COURSES OF STUDY
M.Sc Bioinformatics (Self Financing)
(2018-2020)

DEPARTMENT OF BIOTECHNOLOGY & BIOINFORMATICS
SAMBALPUR UNIVERSITY, JYOTI VIHAR
BURLA- 768019, ODISHA

OUTLINE OF COURSE STRUCTURE
M.Sc. BIOINFORMATICS (Session: 2018-20)

SEMESTER-I

Course Code	Course Name	Credits hours	Marks
BI-411	(A) Physical Sciences (B) Foundation Biology	3	50
BI-412	Chemistry of Biomolecules	3	50
BI-413	Genetics	3	50
BI-414	Microbiology	3	50
BI-415	Molecular Biology- I	3	50
BI-416	Concepts in Computing	3	50
BI-417	Practical (Genetics and Microbiology)	2	50
BI-418	Practical (Biochemistry)	2	50
Optional (Any One)	Add on non credit course: A. Communication Skill B. Leadership & Personality Development		

SEMESTER-II

Course Code	Course Name	Credit hours	Marks
BI-421	Probability and Biostatistics	3	50
BI-422	Bioenergetics and Metabolism	3	50
BI-423	Immunology	3	50
BI-424	Molecular Biology- II	3	50
BI-425	Bioinformatics Resources	3	50
BI-426	Python and R Programming	3	50
BI-427	Practical (Immunology and Molecular Biology)	2	50
BI-428	Practical (Bioinformatics Resources & Programming)	2	50

SEMESTER-III

Course Code	Course Name	Credit hours	Marks
BI-531	Recombinant DNA Technology	3	50
BI-532	Computational Biology	3	50
BI-533	Molecular Modeling and Simulation	3	50
BI-534	Database Management System	3	50
BI-535	Data Warehouse and Data Mining	3	50
BI-536	Computer Aided Drug Design	3	50
BI-537	Practical (DBMS, Data Warehouse and Data Mining)	2	50
BI-538	Practical (Molecular Modeling and Computer Aided Drug Design)	2	50
Optional (Any One)	Add on non credit course: A. Entrepreneurship Development B. Soft Skill & IT Skill		

SEMESTER-IV

Course Code	And Course Name	Credit hours	Marks
BI-541	Genomics, Proteomics and Metabolomics	3	50
BI-542	Computational Genomics and Proteomics	3	50
BI-543 (Elective Paper (Any One)	(A) System Biology	3	50
	(B) Clinical Data Warehouse and Data Mining		
	(C) NGS and Microarray Data Analysis		
BI-544	Seminar	3	50
BI-545	Project work and Viva voce	(9+3)	200
Total Course Credit		**90 CH**	**1600**

Programme Outcome

PO-1	**Critical Thinking:** Take informed actions after identifying the assumptions that frame our thinking and actions
PO-2	**Effective Communication:** Will be able to speak, read, write and listen clearly in person and through electronic media in English and in one Indian Language
PO-3	**Social Interaction (Interpersonal Relation):** Elicit views of others, mediate disagreements and prepared to work in team
PO-4	Entrepreneurship Capability: Demonstrate qualities to be prepared to become an entrepreneurship
PO-5	Ethics: Recognize different value systems including your own, understand the moral dimensions and accept responsibility for them
PO-6	Environment and Sustainability: Understand the issues of environmental contexts and sustainable development
PO-7	Life-Long Learning: Acquire the ability to engage in independent and life-long learning in the context of socio-technological changes

FIRST SEMESTER

BI-411 (A) PHYSICAL SCIENCES 3 CH 50 MARKS

Objective: To bridge the gap between biology and physical sciences needed for the understanding and designing of biological problems for the students of biology background.

CO-1	Remember and understand the basic concepts/Principles of Physical Sciences
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit-I

Basic Mathematics: Logarithms, exponential series, factorials, graphs, coordinate geometry – straight line and non-linear relationships. Differentiation– Rates and limits, Differential coefficients, differentiation of a function, integration – basic concepts of integration, integration by substitution, integration by parts. Matrix algebra – linear transformation between vector spaces, representation of linear transformation by matrices, algebra of matrices, Eigen values and Eigen vectors of linear transformation.

Unit-II

Basic Physics and Computer Fundamentals: Surface tension, viscosity, photoelectric effect, basic characteristics of electricity and magnetism, charge, current, voltage, resistance, capacitor, electric field and impedence diodes, photoresistors, Semiconductors, transistors, integrated circuits and chips.

