Plant and Animal (both mitotic and meiotic). Cell cycle and its molecular events. Cell Cycle: Checkpoint controls, Stem Cells.

Unit III: Cell Membrane and extracellular components

Plasma membrane: Membrane lipids, Membrane proteins Membrane fluidity, Lipids Rafts- Organization and Functions. Components of extracellular space and their functions. Principle of Membrane transport- Active and passive transport, transporters, ion channels.

Unit IV: Endomembrane systems

Endoplasmic reticulum, golgi body, lysosomes. Cell nucleus- nuclear membrane, structure and organization. Sorting and trafficking of proteins in the endomembrane system. Cytoskeleton-Microfilaments and intermediate Filaments; cell motility.

Unit V: Fundamentals of cell signaling

Signaling in cells: G-protein mediated, RTK , $Ca^{++}{}^{m}$, Insulin , Ras-MAPK, Wnt , Hedgehog and toll-like receptor.

Textbooks

1. Karp G., Cell and Molecular Biology: Concepts and Experiments, 7th Edition (John Wiley & Sons, Inc., 2013).
2. Scott, M. P. et al, Molecular Cell Biology, 6th Edition (W. H. Freeman, 2007).
3. Alberts, B. et al., Molecular Biology of the Cell, 5th Edition (Garland Publishing, 2008).
4. Becker, W. M. et al., The World of Cell, 8th Edition (Benjamin Cummings, 2011).

Reference books:

1. Molecular and Cell Biology (Schaum's Outlines series special Indian edition) by W. D.Stansfield, J. S.C. Colome, R. J. Cano and R. N. Sharan (2010), McGraw Hill Education.
2. Cooper, G. M. and Hausman, R. E., The Cell: A Molecular Approach, 5th Edition (ASM Press and Sinauer Associates, Inc., 2009).

BI 235 Genetics **L3-T0-P0-CH 3-CR3**

Unit I: Introduction to Genetics

Definition, scope and applications.

Unit II: Mendelian Genetics

Definition of Phenotype/Traits, Mendel's laws, Mono, Di and Trihybrid crosses, Test cross, Back cross, Applications of Mendel's laws.

Unit III: **Non-Mendelian Genetics**

Deviations from Mendel's laws, gene interactions/epistasis, penetrance, expressivity, incomplete dominance, co-dominance, multiple alleles, pleotropism, sex limited & sex influenced traits. Mitochondrial and Chloroplast inheritance. Epigenetics- Genomic imprinting, Lyons law, isodisomy and heterodisomy.

Unit IV: **Complex Traits**

Heritability, Twin studies; Behavioral traits; Analysis of quantitative and qualitative traits.

Unit V: **Bacterial and Viral Genetics**

Transformation, Conjugation, Transduction. Temperate and lytic phages, T4 phage. Mutagens, Mutant isolation; Mutations at the level of organisms-Auxotrophic, conditional, lethal, antibiotic resistant.

Unit VI: Human Genetics

Introduction to human genetics, role of human genetics in modern medicine, Types of genetic diseases, Types of mutations in human genetics and their nomenclatures.

Unit VII: Genetic Diseases in humans

Disorders of sex chromosomes and autosomes, metabolic disorders, life style disorders-Diabetes, Obesity, etc.

Texts and Reference Books:

1. Gupta P K, Genetics, 4th Edition, Rastogi Publications, 2011. **ISBN-10:** 8171339328
2. Maloy SR, Cronan J E, Freifelder D. Microbial Genetics, 2nd Edition, Narosa Publishing House, 2009. **ISBN-10:** 9788173196973
3. Griffiths A.J., Griffiths A.J.F., Miller J.H., Suzuki D.T. and Lewontin R.C. An Introduction to Genetic Analysis, W.H. Freeman, 7th Edition, 2000**.** ISBN-10: 0-7167-3520-2
4. Tamarin Robert H. Principles of Genetics, Wm. C. Brown Publishers. 6th Edition, 1998. **ISBN-10:** 0697354628
5. Molecular and Cell Biology (Schaum's Outlines series special Indian edition) by W. D. Stansfield, J. S.C. Colome, R. J. Cano and R. N. Sharan, McGraw Hill Education.,2010.
6. Manu L. Kothari. Essentials of Human Genetics Edition-5th Edition, Universities Press, 2009. **ISBN-10: 8173716471**

BI 237 Introduction to Bioinformatics **L3-T0-P0-CH3-CR3**

Unit I: History of Bioinformatics:
Life in space and time, dogmas: central and peripheral, challenges in biology, intersection of classical biology, mathematics and computer science.

Unit II: Introduction to Bioinformatics:
Overview of bioinformatics, Bioinformatics and the internet, Use of information technology for studying Biosciences, observables and data archives, Information flow in bioinformatics.

Unit III: Introduction to nucleic acid world:
The structure of DNA and RNA, gene structure and control, the tree of life and evolution. Protein structure, protein structure prediction and engineering, introduction to proteomics: DNA microarrays, mass spectrometry and systems biology.

Unit IV: Archives and information retrieval:
Database indexing and specification of searching terms, the archives: some of the important biological databases (Nucleic acid, Genome and protein sequence), gateways to archives: access to databases in molecular biology

Unit V: Future of Bioinformatics:
Emerging areas in Bioinformatics: Big data in biology, Systems and synthetic biology, personalized medicine.

Recommended Textbooks and References:

1. Lesk, A. M. (2002). Introduction to Bioinformatics. Oxford: Oxford University Press.
2. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Baxevanis, A. D., & Ouellette, B. F. (2001). Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins. New York: Wiley-Interscience.
4. Pevsner, J. (2015). Bioinformatics and Functional Genomics. Hoboken, NJ.: Wiley-Blackwell.
5. Bourne, P. E., & Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss.
6. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press.

BI239 Biology III Lab (Cell Biology and Genetics) L0-T0-P3-CH6-CR3

1. Prepare culture media for animal tissue culture and handling of cell lines.
2. Isolation of lymphocytes from blood and check their cell viability using trypan blue exclusion method.
3. Membrane fragility/stability test using red blood cells.
4. Isolation of antibiotic resistant mutants and calculation of mutant frequency
5. Replica plating in bacteria
6. Natural transformation in bacteria

SEMESTER IV

BI 222: Microbiology **L-3 T-0 P-0 CH 3 Cr 3**

Unit I: Brief history and development of microbiology

Introduction to study of Microbiology, conflict over spontaneous generation, role of microorganisms in disease, scope of microbiology, development of Koch's postulate.

Unit II: Microbial Taxonomy

Classification system- phenetic, phylogenetic, numerical, morphological, biochemical and molecular characteristics; Novel genomic tools including signatures, uncultured microbes.

Unit III: Prokaryotic cell structure

Bacterial cell wall, cytoplasmic structure and inclusions bodies, sporulation and spore, diversity in bacterial structure actinomycetes, rickettsias, mycoplasma; archaea.

Unit IV: Viruses

Basic structures, classification, double stranded and single stranded DNA and RNA viruses, replication strategies 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; 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: Microbial diseases and their control

Host-pathogen relationship, mechanisms of virulence, quorum sensing, pathogenesis in plants and animals. Antimicrobial chemotherapy, microbial biofilm, microbiome.

Textbooks

1. Willey, J., Sherwood, L. and WoolvertonC., *Microbiology*, 10th edition (McGraw-Hill Science, 2017).
2. Pelczar, M.J., Chan, E.C.S. and Kreig, N.R., *Microbiology*, Publisher McGraw Hill Education (India) Private Limited, ISBN-10 0074623206, 5th Edition, 2001.
3. M. T. Madigan, J. M. Martinko, K. S. Bender, D. H. Buckley, D. A. Stahl, T. Brock, *Brock Biology of Microorganisms, 14th* Edition , Pearson Hall International, 2017.
4. Tortora, G.J., Fernke, B.R. and Case, C.L., *Microbiology – An Introduction,* 9th Edition, Benjamin Cummings, 2009.
5. Molecular and Cell Biology (Schaum's Outlines series special Indian edition) by W. D. Stansfield, J. S.C. Colome, R. J. Cano and R. N. Sharan (2010), McGraw Hill Education.

BI 226: Basic in Biocomputing **L-2 T-0 P-1 CH 4 Cr 3**

Unit I: Basic Concepts

Basic computer organization, Processor and memory, secondary storage devices, Input-Output devices, Computer software, planning the computer program, Computer languages, Concepts of flowcharting, algorithm development, pseudo codes, program compilation etc., Operating system: Windows, Unix (some basic commands).