Computers: types, basic organization of computers, computer languages, software and hardware, operating systems, bit, byte, word, computer memory – types, data processing and storage.

Unit-III

Basic chemistry:atomic structure – waves and wave functions, quantum numbers, atomic orbitals, electronic configuration of atoms and periodic properties of elements, ionic radii's, ionization potential, electronic configuration of molecules. Bond lengths, bond angles, bond order and bond energies, types of chemical bond (weak and strong), intermolecular forces, structure of simple ionic and covalent bonds, carboxylic acids, aldehydes and ketones, amines (overview).

Suggested readings:

1. Basic Mathematics, Serge A. Lang, Springer publisher (1988).ISBN-13: 978-0387967875.
2. Higher Engineering Mathematics, B.S. Grewal and J.S.Grewal, Khanna Publishers, New Delhi (2007).ISBN-13: 978-8900120905.
3. Calculus and analytical geometry, G. B Thomas, R. L. Finney, 9th Ed., Pearson Education Asia (Adisson Wesley), New Delhi (2000). ISBN-13: 978-0201531749.
4. Trigonometry, Algebra and Calculus, T.Veerarajan, Tata McGraw Hill Publishing Co. Ltd, New Delhi (2003). ISBN: 978-0070535077.
5. Fundamentals of Physics, D. Halliday, R. Resnick, J. Walker. John Wiley and Sons (2010).ISBN-13: 978-9971513306.
6. Chemistry: An Introduction to General, Organic, and Biological Chemistry,Karen C. Timberlake. Pearson(2015). ISBN-13: 978-1292061320.
7. Fundamental Principles of Inorganic Chemistry,D Banerjea. Sultan Chand and Sons(2001). ISBN-13: 978-8170148159
8. Fundamentals of Computers,ReemaThareja. Oxford University Press (2015). ISBN-13: 978-0199452729.

BI-411 (B) FOUNDATION BIOLOGY 3 CH 50 MARKS

Objective: To provide basic knowledge of biology for the understanding of the advance courses of Bioinformatics & Biotechnology for the students from non-biology background.

CO-1	Remember and understand the basic concepts/Principles of Foundation Biology
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit I

Chemistry of living organisms: biomolecules, origin of life, cell- unit of living organisms and multicellular organisms, structure of animal, plant and bacterial cell, sub-cellular organelles (cytoskeleton, mitochondria, golgi complex, endoplasmic reticulum, chloroplast, ribosome, lysosome, nucleus).

Unit II

Classification and nomenclature of living organisms (plant and animal): survey of microbial world, diversity in animal and plant kingdom, phylogeny, organic evolution, evidences in support of evolution (morphological, embryological, taxonomy, genetic, biochemical and molecular), origin of species and speciation; environmental and anthropogenic impact on living organisms.

Unit III

Genetics- science of heredity:chromosome number and structure, cell division- meiosis and mitosis, mendelian principle of heredity; monohybrid and dihybrid cross (examples); physiological basis of life (locomotion, respiration, digestion, circulation, excretion); reproduction in plants and animals; hormonal integration of physiological processes.

Suggested readings:

1. Life: The Science of Biology: Volume III: Plants and Animals. David Sadava, David M. Hillis, H. Craig Heller, May Berenbaum. 10th Ed., W. H. Freeman(2003).ISBN-13: 978-1464141249.
2. Biology, Peter H. Raven, George B Johnson, Kenneth A. Mason, 10thEd., Tata McGraw Hill (2013). ISBN-13: 978-9351341802.
3. Life Sciences Fundamentals and Practice (Part I&II), Pranav Kumar, Usha Mina. Pathfinder Academy Pvt. Ltd (2017). ISBN-13: 978-8190642705.
4. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology, P.S. Verma,V.K. Agarwal V.K, S. Chand and Company Limited (2016). ISBN-13: 978-8121924429.
5. Cell Biology for Biotechnologists, Shaleesha A Stanley. Narosa Publishing House (2008). ISBN-13: 978-8173198083.
6. Concepts of Genetics, William S Klug, Michael R Cummings, Charlotte A Spencer,10thEd., Pearson Education Limited (2016). ISBN-13: 978-9332577466.
7. Principles of genetics, Eldon John Gardner, Michael J Simmons, D Peter Snustad, 8th Ed., Wiley India Pvt.Ltd (2014). ISBN-13: 978-8126510436.

BI-412 CHEMISTRY OF BIOMOLECULES 3 CH 50 MARKS

Objective: To offer extensive coverage of important biomolecules (carbohydrates, lipids, nucleic acids, proteins) that are involved in the maintenance and metabolic processes of all living organisms.

CO-1	Remember and understand the basic concepts/Principles of Chemistry of Biomolecules
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit I

Biomolecules: carbohydrates (monosaccharides, disaccharides, formations of polysaccharides and structural diversity), lipids (types of fatty acids and lipids), sphingolipids, conjugated and complex lipids; DNA structures: Nucleotides and nucleosides, DNA double helix, DNA structure (Z-DNA, B-DNA, A-DNA), triple helix DNA, tetraplex DNA, DNA binding proteins, Sequence specific Protein – DNA interactions, RNA secondary and tertiary structures.

Unit II

Protein structure: chemical building blocks, Peptide bond, torsion angles and rotatable bonds, Ramachandran map, protein structures (primary, secondary, super-secondary, tertiary, different classes and sub-classes of protein structures, quaternary), protein folding, protein motifs, and domains; protein structure determination; purification of proteins, crystallization of proteins, X-ray crystallography, NMR and its limitations.

Unit III

Engineering & design of protein structure, Homologous protein, Protein sequencing, Site-directed mutagenesis, Protein flexibility and stability, Engineering of protein structure and applications (case studies). Membrane proteins and its function, Metalloproteins, Carbohydrate binding proteins, Metalloenzymes: Structure and Function.

Suggested reading:

1. DNA Structure and Function,Richard R Sinden. Academic Press(2012). ISBN-13: 978-0126457506.
2. Lehninger Principles of Biochemistry,David L. Nelson, Michael M. Cox, Freeman, W. H. & Company (2008). ISBN-13: 978-0716743392.
3. Fundamentals of Biochemistry: life at the molecular level,Donald Voet, Judith G. Voet, Charlotte W. Pratt, New York: Wiley (2016). ISBN-13: 978-1118129180.
4. Outlines of Biochemistry,Eric E Conn, Paul K Stumpf, George Bruening,Wiley India Pvt.Ltd (2011). ISBN-13: 978-8126509300.
5. Biochemistry, Jeremy M. Berg, John L. Tymoczko, Gregory J. Gatto, LubertStryer,8th Ed., Freeman and company (2015). ISBN-13: 978-1464126109.
6. Harper's Illustrated Biochemistry,Victor W Rodwell, David A Bender, Kathleen M Botham, Victor W Rodwell, David A Bender, Kathleen M Botham, 29th Ed., Mcgraw-Hill Book Company (2015). ISBN-13: 9781259252860.

BI-413 GENETICS 3 CH 50 MARKS

Objectives: To understand human, animal and plant genome, human genetic disorders and molecular genetics based therapies.

CO-1	Remember and understand the basic concepts/Principles of Genetics
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit-I

Mendelian principle: dominance, segregation and independent assortment; extensions of Mendelian principle: co-dominance, Incomplete dominance, gene interactions, supplementary genes, complementary genes, duplicate genes, epistasis, inborn error of metabolism, plieotropy, genomic imprinting; sex determination: sex chromosome, sex determination in plants and animals, dosage compensation, sex linkage, sex limited and sex influenced characters; extra chromosomal inheritance; maternal inheritance, polygenic inheritance in human beings.

Unit-II

Concept of gene: allele, multiple alleles, pseudoallele, complementation tests; linkage and crossing over; linkage and mapping in eukaryotes: two-point cross, three-point cross, haploid mapping (tetrad analysis), human chromosomal maps: X linkage, autosomal linkage, Lod score for linkage testing, Pedigree analysis, penetrance and expressivity, family tree, dominance inheritance, recessive inheritance, sex-linked inheritance; Eukaryotic chromosome: types of chromosomes, DNA arrangement, nucleoprotein composition, chromosomal banding, centromeres and telomeres, C-value paradox.

Unit-III

Mutation: types, causes and detection; Mutant types – lethal, conditional, biochemical, loss of function, gain of function; germinal verses somatic mutants, insertional mutagenesis; structural and numerical alterations in chromosomes (deletion, duplication, inversion, translocation, ploidy and their genetic implications); population genetics: gene pool, gene frequency, Hardy Weinberg genetic equilibrium; gene flow and genetic drift.