Unit II: Internet Technology

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

Unit III: Communication Technology:

Networking Elements: Networking Hardware, Networking services: Types of Networks–LAN, WAN & MAN, Intranet –Wireless communication –Internet services, Uses of Internet, Ethernet and TCP/IP family of protocols.

Unit IV: Bio-mathematics

Points, lines, rays, line segments, planes and describe their relationships, including collinear points and coplanar points and lines. Computing lengths, coordinates, midpoints, differences, and sums of line segments, skew lines and slope of a line, congruent line segments. Representation of a point on the coordinate plane, angle between lines and planes, parallel and perpendicular planes, dihedral angles, Proper and Improper dihedral, torsion angle, matrices and determinants, Scalar and vector algebra.

Recommended Textbooks and References:

1. Lesk, A. M. (2002). Introduction to Bioinformatics. Oxford: Oxford University Press.
2. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

BI 230: Plant Physiology **L3-T0-P0-CH3-CR3**

Unit-I: Introduction to physiology and homeostasis;
Plant nutrition: essential nutrients, deficiencies and plant disorders; heavy metal stress and homeostasis; mechanism of ion uptake by plants.

Unit-II: Transport mechanism in plant:
Osmosis, Active transport and Passive transport, Xylem transport, Phloem Transport; loading and unloading mechanism of food, Short Distance Intracellular transport.

Unit-III: Water relations in plants:
Polarity; water potential in plants; movement of water in plants; soil-plant-atmosphere continuum.

Unit-IV: Photoperiodism:
Photoperiodic response, Physiology of flowering, phytochrome chemistry and mechanism; Senescence and its molecular aspects; Dormancy & Vernalization mechanism; plant biological clock.

Unit-V: Photosynthesis:
Photophosphorylation, Thylakoid membrane in photophosphorelation, C3 cycle, C4 cycle and CAM pathways, photorespiration.

Unit-VI: Plant growth regulators:
Auxins, gibberellins, cytokinins, ethylene, abscissic acid, brassinosteroids, salicylic acid, jasmonic acid, mode of senescence.

Unit-VII: Rhizosphere physiology
Root respiration, rhizosphere and allelopathy, types of chemicals and volatiles.

Textbooks
Taiz, L. and Zeiger, E., Plant Physiology, 5th edition (Sinauer Associates, USA, 2012).
URL: http://www.sinauer.com/media/wysiwyg/tocs/PlantPhysiology5.pdf

Reference Book & Materials
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. http://www.annualreviews.org/journal/arplant
4. Hormones: http://nptel.ac.in/courses/102103012/27

BI 232: Animal Physiology **L-3 T-0 P-0 CH 3 Cr 3**

Unit-I: Introduction to Physiology:
An overview of animal anatomy and body plan; Homeostasis, Organs and Organ systems.

Unit-II: Circulatory system:
Closed and Open circulatory system, Structure and function of heart in higher vertebrates (mammals); Blood as connective tissue- Components of Blood; Blood groups; Blood clotting; Lymph and lumph nodes.

Unit-III: Respiratory system:
Anatomy of lungs in mammals; Mechanism and regulation of breathing; Hemoglobin & Oxyhemoglobin dissociation curve, oxygen and carbon dioxide transport; Acid-Base balance of the blood.

Unit-IV: Digestive system:
Anatomy of alimentary canal in mammals. Role of liver and pancreas in digestion. Mechanism of digestion and absorption in mammals.

Unit-V: Muscular system:
Structure and type of muscles; neuromuscular junction, muscle contraction; Energy requirements of skeletal muscles and metabolism, Neural control of skeletal muscles.

Unit-VI: Nervous system:
Types of neurons and supporting cells. Nerve impulse and mechanism of impulse conduction, Neurotransmitters, Synaptic Integration, Synaptic Plasticity and inhibition.

Unit-VII: Excretory system:
Structure and function of mammalian kidney, Nephron as a functional unit of kidney, Process of filtration and urine formation: Renal control of electrolyte and acid-base balance.

Unit-VIII: Reproductive system:
Concept of seasonal and nonseasonal breeding; Female reproduction system – reproductive cycle, Structure of Ovary. Male reproductive system: Structure of testis, mechanism of spermatogenesis, structure of sperm;. Mechanism and process of fertilization

Unit-IX: Endocrinology:
Endocrine organs and hormones in vertebrates (mammals); Mechanism of hormone action and signal transduction; thyroid and pancreatic metabolic disorders.

Unit X: Regulation of Metabolism:
Nutritional requirements, metabolic rate and caloric requirements, anabolic requirements, vitamins and minerals, free radicals and antioxidants, regulation of energy metabolism.

Textbooks

1. Guyton, C. and Hall, E., Text book of Medical Physiology, 12th edition (W.B. Saunders Company, 2010).
2. Hill, R.W., Wyse, G. A. and Anderson, M., Animal Physiology, 3rd edition (Sinauer Associates, 2012).
3. Kim E. Barrett. et. al., Ganong's Review of Medical Physiology, 24th Edition (Lange Basic Science, Tata McGraw Hill, 2012.)

BI 234: Biochemistry I **L-3 T-0 P-0 CH 3 Cr 3**

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. Biological membrane transport and membrane dynamics.

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; Enzyme catalysis Coupled processes; Thermodynamic principles-first and second laws of thermodynamics; ATP as universal currency of energy in biological system. Biological oxidation reduction reaction and free energy.

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. Molecular and Cell Biology (Schaum's Outlines series special Indian edition) by W. D. Stansfield, J. S.C. Colome, R. J. Cano and R. N. Sharan (2010), McGraw Hill Education.
2. Berg JM, Tymoczko JL, StryerL.Biochemistry: International Edition, 7th edition, W.H. Freeman and Macmilan. 2011.

BI 236: Biology Lab-IV (Physiology & Biochemistry) L0-T0-P2-CH4-CR2

1. Preparation and staining of blood film with Leishman's stain. Total count of RBC and WBC.
2. Preparation of plasma and determination of plasma clotting time.
3. Study of osmosis and plasmolysis plants.
4. Study of Germination and impact of water stress on germination.
5. Separation of amino acids by TLC and determination of Rf values.
6. Rancidity measurement in fats and oils

BI 228: Biology Lab-V (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. Antimicrobial sensitivity test and demonstration of drug resistance.
6. Maintenance of stock cultures: slants, stabs and glycerol stock cultures.
7. Determination of Minimum Inhibitory Concentration (MIC)
8. Screening of bacteria for production of extracellular enzymes
9. Sampling techniques; waste water analysis for physiochemical characteristics such as pH conductivity, TDS, DO.

Reference books

1. Cappuccino, J. G., & Welsh, C. (2016). *Microbiology: a Laboratory Manual*. Benjamin-Cummings Publishing Company.
2. Collins, C. H., Lyne, P. M., Grange, J. M., & Falkinham III, J. (2004). *Collins and Lyne's Microbiological Methods* (8th ed.). Arnolds.
3. Tille, P. M., & Forbes, B. A. *Bailey & Scott's Diagnostic Microbiology.*

SEMESTER V

BI 321: Molecular Biology I **L-2 T-1 P-0 CH 3 Cr 3**

Unit I: Nucleic acid structure and function
Introduction to molecular biology, chemical nature of the genetic material: Avery et al experiment; Hershey and Chase experiment; Structure of DNA and RNA: DNA double helix; Base pairings in DNA, A, B and Z DNA, RNA secondary structures

Unit II: DNA to Chromosome
Introduction to genomes of bacteria, eukaryotes, organelle and viruses: linear and circular chromosomes, single stranded and doubles stranded DNA/RNA viral genome, Organization DNA into chromosomes: DNase I sensitive regions, heterochromatin and euchromatin, DNA methylation (e.g. X chromosome inactivation)

Unit III: Replication, repair and recombination
DNA replication: Chemistry of replication, DNA polymerases, synthesis of leading and lagging strands Errors in DNA and repair: pyrimidine dimer, nick and gap in DNA, AP sites, base mispairing; photolyase; mismatch, base excision and nucleotide-excision repair mechanisms, SOS response. Recombination: Homologous recombination, site specific recombination, transposition

Unit IV: Transcription
Prokaryotic transcription: RNA polymerase, promoters, sigma factors, initiation, elongation and termination (Rho-dependent and independent), Eukaryotic transcription: types of RNA polymerases, promoters and enhancers, transcription factors, TBP and TAFs, RNA modification and processing

Unit V: Translation
Translation in prokaryotes and eukaryotes: Ribosome, tRNA, amino-acyl tRNA synthetases, genetic code, translation-initiation, elongation, termination and ribosome recycling,

Unit VI: Regulation of gene expression
Transcriptional regulation in bacteria: regulation of lac and trp operons in bacteria, regulation by sigma factors, anti-sigma factors, anti-sense RNA, two component regulatory system in bacteria, Concept of eukaryotic gene regulation.