Suggested reading:

1. Principles of genetics, Eldon John Gardner, Michael J Simmons, D Peter Snustad, 8th Ed., Wiley India Pvt. Ltd (2014). ISBN-13: 978-8126510436.
2. Genetics, Monroe W Strickberger. 3rdEdition. Prentice Hall India Learning Private Limited (2015). ISBN-13: 978-9332555105.
3. Genetics, B.D. Singh, Kalyani Publishers / LyallBk Depot (2016). ISBN-13: 978-8127248673.
4. Genetics: From Genes to Genomes, Leland H Hartwell, Leroy Hood, Michael L Goldberg,Tata Mcgraw Hill Publishing Co Ltd (2015). ISBN-13: 978-9339219888.
5. Principles of Population Genetics, Andrew G. Clark, Daniel L. Hartl, 4th Ed., Sunderland: Sinauer Associates (2007). ISBN-13: 978-0878933082.
6. Principles of Genetics, Robert H. Tamarin, 7th Edition, Tata McGraw-Hill Edition. ISBN-0-07-048667-0.

BI-414 MICROBIOLOGY 3 CH 50 MARKS

Objective: To familiarize the students with basic concepts of microbiology including classification, identification, culture techniques, growth kinetics, physiology and preservation methods for microorganisms.

CO-1	Remember and understand the basic concepts/Principles of Microbiology
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit-I

An overview of the microbial world (bacteria, archea, eukaryote). Classification of archea and eubacteria as per Bergey's manual; microbial phylogeny. Structural organization of prokaryotic cell (bacterial wall, capsule, flagella, pilli, pronucleus, ribosomes, plasmid).

Unit-II

Bacterial nutrition and nutritional category, bacterial culture: synchronomous and asynchronous culture, continuous culture and chemostat. Bacterial growth, mathematical expression of growth, generation time, specific growth rate.

Bacterial metabolism: glucose dissimilation pathways, bacterial respiration with organic and inorganic reluctant, chemolithotrophy. General principle of bacterial conjugation, transduction and transformation. Bacterial pathogenecity and anti-microbial compounds.

Unit-III

Virus**:** generalproperties, structure, purification, cultivation;principle of viral taxonomy. Bacteriophage: structure, classification, one-step growth experiment. Production of DNA phage, RNA phage, lytic cycle, temperate phage and lysogeny. Animal virus and its reproduction, viral infection (presistent, latent and slow virus infection). Plant virus and their transmission. Anti-viral agents; M-13, Lambda, HIV, Influenza virus, Viriods and Prions.

Suggested reading:

1. Microbiology,Jr Michael J Pelczar, Ecs Chan, Noel R Krieg,Tata Mcgraw Hill Publishing Co Ltd (2016). ISBN-13: 978-0074623206.
2. Brock Biology of Microorganisms, Michael T Madigan, John M Martinko, Kelly S Bender, Pearson Education Limited (2014). ISBN-13: 978-9332586864.
3. Microbiology: An Introduction,Gerard J Tortora, Berdell R Funke, Christine L Case,8thEdition, Pearson/Benjamin Cummings(2015). ISBN-13: 978-9332575417.
4. Microbiology: Principles and Applications,J. Black, Prentice Hall(2004). ISBN-13: 978-0131907454.
5. Microbiology,Donald A. Klein, John P. Harley, Lansing M. Prescott, 6th Ed., McGraw Hill(2005).ISBN-13: 978-0072951752.
6. Microbiology: A Human Perspective, Eugene Nester, Denise Anderson, Jr., C. Evans Roberts, Martha Nester, 6th Ed., McGraw-Hill Science/Engineering/Math (2008). ISBN-13: 978-0077250416.

BI-415 MOLECULAR BIOLOGY- I 3 CH 50 MARKS

Objective: To educate the students on basic components and complex architecture of genetic material in different organisms and to introduce mechanism and regulation of replication of genetic material in different organisms.

CO-1	Remember and understand the basic concepts/Principles of Molecular Biology-1
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit-I

Genetic organization of prokaryotes and eukaryotes including nuclear genome and organelle genome; DNA as the genetic material (experimental evidences); central dogma; genome complexity; C-value paradox, Cot value, repetitive DNA, satellite DNA; gene structure in prokaryotes and eukaryotes; split genes, overlapping genes, pseudogenes, clusters and repeats.

Unit-II

Condensation of chromosome, Lampbrush chromosome, Polytene chromosome, Supercoiling of DNA, nucleosomes, DNA methylation, genetic imprinting, epigenetic inheritance, Transposable elements, types of transposable elements, mechanism of transposition, retroposons and its types, mechanism of retrotransposition, rearrangement of DNA.

Unit-III

DNA replication: models of DNA replication, enzymes of DNA replication, pprocess of DNA replication (initiation, elongation, termination), DNA replication at the telomere; organization and replication of extranuclear genome (Mitochondrial and Chloroplast) genome, DNA recombination (site specific and homologous); DNA repair (base-excision, mis-match, SOS, recombination); Phage strategies (lysogenic cycle and lytic cycle).

Suggested reading:

1. Molecular Biology of the Cell, Bruce Alberts, Alexander Johnson, Julian Lewis, 6th Ed., Taylor & Francis Group / Spon Press (2015). ISBN-13: 9780815344643.
2. Genes IX, Benjamin Lewin, Jones and Bartlett Publishers (2010). ISBN-13: 978-9380108537.
3. Molecular cell biology, Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, HiddePloegh, Angelika Amon, Kelsey Martin, 8th Ed., WH Freeman(2016). ISBN-13: 978-1464183393.
4. Molecular Biology of the Gene, James D Watson, Tania A Baker, Stephen P Bell,Pearson Education Limited (2017). ISBN-13: 978-9332585478.
5. Cell and Molecular Biology, Gerald Karp, 5th Edition, John Wiley (2013). ISBN-13: 978-1118301791.
6. Cell Biology, Thomas D. Pollard, William C. Earnshaw, Jennifer Lippincott-Schwartz, 3rd Ed., Elsevier - Health Sciences Division (2017). ISBN-13: 978-0323417402.

BI-416 CONCEPTS IN COMPUTING 3 CH 50 MARKS

Objectives: To provide basic knowledge of computer organization, operating systems, and application programs.

CO-1	Remember and understand the basic concepts/Principles of Concepts in Computing
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit -I

Introduction to computers – data and information, Basic structure of computer: CPU, I/O devices, memory, secondary storage devices; data representation: overview of binary, octal and hexadecimal number system; concept of low-level and high-level language, compiler, interpreter; application programs: basic concept of word processing, spreadsheet, presentation and other application software.

Unit-II

Classification of computers (mainframes, mini computers, microcomputers, special purpose computers); types of modern computing: workstations, servers, grid computing, cloud computing; an overview of computer viruses; internet and its resources, world wide web (www): associated tools, services, resources and various terminologies; computer networking; computer security.

Unit-III

Operating system concepts, salient features of Windows, UNIX and GNU/Linux; Unix file system, file and directory commands, file permissions. Basic commands, I/O redirection and piping, simple and advanced filters, *sed* command, *vi* as text editor, archives and file compressions. Processes: background processes and scheduled processes. Alias and environmental variables.

Suggested reading:

1. Fundamentals of Computers, ReemaThareja. Oxford University Press (2015). ISBN-13: 978-0199452729.
2. Computer fundamentals, P.K Sinha, P Sinha. BPB publications (2010). ISBN-13: 9788176563604.
3. Computer Fundamentals, Anita Goel, Pearson Education Limited (2016). ISBN-13: 978-8131733097.
4. Introduction To Unix & Shell Programming, Mg Venkateshmurthy, Pearson Education Limited (2016). ISBN-13: 978-8177587456.
5. Introduction to Unix, David I Schwartz, Pearson Education Limited (2016). ISBN-13: 978-8131722343.

BI-417	**Practical (Genetics and Microbiology)**	**2 CH**	**50 marks**
BI-418	**Practical (Biochemistry & Linux)**	**2 CH**	**50 marks**

SECOND SEMESTER

BI-421 PROBABILITY AND BIOSTATISTICS 3 CH 50 marks

Objective: To make the students acquainted with the various statistical techniques for the collection, organization, analysis and interpretation of the experimental data.

CO-1	Remember and understand the basic concepts/Principles of Probability and Biostatistics
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit I

Concepts from probability: elementary sets as events and their complements, independent and disjoint events, probability rules, permutations and combinations, probability distributions, binomial distribution, poisson distribution, random variables and their properties, continuous random variables, conditional probability and Bayes theorem.