Text Books:

1. Lewin's Genes XII by J. E. Krebs, E. S. Goldstein and S. T. Kilpatrick (Edn 12th 2017) (Alternatively, Lewin's Gene X and Lewin's
2. Genex XII by same authors)
3. Molecular Biology of the Gene by J. D. Watson, T.A. Baker, S.P. Bell, Gann, M. Levine and R. Losick (Edn 6th 2007).

Reference Books:

1. Molecular Biology of the Cell by B. Alberts, A. Johnson, J. Lewis, M.
2. Raff, K. Roberts, D, Morgan (Edn 6th, 2014).

BI 337: Developmental Biology **L-3 T-1 P-0 CH 4 Cr 4**

Unit I: History of developmental biology:
Historical perspective and different techniques in developmental biology, Model Organisms: An overview of model organisms Criterion of model organism. Key features of some model organisms.

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

Unit III: Patterning of body plan in model Invertebrate:
Early pattern formation and laying of body axis planes, Axis formation and anterior/posterior patterning and dorsal/ventral patterning in Drosophila/C.elegans (maternal effect genes, segmentation, zygotic genes).

Unit IV: Patterning of body plan in model Vertebrate:
Early embryogenesis: morula and blastula formation, early cell differentiation, Cell lineages and developmental controls, formation of germ layers, gastrulation, Axis formation and anterior/posterior patterning and dorsal/ventral patterning in zebra fish/mouse/human.

Unit V: Cell differentiation:
Cell fate determination, Differentiation of Specialized Cells: Stem cell differentiation, tissue regeneration, morphogenesis, Cancer stem cells.

Unit VI: Plant Embryonic Development and Patterning
Embryogenesis in plant: Development of Male and Female Gametophyte. Embryogenesis. Axial and Radial patterning in plants. Developmental control genes in a model plant (*Arabidopsis*).

Unit VII : Plant Meristems and Differentiation.
Organization of Shoot Apical Meristem (SAM) and Root Apical Meristems (RAM). Floral meristems and development. Leaf Ontogeny.

Unit VIII: Factors influencing Plant Development:
Photomorphogenesis and Skotomorphogenesis. Role of Micro RNAs. Recent advances in apomixes and Self-incompatibility**.**

Text books

1. Scott F. Gilbert. Developmental Biology, (Sinauer Associates Inc; 10 edition (2013)
2. Lewis Wolpert. Principles of Development, (Oxford University Press, 5th edition, 2015)

Reference books

1. Bruce Alberts et al, Molecular Biology of the Cell, (Garland Science; 6th edition, 2014).
2. Benjamin Lewin, Gene XII (Jones and Bartlett Publishers, 12th edition, 2017).
3. James D. Watson et al., Molecular Biology of the gene (Pearson Prentice Hall, 6thedition, 2013).

BI 339: Bio programming and Biostastics **L-2 T-0 P-1 CH 4 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

Unit III: Data analysis

Exploratory data analysis and statistical inference, Chi-square test for independence, P-value and z-score of the statistic, statistical software and their use for data analysis.

Unit IV: Programming languages

C language Introduction –Tokens –Keywords, Identifier, Variables, Constants, Operators –Expression–Data types, Conditional and Unconditional Control Statement–Looping Statement: while, do-while, for –nested loop, 2D and 3D Arrays.

(1) C: File handling in C, Modes for files, Functions used in files.
(2) String Handling: String declaration–String library functions –String Manipulation
(3) 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.

Recommended Textbooks

1. Jhonson RA et al. (2015) Miller & freud's probability and statistics for engineers.
2. Ross S (2018) Introduction to probability and statistics for engineers and scientists.
3. Kamthane AN (2008) Programming with ANSI and Turbo C.
4. Kanethkar Y (2016) let us C.
5. Kernighan BW & Ritchie D (2015) The C Programming Language.

Reference Books

1. Object Oriented Programming with C++ by Balagurusamy Publisher: TMH; Sixth edition
2. Introduction to Java Programming by Y. Daniel Liang Publisher: Pearson; 10 edition
3. Fundamentals of Biostatistics by Bernard Rosner Publisher: Cengage Learning; 7 edition
4. Programming with Java by Balagurusamy Publisher: McGraw Hill Education (India)

BI 341: Immunology I **L-3 T-0 P-0 CH 3 Cr 3**

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: Antigen:
Antigenicity vs immunogenicity, factors that influence immunogenicty, B and T cell epitopes, haptens.

Unit-V: 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, Class switching, Affinity maturation and somatic hypermutation, Monoclonal antibodies.

Unit-VI: MHC and Antigen Presentation:
General organisation and inheritance of the MHC, MHC molecules and genes, Cellular distribution of MHC molecules, Intracellular and extracellular antigen processing pathways.

Unit-VII: Cytokines and cytokine receptors:
Properties of cytokines, cytokine receptors, Cytokine signal transduction, cytokines secretion by Th1 and Th2 subsets and cross regulation

Unit-VIII: T cell and B cell maturation and activation:
Basics of T and B maturation, Self-MHC restriction of T and of B cells, T and B cell activation and differentiation

Unit-IX: Effector mechanisms:
Effector T cells, cytotoxic T cells, NK cells, ADCC, and hypersensitivity.

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 (WileyBlackwell, 11th Edition).

BI 343: Computational Biology **L-2 T-1 P-0 CH 3 Cr 3**

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

Unit-II: Algorithms:
Multiple sequence alignments (CLUSTALW and CLUSTALX), Amino acid substitution matrix (BLOSUM, PAM), Nucleotide Substitution Patterns: Jukes Cantor Model, Kimura's model etc.

Unit-III: Phylogenetic Analysis:
Distance based methods and character based methods, Statistical approaches to Gene Prediction,

Unit-IV: Molecular modeling:
Protein structure prediction, *ab-initio*, Threading and Homology modeling, backbone construction and side chain addition; scoring method, evaluation

Unit-V: Methods for comparison of 3D structure of proteins.
Analysis and superimpose protein 3D structures, protein structure comparison

Unit-VI: Docking of molecules:
Protein-ligand interactions, Drug designing, buried and exposed residues; side chains and neighbors; fixed regions; hydrogen bonds; elements of *in silico* drug design; Virtual library.

Unit-VII: Molecular interactions:
Protein-protein, protein-DNA, protein-carbohydrate,

Unit-VIII: Molecular Mechanics:
Calculation of conformational energy for biomolecules, Molecular dynamics and quantum mechanics, Monte Carlo simulation,

Text books

5. Brown, T. A. *Genomes II* (2nd Edition, Wiley – Liss2002).
6. Primrose. *Principles of Genome Analysis and Genomics* (3rd Edition, Blackwell2003).
7. Baxevanis A. D *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins*, (Wiley-Interscience.2001).
8. Andrew Leach. Molecular modeling: principles and applications. 2nd ed. Pearson Education. 2001.
9. Atkins and Friedman. Molecular quantum mechanics. Oxford University Press. 4th ed. 2005.
10. David C. Young. Computational Drug Design. A guide for Computational and Medicinal Chemists. Wiley. 2009

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 345: Biology Lab VI (Molecular Biology) L0-T0-P3-CH6-CR3

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
6. 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

BI 347: Biology Lab VII (Immunology) L0-T0-P3-CH6-CR3

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

Practical books

1. Practical Immunology, 4th Edition Frank C. Hay, Olwyn M. R. Westwood WileyBlackwell, 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.

SEMESTER VI

BI 340: Molecular Genetics **L-3 T-0 P-0 CH 3 Cr 3**

Unit I: Fundamentals of molecular genetics

Background, definition, scope and applications. Introduction to biomolecules - DNA, RNA, proteins, cell precursors- carbohydrates and lipids.

Unit II: Molecular events leading to variations

Origin of mutants, nomenclature, types of mutations, mutation at the level of DNA, gene, organism, isolation (Ames test), forward and reverse mutations, mutation rate, Applications of mutant organisms.

Unit III: Recombinant DNA technology

Polymerizations including polymerase chain reaction (PCR) and other types (Multiplex, LAMP, RT, Real time), polymerase enzymes, restriction endo/exo-nuclease enzymes, ligases; cloning vectors (Prokaryotic, Eukaryotic, Shuttle), functional complementation, transposon tagging, subtractive hybridization, marker assisted cloning, cDNA and genomic libraries.

Unit IV: Identification and assessment of variations

Restriction fragment length polymorphism (RFLP), Single strand polymorphism (SSCP), Denaturing high performance liquid chromatography (DHPLC), Random amplification of polymorphic DNA (RAPD), DNA sequencing-conventional method, Sanger's method, Next generation sequencing.

Unit V: Human, plant and microbial molecular genetics

Nomenclature of human genes and mutations, Phenotype, Genotype, Pedigree analysis- construction and analysis of monogenic diseases/disorders (Autosomal-dominant and recessive, X linked-dominant and recessive, Mitochondrial, multifactorial inheritance/complex traits, SNPs-Types & application, Y chromosome, Fluorescence In-Situ Hybridization (FISH); Comparative Genomic Hybridization (CGH), Linkage analysis, GWAS.

Unit VI: Sequencing of genomes of different organisms

Inception, major milestones, accomplishments, challenges (ELSI), applications in modern medicine.

Unit VII: Genome editing approaches

Homologous Recombination, RNAi technique, Site specific nucleases- Cas9-CRISPR, TALENS, Zn-Finger protein. Conditional knockout-Cre-Lox p mechanism, Knock-in, Animal models for human diseases.

Unit VIII: Evolution at molecular level in population

Gene frequency; Hardy Weinberg law; Factors influencing Hardy Weinberg equilibrium-Mutation, Selection, Migration, Gene flow, Genetic drift; Human genetic diversity, Origin of major human groups.

Texts Books & Reference Books:

1. Kothari, M. L., Essentials of Human Genetics, 5th Edition, Orient Black Swan Publisher, 2008. ISBN: 978-8173716478.
2. Strachan, T and Read, A. P, Human molecular genetics, 4th Edition, Garland Publishing, 2010. ISBN-13: 978-0815341499.
3. Tamarin R H. Principles of Genetics, 7th Edition, McGraw Higher Ed Publishers, 2010. ISBN: 9780070486676.
4. Edward S. T. Michael. C, M. F. Smith, Essential medical genetics, 6th Edition, Wiley-Blackwell publications, 2011. ISBN: 978-1405169745.
5. John P, Redesigning Life: How genome editing will transform the world, 1st Edition, Oxford University Press, 2016. ISBN-13: 978-0198766827.
6. Susan Elrod, Schaum's Outline of Genetics, 5thEdition (Schaums Outline Series), McGraw-Hill Education, 2010. ISBN-13: 978-0071625036

BI 342: Advanced Programming I **L-2 T-0 P-1 CH 4 Cr 3**

Unit I: Fundamentals of Unix

Types of shells, Shell functionality, I/O redirection- stdin, stdout, and stderr; Introduction to text editors in unix (such as vi, emacs, etc): basic text input and navigation, moving and copy text, searching for and replacing text, etc.; join operation, Writing first script- Writing script & executing basic script, Debugging script, Making interactive scripts, Running external codes from unix shell, running codes in remote servers from local terminal, Basic concept of job scheduling in High Performance Computing clusters, Processes Management in Unix.

Unit II: Commands and expressions

Variables (default variables), Mathematical expressions; Conditional statements - If-else-elif, Test command, Logical operators-AND,OR,NOT, ase –esac, Loops- While, For, Until, Break & continue, Command line arguments- Positional parameters, Set & shift, IFS, Break & continue, pipes and filters, Functions & file manipulations- Processing file line by line, Functions; Regular Expression & Filters- What is regular expression?, Grep, cut, sort commands, Grep patterns; SED & AWK

UNIT III: R programming-I

Introduction to R, The RStudio interface to R, R Package Repositories, Installation of R Packages, Basic Syntax, Data Types, Data Objects, Object types (Vectors , Matrices, Data Frames, Arrays, Lists), Subsetting of data objects, Combining Objects (cbind, rbind), Merging Data Frames, Filtering Data, Operators and Calculations, Reading and Writing External Data

UNIT IV: R programming-II

Control Structures, Operators-Comparison operators; Conditional operators- if, ifelse, Logical operators; Loops- for, while; R Functions; apply (tapply, sapply, lapply); Using in-built functions for Statistical testing in R, Manipulating data in R; Executing bioinformatics data analysis workflows in R; Graphics in R, Scatter Plots; Line Plots- Single data set, Many Data Sets; Bar plot and error bars; Histograms; Pie Charts; Color Selection Utilities; Saving Graphics to File

UNIT V: Applications

R- Bioconductor , Gene expression analysis using microarray or RNA-Seq data using R and Unix shell scripts, Normalization, Differential Expression, Clustering, Gene set enrichment and pathway analysis

TEXT BOOK

1. Vince Buffalo (Author), "Bioinformatics Data Skills: Reproducible and Robust Research with Open Source Tools", O'Reilly Media, 1st edition (1 July 2015)
2. Robert Gentleman, "R Programming for Bioinformatics", Chapman and Hall/CRC, July 14, 2008
3. William N. Venables, David M. Smith , "An Introduction to R", [https://cran.r-project.org/doc/manuals/r-release/R-intro.pdf]

REFERENCES

1. http://www.unix.org/what_is_unix.html
2. UNIX / Linux Tutorial - https://www.tutorialspoint.com/unix/index.htm
3. R: The R Project for Statistical Computing - https://www.r-project.org/
4. The Shell Scripting Tutorial https://www.shellscript.sh/
5. R Introduction | R Tutorial- http://www.r-tutor.com/r-introduction
6. R Tutorial for beginners - https://www.statmethods.net/r-tutorial/index.html
7. Bioconductor - https://www.bioconductor.org/
8. RStudio- https://www.rstudio.com/

BI 346: Bioinformatics software and Algorithms L-3 T-0 P-0 CH 3 Cr 3

Unit I: Computational Models:
Introduction, Random Access Machine, Turing machine, circuit model, Parallel Random Access Machine, Bulk Synchronous Parallel model

Unit-II: Introduction to Algorithms
Algorithms and Complexity: Biological algorithms versus computer algorithms, upper bound of polynomial form of time complexity, solution of some common recurrence relations, homogeneous and inhomogeneous recurrences, change of variable, generating functions, amortization, basic data structures, correct versus incorrect algorithms, Fast versus slow algorithms, Simple Algorithms, Analyzing Algorithms, Asymptotic Notation

Unit-III: Algorithm Design Techniques:
Design Methods and applications: divide and conquer, Greedy Method, dynamic programming, Approximation algorithms, Randomized algorithms, Graph algorithms, Backtracking, branch and bound, lower bound techniques, genetic algorithms and parallel algorithms

Unit-IV: Bioinformatics Algorithms:
Introduction, Computer and biological algorithms, matching algorithms: exact string matching algorithms, approximate string matching, comparing biological sequences, protein identification problem

Unit-V: NP-Completeness:
Easy and hard problems, Polynomial time, Hamiltonian cycles, non-deterministic polynomial time, problem reduction, NP-Complete problems and approximation algorithms.

Text books

1. Basu, S.K., Design Methods and Analysis of Algorithms (Prentice Hall of India (Pvt)
1. Ltd, New Delhi. 2005).
2. Baxevanis A. D Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins,
3. (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 348: Analytical Techniques **L-3 T-0 P-0 CH 3 Cr 3**

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:
UV, Visible, Photoluminescence; 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 – Gelpermeation, Ion exchange, Hydrophobic, Reverse-phase and Affinity chromatography; HPLC andFPLC; Criteria of protein purity, Ultrafiltration and other membrane techniques, dialysis.

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

Unit VI Radioactivity
Radioactive materials and Radiological techniques 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 VII: 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. Molecular and Cell Biology (Schaum's Outlines series special Indian edition) by W. D. Stansfield, J. S.C. Colome, R. J. Cano and R. N. Sharan (2010), McGraw Hill Education.
2. R. Scopes, Protein Purification - Principles & Practices, 3rd Edition, Springer Verlag, 1994.