Unit II

Systematic organization and display of data**:** populations, samples, types of data, frequency tables and histograms; graphical methods (histograms, box and whisker plots), measure of central tendency (arithmetic mean, median, mode, geometrical mean), measure of dispersion (range, mean deviation, variance, standard deviation, coefficient of variation), normal distribution: importance and properties; areas under standard normal curve; central limit theorem, skewness and kurtosis.

Unit III

Tests of hypothesis**:** student's t-test, paired t-test, hypothesis testing; categorical data and chi-square tests: 2 x 2 contingency table, correlation and linear regression: scatter diagram, pearson's correlation coefficient, regression analysis, multiple regression; analysis of variance: one-way analysis of variance, two way analysis of variance, non-parametric methods and its advantages and disadvantages, Wilcoxon rank-sum test, Wilcoxon signed-rank test. Principal component analysis.

Suggested readings:

1. Introductory Biostatistics for the Health Sciences, Michael R. Chernick, Robert H. Friis, Wiley-Interscience Publications (2003). ISBN-13: 9780471411376.
2. Statistics: Concepts and Applications, Nabendu Pal, Sahadeb Sarkar, Prentice-Hall Of India Pvt Ltd (2009). ISBN-13: 9788120334458.
3. Handbook of Computational Statistics Concepts and Methods. J. E. Gentle, Wolfgang Hardle, Yuichi Mori, Springer (2004). ISBN-13: 9783540404644.
4. Schaum's Outline of Statistics, Murray R. Spiegel, Larry J. Stephens, 3rd Ed., McGraw-Hill New Delhi (2000). ISBN-13: 9780070151536.
5. Probability and statistics for engineers and scientists, Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying E. Ye, 9th Ed., Pearson (2011). ISBN-13: 9781292161365.
6. Probability, statistics and random Processes, Veerarajan T, 3rd Ed., Tata McGraw-Hill (2015). ISBN-13: 9780070669253.

7. Data mining: Introductory and advanced topics, Margaret H Dunham, Pearson Education Limited (2013). ISBN-13: 9788177587852.

BI-422 BIOENERGETICS AND METABOLISM 3 CH 50 marks

Objective: To provide an insight into complete set of chemical reactions of metabolism as well as the regulatory interactions that guide these reactions.

CO-1	Remember and understand the basic concepts/Principles of Bioenergetics and Metabolism
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit I

Enzymes: basic concepts and kinetics, classification of enzymes, coenzymes and cofactors, effect of temperature and ph on enzyme activity, Michaelis-Menten kinetics, inhibitors and activators, enzyme inhibition (competititive, non-competitive, uncompetitive), allosteric enzymes and regulation, concepts of bioenergetics, multi-enzyme complexes, regulatory enzymes, feedback and feed forward systems, bisubstrate reaction kinetics, enzyme substituted model (ping pong model).

Unit II

Metabolism and regulation of carbohydrate (glycolysis, gluconeogenesis, pentose phosphate phathway and its physiological significance); carbohydrate biosynthesis in plants, co-ordinated regulation of glycogen synthesis and breakdown; citric acid cycle, regulation of citric acid cycle, glyoxylate cycle, electron transport in mitochondria and chloroplast; principle of oxidative and photophosphorylation.

Unit III

Amino acid oxidation and production of urea (metabolic fates of amino groups, fatty acid catabolism (digestion, metabolism and transport of fats), oxidation of fatty acids, ketone bodies, lipid biosynthesis, urea cycle, pathway of amino acid degradation), biosynthesis of amino acids, biosynthesis of nucleotides (purines and pyrimidines), metabolic disorders, inborn error due to metabolism, hormonal regulation of metabolism.

Suggested readings:

1. Lehninger Principles of Biochemistry, David L. Nelson, Michael M. Cox, Freeman, W. H. & Company (2008). ISBN-13: 978-0716743392.
2. Biochemistry, Jeremy M. Berg, John L. Tymoczko, Gregory J. Gatto, Lubert Stryer, 8th Ed., Freeman and company (2015). ISBN-13: 978-1464126109.
3. Fundamentals of Biochemistry: life at the molecular level, Donald Voet, Judith G. Voet, Charlotte W. Pratt, New York: Wiley (2016). ISBN-13: 978-1118129180.
4. Basic Concepts In Biochemistry: A Student's Survival Guide, Hiram F. Gilbert, 2nd Ed., McGraw-Hill Publisher (1999). ISBN-13: 9780071356572.
5. Harper's Illustrated Biochemistry, Victor W Rodwell, David A Bender, Kathleen M Botham, Victor W Rodwell, David A Bender, Kathleen M Botham, 29th Ed., Mcgraw-Hill Book Company (2015). ISBN-13: 9781259252860.