SEMESTER VII

BI 441: Biochemistry II **L-3 T-0 P-0 CH 3 Cr 3**

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. Isolation and purification of enzymes.Methods of enzyme isolation and purification, determination of molecular mass and purity ofenzymes; some examples of industrial application of enzymes

Unit III: Biochemistry of polypeptide and steroid hormones,
Hprmones and hormonal cascade system, structure, biosynthesis, hormone-receptor interaction and regulation

Unit IV: Carbohydrate metabolism and biological oxidation
Glycolysis and citric acid cycle, glyoxalate cycle, gluconeogenesis,Calvin cycle, pentose phosphate pathwayand glycogen metabolism; oxidoreductases, redox potential, electron transport chain, oxidativephosphorylation and photophosphorylation;-Diseases related to impaired carbohydrare metabolism

Unit V: Lipid metabolism
Metabolism of fatty acids, ketone bodies – formation and utilization, biosynthesis of cholesterol. Diseases related to impaired lipid metabolism

Unit VI: Protein metabolism
Pathways of amino acid metabolism, transamination, transdeamination and deamination; Biosynthesis. Diseases related to impaired protein metabolism

Unit VII: Nucleic acid metabolism
Synthesis and degradation of nucleotides; metabolism of purines and pyrimidines. Diseases related to impaired nucleic acid metabolism

Text books

1. Stryer L. (2007) Biochemistry, W.H.Freeman.
2. Voet D and VoetJ.G.,.Fundamentals of Biochemistry (John Wiley and Sons, 2004).
3. Nelson D.L. and Cox M.M. (2017) Lehninger's Principles of Biochemistry, Freeman & Co, New York.
4. Thomas M Devlin(2010) Text ofBiochemistry with Clinical Correlations, Wiley-Liss

Reference books

1. Zubay G. (1999) Biochemistry, 4th Ed., Win C. Brown Comm.,lnc.
2. Devlin, T.M., Text book of Biochemistry (John. Wiley and Sons. 2002).

BI 443: Molecular Biology II **L-3 T-0 P-0 CH 3 Cr 3**

Unit I: DNA structure in detail
DNA double helix: endo- and exo sugars, syn- and anti- conformation of N-bases, W-C and Non-W-C base pairing, roll, slide and twist in DNA, DNA supercoiling: Super coiling, superhelical density, Lk, Wr and Tw, topoisomerases Genome complexity: DNA re-association kinetics, Cot curve, C-value paradox, repetitive and unique sequences.

Unit II: Regulation of DNA replication and chromosomes
DNA replication in prokaryotes: initiation, elongation and termination; regulation of replication, segregation of chromosomes to daughter cells DNA replication in eukaryotes: initiation, elongation and termination, telomerase and aging, regulation of DNA replication DNA packaging into chromosomes: histone proteins and nucleosome, covalent modification in DNA and hisones

Unit III: Mechanisms of DNA recombination and Repair
DNA errors and its repair, translesion DNA synthesis, regulation of Y-family of polymerases in bacteria and eukaryotes, Non-homologous end joining (NHEJ) Recombination: Gene conversion, Holliday model, double strand break repair model, mating type switching in yeast, , FLP/FRT and Cre-Lox recombination, transposition- DNA transposons and retroposons and mechanism.

Unit IV: Transcription and RNA processing
Transcription in prokaryotes and eukaryotes, splicing, alternative splicing mRNA modification: capping, polyA addition, editing, nonsense and nonstop mediated decay, transport, rRNA processing, base modification, tRNA processing and modifications, Ribosome formation

Unit V: Mechanisms of translation
Genetic code, Translation initiation, elongation, termination, ribosome recycling in prokaryotes and eukaryotes, IRES in eukaryotes, Codon anticodon interaction, ribosome profiling, co-translational protein folding

Unit VI: Gene regulation
Gene regulation at different level, DNA protein interactions: HLH, Leucine zipper, Zn-finger motif proteins, repressor, activators RNA in gene regulation: RNA binding proteins, RNA stability, UTR mediated gene regulation, Riboswitch, RNA interference.Translational gene regulation, Post translational gene regulation: covalent modification of proteins: phosphorylation, methylation, acetylation adenylation, arginylation, Ubiquitination.

Text Books:

4. Lewin's Genes XII by J. E. Krebs, E. S. Goldstein and S. T. Kilpatrick (Edn 12th 2017) (Alternatively, Lewin's Gene X and Lewin's
5. Genex XII by same authors)
6. Molecular Biology of the Gene by J. D. Watson, T.A. Baker, S.P. Bell, Gann, M. Levine and R. Losick (Edn 6th 2007).

Reference Books:

3. Molecular Biology of the Cell by B. Alberts, A. Johnson, J. Lewis, M.
4. Raff, K. Roberts, D, Morgan (Edn 6th, 2014).

BI 445: Immunology II **L-3 T-0 P-0 CH 3 Cr 3**

Unit I: Vaccinology

Active and passive immunization; live, killed, attenuated, subunit vaccines; vaccine technology: role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines. Antibody genes and antibody engineering:chimeric, generation of monoclonal antibodies, hybrid monoclonal antibodies; catalytic antibodies and generation of immunoglobulin gene libraries, idiotypic vaccines and marker vaccines, viral-like particles (VLPs), dendritic cell based vaccines, vaccine against cancer, T cell based vaccine, edible vaccine and therapeutic vaccine.

Unit II: Clinical immunology

Immunity to infection : bacteria, viral, fungal and parasitic infections (with examples from each group); hypersensitivity: Type I-IV; autoimmunity; types of autoimmune diseases; mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; treatment of autoimmune diseases; transplantation: immunological basis of graft rejection; clinical transplantation and immunosuppressive therapy; tumor immunology: tumor antigens; immune response to tumors and tumor evasion of the immune system, cancer immunotherapy; immunodeficiency: primary immunodeficiencies, acquired or secondary immunodeficiencies, autoimmune disorder, anaphylactic shock, immunosenescence, immune exhaustion in chronic viral infection, immune tolerance, NK cells in chronic viral infection and malignancy.

Unit III: Immunogenetics

Major histocompatibility complex genes and their role in autoimmune and infectious diseases, HLA typing, human major histocompatibility complex (MHC), Complement genes of the human major histocompatibility complex: implication for linkage disequilibrium and disease associations, genetic studies of rheumatoid arthritis, systemic lupus erythematosus and multiple sclerosis, genetics of human immunoglobulin, immunogenetics of spontaneous control of HIV, KIR complex.

Recommended Textbooks and References:

5. Kindt, T. J., Goldsby, R. A., Osborne, B. A., & Kuby, J. (2006). *Kuby Immunology*. New York: W.H. Freeman. Brostoff, J., Seaddin, J. K., Male, D., & Roitt, I. M. (2002). *Clinical Immunology.* London: Gower Medical Pub.
1. Murphy, K., Travers, P., Walport, M., & Janeway, C. (2012). *Janeway's Immunobiology.* New York: Garland Science. Paul, W. E. (2012). *Fundamental Immunology*. New York: Raven Press.
6. Goding, J. W. (1996). *Monoclonal Antibodies: Principles and Practice: Production and Application of Monoclonal Antibodies in Cell Biology, Biochemistry, and Immunology.* London: Academic Press.
2. Parham, P. (2005). *The Immune System*. New York: Garland Science.

BI 447: Biological Database Management System **L-2 T-0 P-1 CH 4 Cr 3**

UNIT I Introduction

Database -System Applications- Purpose of Database Systems, View of Data, Database Languages, introduction to Relational Databases, Database Design, Data Storage and Querying, Transaction Management, Database Architecture, Database Users and Administrators, History of Database Systems.

UNIT II Database design and E-R model

Overview of the Design Process, The Entity-Relationship Model, Constraints, Removing Redundant Attributes in Entity Sets, Entity-Relationship Diagrams, Reduction to Relational Schemas, Entity-Relationship Design Issues, Extended ER Features, Alternative Notations for Modeling Data, Other Aspects of Database Design.

UNIT III Relational model and design techniques

Introduction to the Relational model: Structure of Relational Databases, Codd's 12 rule, Database Schema, Keys, Schema Diagrams, Relational Query Languages, Relational Operations. Relational Database Design: Features of Good Relational Designs, Atomic Domains and First Normal Form, Decomposition Using Functional Dependencies, Functional-Dependency Theory, Algorithms for Decomposition, Decomposition Using Multivalued Dependencies, More Normal Forms, Database- Design Process, Modeling Temporal Data.

UNIT IV Structure and Language

Overview of the SQL Query Language, SQL Data Definition, Basic Structure of SQL Queries, Additional Basic Operations, Set Operations, Null Values, Aggregate Functions, Nested Subqueries, Modification of the Database.

UNIT V Biological database management

Introduction to Biological Data Integration - specifications. -Challenges Faced in the Integration of Biological Information: -Nature of Biological data,- Data sources in Life Sciences, -Challenges in information integration-. Data management in Bioinformatics, Dimensions -Describing the Space of Integration Solutions. 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.

TEXT BOOK

1. Abraham Silberschatz, Henry F. Korth, S. Sudarshan, "Database System Concepts", McGraw-Hill, 6th Edition, 2011.

REFERENCES

1. Raghu Ramakrishnan, Johannes Gehrke, "Database Management System", McGraw Hill, 3rd Edition 2003
2. Elmashri & Navathe, "Fundamentals of Database System", Addison-Wesley Publishing, 3rd Edition, 2000
3. Date C.J, "An Introduction to Database", Addison-Wesley Pub Co, 7th Edition, 2001
4. Jeffrey D. Ullman, Jennifer Widom, "A First Course in Database System", Prentice Hall, AWL 1st Edition, 2001
5. Peter Rob, Carlos Coronel, "Database Systems - Design, Implementation, and Management", 4th Edition, Thomson Learning, 2001.
6. Zoe Lacroix, Terence Critchlow," Bioinformatics: Managing Scientific Data", Morgan Kaufmann Publishers (Elsevier Science), 2003

BI 449: Advanced programming II **L-2 T-0 P-1 CH 4 Cr 3**

Unit I:
Introduction to Perl, history, present status and availability, role of Perl in Human Genome Project (HGP), different IDEs, introduction to scalar data, scalar variables usage, string manipulations.

Unit II:
Lists and arrays, introduction to array operations, Multidimensional arrays and advanced array operations, Control structures: loops and conditional statements, Input and output, File and directory handling.

Unit III:
Introduction to Hashes, Patterns and Regular expressions, matching regular expressions and text processing with regular expressions, Perl functions and subroutines, split operator and join function.

Unit IV:
Perl one-liners, introduction to Perl modules, installation and usage of simple Perl modules, introduction to BioPerl, various Bioperl modules and their applications, threading: introduction to parallel computing.

Text books:

1. Learning Perl – 2011 by Schwartz, Randal L
2. Mastering Perl 2014 by Brian D. Foy
3. Programming Perl 2012 by Christiansen and Tom
4. Beginning Perl for Bioinformatics: An Introduction to Perl for Biologists 2009 By James Tisdall
5. Mastering Perl For Bioinformatics 2003 by James Tisdall

BI 451: Biology Lab VIII (Biochemistry) **L-0 T-0 P-3 CH 6 Cr 3**

1. Purification and characterization of an enzyme from a recombinant source (such as Alkaline Phosphatase or Lactate Dehydrogenase or any enzyme of the institution's choice).
    a) Preparation of cell-free lysates
    b) Ammonium Sulfate precipitation
    c) Ion-exchange Chromatography
    d) Gel Filtration
    e) Affinity Chromatography
    f) Dialysis of the purified protein solution against 60% glycerol as a demonstration of storage method
    g) Generating a Purification Table (protein concentration, amount of total protein; Computing specific activity of the enzyme preparation at each stage of purification)
    h) Assessing purity of samples from each step of purification by SDS-PAGE Gel Electrophoresis Enzyme Kinetic Parameters: Km, Vmax and Kcat.
2. Experimental verification that absorption at OD_{260} is more for denatured DNA as compared to native double stranded DNA. reversal of the same following DNA renaturation. Kinetics of DNA renaturation as a function of DNA size.
3. Biophysical methods (Circular Dichroism Spectroscopy, Fluorescence Spectroscopy).
4. Determination of mass of small molecules and fragmentation patterns by Mass Spectrometry.

BI 453: Biology Lab IX (Immunology) **L-0 T-0 P-3 CH 6 Cr 3**

1. Blood film preparation and identification of leucocytes by Giemsa stain.
2. Antibody titre by ELISA method.
3. Ouchterlony's double diffusion assay
4. Immunoelctrophoresis and radial immune diffusion.
5. SDS-PAGE and immune blotting.
6. Immunodiagnostics using commercial kits.
7. Enzyme linked immunosorbent assay (DOT-ELISA)

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.

SEMESTER VIII

BI 448: Genomics and Proteomics **L-3 T-0 P-0 CH 3 Cr 3**

Unit I: Basics of genomics and proteomics
Brief overview of prokaryotic and eukaryotic genome organization; transposons; telomeres; extra-chromosomal DNA: bacterial plasmids, mitochondria and chloroplast genome.

Unit II: Genome mapping
Genetic and physical maps; markers for genetic mapping; methods and techniques used for gene mapping, physical mapping, linkage analysis, cytogenetic techniques, FISH technique in gene mapping, somatic cell hybridization, radiation hybrid maps, comparative gene mapping.

Unit III: Genome sequencing techniques and genome sequencing projects
Sanger vs NGS; whole genome shotgun vs clone contig method of genome sequencing; contig assembly; genome sequencing projects for microbes (*Haemophilus influenzae*); Human Genome Project; genome annotation; databases of genomes; accessing and retrieving genome project information from the web.

Unit IV: Comparative genomics
Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing, SNPs; metagenomics; use of genomes to understand evolution of eukaryotes, track emerging diseases and; design new drugs (pharmacogenomics).

Unit V: Proteomics
Aims, strategies and challenges in proteomics; proteomics technologies: isoelectric focusing and 2D-PAGE, mass spectrometry (MALDI-TOF, and ESI-MS/MS), yeast 2-hybrid system, proteome databases; protein sequence alignments (local and global); quantitative proteomics.

Unit VI: **Functional genomics and proteomics and system biology**
Transcriptome analysis for identification and functional annotation of genes, RNAseq, mining functional genes in genome, gene function- forward and reverse genetics, gene ethics; protein-protein and protein-DNA interactions; protein chips and functional proteomics; clinical and biomedical applications of proteomics; introduction to metabolomics, lipidomics, and systems biology.

Recommended Textbooks and References:

1. Brown T.A., Genomes 4, 4th Edition. Garland Science 2017.
2. Primrose, S. B., Twyman, R. M., Primrose, S. B., & Primrose, S. B. Principles of Gene Manipulation and Genomics. Malden, MA: Blackwell Pub. 2006.
3. Campbell, A. M., & Heyer, L. J., Discovering Genomics, Proteomics, and Bioinformatics. 2nd Edition. San Francisco: Benjamin Cummings 2006.

BI 442: Structural Bioinformatics **L-2 T-0 P-1 CH 4 Cr 3**

Unit-I: Introduction to Macromolecular Structure
Proteins: Primary Structure, Secondary Structure, Tertiary Structure, Quaternary Structure;
Nucleic Acids: DNA (A, B, Z forms) structure, RNA structures;

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.

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

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

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

Textbooks & References:

1. Andrew Leach. Molecular modeling: principles and applications. 2nd ed. Pearson Education. 2001.
2. Jenny Gu and Philip E Bourne. Structural Bioinformatics, 2nd Edition 2009.
3. Stephen Neidle. Principle of nucleic acid structure. 2007.

BI 444: Cell Biology II **L-3 T-0 P-0 CH 3 Cr 3**

Unit I: Techniques in Cell Biology
Advanced Microscopy: Confocal and immunofluorescence microscopy, FISH. Scanning and transmission microscopes, fixation and staining techniques for EM. Techniques for detection of Cancer.

Unit II: Cancer Biology
Cell Cycle misregulation and cancer. Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, virus-induced cancer, metastasis. Therapeutics for Cancer

Unit III: Interaction of the cell with its environment
General principles of cell communication: cell-cell communications, cell-environment communications. Role of different adhesion molecules: Desmosomes, Hemi-desmosomes, Gap junctions, Tight Junctions, Plasmodesmata . Organelle Interconnectivity and communications.

Unit IV: Cell Organelles
Energy utilization in cells. Mitochondria: Structure, function and its role in aerobic respiration. Chloroplast: Structure and function. Inheritance of Mitochondrial and chloroplast genes, maternal inheritance. Organelle Interconnectivity and communication of Mitochondria with the endomembrane system.

Unit V: Cell signalling II
Bacterial two component system. Plant two component system. Bacterial chemotaxis and quorum sensing. Cytokine signalling. Signalling pathways in Apoptosis. Signal transduction associated with Cancer.

Textbooks:

1. Karp G., Cell and Molecular Biology: Concepts and Experiments, 7th Edition (John Wiley & Sons, Inc., 2013).
2. Scott, M. P. et al, Molecular Cell Biology, 6th Edition (W. H. Freeman, 2007).
3. Alberts, B. et al., Molecular Biology of the Cell, 5th Edition (Garland Publishing, 2008).
4. Pecorino, Lauren. Molecular biology of cancer: mechanisms, targets, and therapeutics. 4th Edition (Oxford university press, 2012.)