BI-423 IMMUNOLOGY 3 CH 50 marks

Objective: To educate the students on cells, organs and their mechanism of action in protecting our body from any pathogenic organism or substances. In addition, the subject educates student regarding the use of immune molecules (like antibodies and cytokines) for therapeutic and diagnostic purposes.

CO-1	Remember and understand the basic concepts/Principles of Immunology
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit-I

Basics of immunity, cell and organs of immune system in human and evolution of immune system, immunogen, antigen and haptens, factors affecting immunogenicity, immunoglobulins – classification, structure and properties, primary and secondary immune response, genetic basis of generation of antibody diversity, other B cell receptors.

Unit-II

T-cell receptors, major histocompatibility complex proteins, antigen processing and presentation, complement activation. Interleukins. Brief idea regarding immunology of allergy, AIDS, organ transplantation; autoimmune diseases; cancer types, causes and mechanisms.

Unit-III

Immunotechnology – antigen-antibody interaction, affinity and avidity, agglutination, precipitin formation, immunodiffusion (SRID and DRID). Immunoelectrophoresis – types and uses, radio immuno assay, ELISA, western blotting, ELISPOT assay, immunofluorescence, immunoelectron microscopy; surface plasmon resonance, biosensor assays for assessing ligand-receptor interaction, CMI techniques- lymphoproliferation assay, mixed lymphocyte reaction.

Suggested readings:

1. Immunology, Janis Kuby, 3rd Edition, WH Freeman (2007). ISBN-13: 9789812435163.
2. Janeway's Immunobiology, Kenneth Murphy, 8th Edition, Garland Science 2016. ISBN-13: 9780815345305
3. Cellular and Molecular Immunology, Abul K. Abbas, Andrew H. H. Lichtman, Shiv Pillai, 7th Ed., Elsevier (2001). ISBN-13: 9788131248928.
4. Kuby Immunology. Judith A Owen, Jenni Punt, Sharon A Stranford, 7th Ed., W.H. Freeman and Co., New York (2013). ISBN-13: 9781429219198
5. Essential Immunology, Ivan M Roitt, Peter J Delves, 12th Ed., Blackwell Scientific Publications (2011). ISBN-13: 9781405196833.
6. Principle of gene manipulation and Genomics, S.B Primrose, R.M Twyman, 6th Ed., Blackwell Science Ltd (2014). ISBN-13: 9788126548392

BI-424 MOLECULAR BIOLOGY- II 3 CH 50 marks

Objective: To enables the student to answer the complex mechanism of action and regulation of various timely response of cell according to the surrounding.

CO-1	Remember and understand the basic concepts/Principles of Molecular Biology-II
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit-I

Transcription: components of transcription machinery in prokaryotes and eukaryotes, trancriptional factors, transcription process (initiation, elongation and termination); post-transcriptional processing, regulation of transcription (protein-DNA interaction: zinc finger motif, homeodomain, helix-loop-helix, leucine zipper), m-RNA stability, m-RNA editing; nuclear splicing, catalytic RNA, mechanism of gene silencing.

Unit-II

Translation:genetic code- principle of translation, translation machinery in prokaryotes and eukaryotes (t-RNA, aminoacyl synthetase, ribosome), translation process (initiation, elongation and termination). Regulation of gene expression: constitutive and induced gene expression; regulation of gene expression in prokaryotes and eukaryotes; operon concept (lac, ara, trp and his).

Unit-III

Protein trafficking (glycosylation, coated vesicles, budding and fusion reactions, protein localization, receptor recycle), Signal transduction (carriers and channels, G protein mediated, Ras/MAPK pathway, cAMP mediated, JAK-STAT pathway), cell cycle and its regulation, genetics of cancer (proto-oncogenes, tumor suppressor genes), signaling pathways.