BI 446: Genetic Engineering **L-3 T-0 P-0 CH 3 Cr 3**

Unit I: Introduction and tools for genetic engineering
Overall impact of genetic engineering in modern society; Tools required for genetic engineering experiments – host strains; restriction endonucleases, restriction mapping, restriction-modification methylases; DNA and RNA ligase,DNA ligation using: cohesive-ended and blunt-ended DNA fragments; linkers, adaptors; homopolymeric tailing, nucleic acids modifying enzymes;. Methods for protein-DNA, protein-RNA and protein-protein interactions (co-immunoprecipitation, pull-down assay, mammalian two-hybrid and yeast-two hybrid assay) .

Unit II: Nucleic acid hybridisation methods
Radioactive and non-radioactive labelling of nucleic acids and proteins, southern, northern, western, south-western, far western, eastern, colony, fluorescence in situ hybridisation (FISH) and detection of chromosomal abnormalities.

Unit III: Polymerase chain reaction and its application
Principles of PCR: primer design; fidelity of thermostable DNA polymerases; types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR; site-specific mutagenesis *in vitro* and *in vivo*; methods of mutation detection (SSCP, DGGE, RFLP). PCR in molecular diagnostics (viral and bacterial detection).

Unit IV: **Molecular vectors and expression systems**
Plasmids; Bacteriophages; M13 vectors; pUC19 and Bluescript vectors, phagemids; Lambda vectors; Insertion and replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Ti plasmid and Ri plasmid based vectors Construction of cDNA and genomic DNA libraries ; library screening methods Transformation, transduction and transfection methods. Expression vectors. Overexpression of recombinant protein in bacteria, Baculovirus, yeast and mammalian cells; Inclusion bodies formation and strategies to overcome; purification of recombinant proteins.

Unit V: Application of Genetic engineering
Gene silencing techniques: siRNA and miRNA construction of shRNA vectors; methods to generate transgenic animals and plants; DNA and protein microarrays genome editing technologies; ZFNs, TALEN, Cre-Lox and CRISPR/Cas9) system): Gene therapy;

Recommended Textbooks and References:

1. Old, R. W., Primrose, S. B., & Twyman, R. M. (2001). Principles of Gene Manipulation: an Introduction to Genetic Engineering. Oxford: Blackwell Scientific Publications.
2. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub. 4. Selected papers from scientific journals, particularly Nature & Science.
4. Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc.

BI 450: Applied Microbiology and Bioprocessing Engineering L-3 T-0 P-0 CH 3 Cr 3

Unit I : Kinetics of Substrate Utilization, Product Formation and Biomass Production in Cell Culture: Bioprocess Development an Interdisciplinary Challenges, Stoichiometry of microbial growth and chemical reaction and product formation. Isolation, screening and maintenance of industrially important microbes; Microbial growth and death kinetics ; Microbial growth in Batch culture, Specific growth rate, Monod equation, Growth in continuous culture, chemostat models, Turbidostate and Fed batch culture, Strain improvement for increased yield and other desirable characteristics.

Unit II: Energy and Material Balance in Bioprocess systems Energy and Material balance: System and process, steady state and equilibrium, Law of conservation of mass, Procedure for material balance calculation, calculation of hydraulic retention time of bioreactors.

Unit III: Transport Phenomena in Bioprocess systems : Diffusion theory, Role of diffusion in bioprocessing, Film theory, Convective mass transfer: liquid solid mass transfer, liquid liquid mass transfer, Gas liquid mass transfer

Unit IV: Design of Biological Reactors , Scale up and Control: Types of fermentation and fermenters; 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;

Unit V: **Upstream processing:** Media formulation; Sterilization; Aeration and agitation in bioprocess; Measurement and control of bioprocess parameters; Scale up and scale down process.

Text books

1. Stanbury RF and Whitaker A., Principles of Fermentation Technology, ButterworthHeinemann, 2nd Edition 2008. 2. Baily JE and Ollis DF., Biochemical Engineering fundamentals, 2nd Edition, McGraw-Hill
2. Shuler ML and Kargi F., Bioprocess Engineering: Basic concepts, 2nd Edition, PearsonIN, 2015.
3. Pauline M Doran., Bioprocess Engineering Principles , 2nd Edition, Academic Press, 2016

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.

BI 452: System Biology **L-2 T-0 P-1 CH 4 Cr 3**

UNIT I: Systems Biology – Fundamentals:
Concept of complex systems, systems theory, reductionism vs. holism, artificial systems vs. biological systems, synthetic biology, hierarchical organization in biological systems, history of systems biology (including some examples), OMICs and Big data in biology, systems medicine.

UNIT II: Representations of Biological Systems:
What is a model?, mathematical models in biology, Standards for systems biology, Systems Biology Markup Language (SBML), Systems Biology Graphical Notation (SBGN), basics of control theory, logical modelling, block diagram, enzyme kinetics, genome-scale metabolic networks, Basics of Metabolic control analysis (MCA) and Flux Balance Analysis (FBA), Basics of Biochemical Systems Theory (BST).

UNIT III: Basics of networks and graph theory:
Network topology, nodes, edges, directed vs. undirected network, regular network, random network, small world network, scale free network and power law; Network parameters: centrality, degree centrality, betweenness centrality, clustering coefficient, network diameter, shortest path, identifying hubs, node failure and robustness.

UNIT IV: Examples of biological networks:
Protein contact network, gene co-expression network, protein-protein interaction networks, gene regulatory networks, metabolic networks, neuronal networks (nervous system), species interaction network (plant-microbe interactions, host-pathogen interactions), ecological networks (food web).

UNIT V: Tools and methods
Big data integration in biology, challenges in heterogeneous data integration, Gene Ontology, Semantic Systems Biology, Basic modelling/simulation tools, R-bioconductor, cytoscape, MeV, galaxy, CellDesigner, COPASI, STRING, KEGG PATHWAY Database, Reactome Pathway Database, BioCyc, MetaCyc, Systems Biology Workbench, Pathway Commons.

Text books:

1. Alon, Uri. An introduction to systems biology: design principles of biological circuits. CRC press, 2006.
2. Newman, Mark. Networks: an introduction. Oxford university press, 2010.
3. Segel, L. A., Modeling Dynamic Phenomena in Molecular and Cellular Biology, Cambridge University Press, 1984
4. Foundations of Systems Biology (MIT Press) 1st Edition Edition by Hiroaki Kitano (Editor)

BI 454: Biology lab X (Genetic Engineering) **L-0 T-0 P-2 CH 4 Cr 2**

1. Amplification of gene of interest by Polymerase Chain Reaction and analysis by agarose gel electrophoresis
2. Restriction digestion of insert and vector; Ligation of digested insert and vector
3. Confirmation of the insert by Colony PCR and Restriction mapping
4. Expression of recombinant protein, concept of soluble proteins and inclusion body formation in *E. coli*, SDS-PAGE analysis
5. Purification of His-Tagged protein on Ni-NTA columns

Recommended Textbooks and References:

1. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

BI 456: Biology lab XI (Applied Microbiology) **L-3 T-0 P-0 CH 4 Cr 2**

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.
6. Purification of amylase/protease/cellulase 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 IX

Elective I

BI 527: Animal Biotechnology **L-3 T-0 P-0 CH 3Cr 3**

Unit-I: Animal Cell Culture:

Brief history of animal cell culture; Basic requirement for animal cell culture; Cell culture media, serum and reagents; Culture of mammalian cells; tissue and organs; Primary and secondary cell culture; Continuous cell lines; Suspension culture; Common cell culture contaminants; Application of animal cell culture for toxicity study and production of vaccines and pharmaceutical proteins; Stem cells and their application.

Unit-II: Animal Reproductive Biotechnology:

structure of sperms and ovum; cryopreservation of sperms and ova of livestock; artificial insemination; super ovulation, embryo recovery and in vitro fertilization; cryopreservation of embryos; embryo transfer technology.

Unit-III: Diagnostic methods:

Radio immunoassays; Immunoblotting; nucleic acid probe hybridization; PCR, Real time PCR; Nucleic acid sequencing; Molecular diagnostics of pathogen in animals.

Unit-IV: Vaccinology:

History of development of vaccines, introduction to the concept of vaccines, conventional methods of animal vaccine production, recombinant approaches to vaccine production, modern vaccines.

Unit-V: Animal genomics:

Different methods of characterization of animal genomes; SNP, STR, QTLs, RFLP, AFLP, RAPD; Genetic basis for disease resistance in animals; Gene knock out technology and Animal models for human genetic disorders.

Unit-VI: DNA forensics:

Immunological and nucleic acid based methods for identification of animal species; detection of adulteration in meat using DNA based methods; 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; bio-terror agents; Bio-crimes and Bio-terrorism.

Text books

1. Pörtner, R. (2007). Animal Cell Biotechnology: Methods and Protocols. Totowa, NJ: Humana Press.
2. Glick, B.R., & Pasternak, J.J. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, D.C.; ASM Press.
3. Pinkert, C. (2006). Transgenic Animal Technology, Academic Press.

Reference books

1. Masters, John R.W. (2000). Animal Cell Culture – A Practical Approach, Oxford University Press.
2. Gordon, I. (2005). Reproductive Technologies in Farm Animals. Oxford. CAB International.

BI 529: Microbial Biotechnology **L-3 T-0 P-0 CH 3 Cr 3**

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: Microbial Process Optimization
Basic Principles of bioprocess as applied to selected microbes; Process optimization of selected products.

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

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

Unit V: Food Microbiology
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 531: Plant Biotechnology **L-3 T-0 P-0 CH 3 Cr 3**

Unit I: Plant tissue culture

historical perspective; totipotency; organogenesis; Somatic embryogenesis; tissue culture media- nutrients and plant hormones, sterilization techniques; initiation and maintenance of callus and suspension cultures; single cell clones, applications of tissue cultures micropropagation.

Unit II: **Somaclonal variation**

Androgenesis and embryogenesis, their applications. Protoplast culture and somatic hybridization - isolation; culture and usage; somatic hybridization - methods and applications; cybrids and somatic cell genetics; plant cell cultures for secondary metabolite production. Synthetic seed production

Unit III: **Genetic engineering**

Agrobacterium-plant interaction; Ti and Ri plasmids: disarmed Ti plasmid, opines and their significance; Molecular mechanism of T-DNA transfer; Genetic transformation - *Agrobacterium*-mediated gene delivery; cointegrate and binary vectors and their utility; screenable and selectable markers; characterization of transgenic plants.

Unit V: Other methods of gene transfer into plants

Direct gene transfer - PEG-mediated, electroporation, particle bombardment, alternative methods, chloroplast transformation; marker-free methodologies; advanced methodologies - cisgenesis, intragenesis and genome editing (ZFN, CRISPR/Cas, TALEN)

Unit VI: Application of transgenics

insect resistance, virus resistance, abiotic stress tolerance, longer shelf life (including strategies for suppression of endogenous genes), male sterility, enhanced nutrition (golden rice), edible vaccines, phytoremediation, synthetic biology- production of biochemicals for healthcare (Phytopharmaceuticals) and industry

Unit VII: Omics technologies

Genomics, Transriptomics, Metablomics; genome sequencing strategies, Bioinformatics tools and genome annotation, forward and reverse genetic strategies; gene, promoter and enhancer traps for gene discovery, differential gene expression analysis- microarray and RNAseq. VIGS and RNAi.

Recommended Textbooks

1. Slater, A., Scott, N. W., & Fowler, M. R. (2008). *Plant Biotechnology: an Introduction to Genetic Engineering*. Oxford: Oxford University Press.
2. Buchanan, B. B., Gruissem, W., & Jones, R. L. (2015). *Biochemistry & Molecular Biology of Plants*. Chichester, West Sussex: John Wiley & Sons.

References

1. Umesha, S. (2013). *Plant Biotechnology.* The Energy And Resources.
2. Slater, A., Scott, N. W., & Fowler, M. R. (2003). *Plant Biotechnology: The Genetic Manipulation of Plants*. Oxford: Oxford University Press.

BI 533: Bioethics, Biosafety and IPR **L-3 T-0 P-0 CH 3 Cr 3**

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 & amendment rules 2016

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.Ltd., 2007).
2. Kankanala C., *Genetic Patent Law & Strategy*, (1st Edition, Manupatra Information 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

SEMESTER X

Elective II

BI 528: Molecular Modelling and drug design L-3 T-0 P-0 CH 3 Cr 3

Unit I Concepts in Molecular Modelling:
Introduction to Molecular Geometry, Coordinate systems, Molecular graphics, surfaces, Space for Optimization of Algorithm of Molecular Geometry, Z-Matrix, Molecular Vibrations, Electrostatic Charges, Multipole Moments, Fermi Contact Density, Electronic Spatial Extent and Molecular Volume, Electron Affinity and Ionization Potential, Hyperfine Coupling, Dielectric Constant, Force Field Customization. Equilibrium structures, potential energy surfaces, free energies, the standard tools of the molecular modelling: Molecular mechanics, force fields, types of force fields

Unit II Molecular Dynamics
Introduction to Molecular Dynamics, Density Functional Theory, Linear Scaling Techniques, Ab initio Methods and Hartree-Fock Approximations.

Unit III Drug Design
Introduction to drug designing, drug design to discovery and development, drug metabolism, toxicity and pharmacokinetics, toxicology considerations, problems and drawbacks on drug discovery and development. Drug Target classification, identification and validation strategies, Design and development of combinatorial libraries for new lead generation Structure-based design – 'de novo' design methodologies 3D-database searching techniques, docking QSAR: Statistical techniques behind QSAR, classical QSAR, molecular descriptors 3D QSAR and COMFA.

Unit IV Molecular Docking
Introduction to molecular docking, Rigid docking, Flexible docking, manual docking, Advantage and disadvantage of Flex-X, Flex-S, AUTODOCK and other docking software, Scoring Functions, Simple Interaction Energies, GB/SA scoring (implicit solvation), CScore (consensus scoring algorithms).

Unit V Pharmacophore Models
Historical Perspective and Viewpoint of Pharmacophore, Functional Groups Considered as Pharmacophores, Ehrlich's "Magic Bullet", Fischer's "Lock and Key", Two-dimensional Pharmacophores, Three-dimensional Approach of Pharmacophores, Criteria for Pharmacophore Model, Pharmacophore Model Generation Software Tools, Molecular Alignments, Handling Flexibility, Alignment Techniques, Scoring and Optimization, Pharmacophores, Validation and Usage, Automated Pharmacophore Generation Methods, GRID-based Pharmacophore Models, Pharmacophores for Hit Identification, Pharmacophores for Human ADME/Tox-related Proteins.

Unit VI Library and Database
Molecular and Structural Database, Protein Data Bank, Bioactivity Databases, Gene and Protein Sequence Databases, Cambridge Crystallographic Database, Compound Storage and Management.

Textbooks & References:

1. Andrew Leach. Molecular modeling: principles and applications. 2nd ed. Pearson Education. 2001.
2. Atkins and Friedman. Molecular quantum mechanics. Oxford University Press. 4th ed. 2005.
3. David C. Young. Computational Drug Design. A guide for Computational and Medicinal Chemists. Wiley. 2009.

BI 530: Evolutionary Genomics **L-3 T-0 P-0 CH 3 Cr 3**

Unit I: Evolutionary genomics:
Definition, scope and applications, Theories of evolution, selection vs. neutral theory, genome composition and complexity

Unit II: Base Substitution in evolution
Base substitutions in DNA, parity rules, mutation bias between the strands, AT and GC skews in DNA strands, transition and transversion bias, Gene distribution asymmetry, transcription induced mutation bias, Mutation is AT biased

Unit III: Genetic code and Evolution
Codon degeneracy, codon usage bias, measures of codon usage bias, selection on codon usage bias, ribosome profiling, tRNA modification role

Unit IV: Macromolecular evolution:
Protein evolution, role of protein folding, intrinsically disordered proteins

Unit V: Genetic drift and Evolution
Mutation within and across genomes, genome wide association studies (GWAS), selection-mutation and drift theory, population genetics, disease causing mutations, selection, drift, cancer and evolution of tumor, artificial selection of recessive traits

Texts books

1. Bergstrom C. T., Dugatkin L. A., (2012) Evolution, I S Edition, W. W. Norton & Company.
2. Griffiths A.J., Griffiths A.J.F., Miller J.H., Suzuki D.T. and Lewontin R.C. (2008) An Introduction to Genetic Analysis, W.H. Freeman.
3. Hartl (2011) Genetics: Analysis of Gene and Genomes, Jones & Bartlett Publisher.