Suggested readings:

1. Molecular Biology of the Cell, Bruce Alberts, Alexander Johnson, Julian Lewis, 6th Ed., Taylor & Francis Group / Spon Press (2015). ISBN-13: 9780815344643.
2. Genes IX, Benjamin Lewin, Jones and Bartlett Publishers (2010). ISBN-13: 978-9380108537.
3. Molecular cell biology, Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Angelika Amon, Kelsey Martin, 8th Ed., WH Freeman (2016). ISBN-13: 978-1464183393.
4. Cell and Molecular Biology, Gerald Karp, 5th Edition, John Wiley (2013). ISBN-13: 978-1118301791.
5. Cell Biology, Thomas D. Pollard, William C. Earnshaw, Jennifer Lippincott-Schwartz, 3rd Ed., Elsevier - Health Sciences Division (2017). ISBN-13: 978-0323417402.
6. Molecular Biology of the Gene, James D Watson, Tania A Baker, Stephen P Bell,Pearson Education Limited (2017). ISBN-13: 978-9332585478.
7. Genetics, Monroe W Strickberger. 3rd Edition. Prentice Hall India Learning Private Limited (2015). ISBN-13: 978-9332555105.

BI-425 BIOINFORMATICS RESOURCES 3 CH 50 MARKS

Objective: To develop the ability to use the various resources of bioinformatics to retrieve, analyze and predict the sequence, structure and function of genes and proteins.

CO-1	Remember and understand the basic concepts/Principles of Bioinformatics Resources
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit I

Bioinformatics: origin and applications; biological databases and bioinformatics tools, organization of databases: data contents and formats, purpose and utility in life sciences. Major Bioinformatics resources: NCBI, EBI, ExPASy, RCSB; open access bibliographic resources and literature databases: PubMed, BioMed central, public library of sciences (PloS), CiteXplore.

Unit II

Sequence databases: formats, querying and retrieval; nucleic acid sequence databases: GenBank, EMBL, DDBJ; protein sequence databases: Uniprot-KB: SWISS-PROT, TrEMBL, UniParc; repositories for high throughput genomic sequences: EST, STS GSS; Genome databases at NCBI, EBI, TIGR, SANGER; viral genomes, archea and bacterial genomes; eukaryotic genomes (yeast, drosophila, *C. elegans*, rat, mouse, human, plants such as *Arabidopsis thaliana*, rice).

Unit III

Structure databases: PDB, NDB, PubChem, ChemBank. Derived Databases: basic concept, collection of primary data and basic principles for deriving secondary data, organization of data, contents and formats of database entries, identification and interpretation of patterns in sequences; sequence patterns: InterPro, Prosite, Pfam, ProDom; structure patterns: FSSP, DSSP. Extraction of knowledge resources onimmunology, plant, animal and infectious diseases: databases and servers published in NAR Database and web server issues; bioinformatics journals viz. BMC bioinformatics.

Suggested readings:

1. Bioinformatics (Databases, Tools and Algorithms), OrpitaBosu, Simminder Kaur Thukral, Oxford Univerrsity Press (2007). ISBN-13: 9780195676839.
2. Introduction to Bioinformatics, Arthur M. Leask, Oxford University Press (2014). ISBN-13: 9780198724674
3. Bioinformatics: Sequence and Genome Analysis, David Mount, CBS Publishers & Distributors. ISBN-13: 9788123912417.
4. Fundamental Concepts of Bioinformatics, Dan E Krane, Michael L Raymer, Pearson EducationIndia (2003). ISBN-13: 9788177587579.
5. Bioinformatics: Concepts, Skills and Application, S. C. Rastogi, NamitaMendiratta and ParagRastogi, CBS Publishers & Distributors, 2003. ISBN-13: 9788123914824.
6. Bioinformatics: Principles and Application,Zhumur Ghosh and BibekanandMallick, Oxford Publication (2015). ISBN-13: 9780195692303.

BI-426 PYTHON & R LANGUAGE PROGRAMMING 3 CH 50 MARKS

Objective: To acquire programming techniques essential for analysis and processing of biological data from the best compatible programming languages (Python and R).

CO-1	Remember and understand the basic concepts/Principles of Python and R Language Programming
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit I

Introduction to python programming: basics, interpreter and compiler, variables, expressions, operators, statements; conditional execution: conditional and logical operators; functions: in-built functions, user defined functions; iteration: iterative operators; strings: string structure and functions; files: creation, writing and updating files; lists: elements, methods, functions; dictionaries: structure and methods, text parsing; tuples: methods and uses; regular expressions: matching and extraction.

Unit II

Applications of Python; networked programs: Retrieval and parsing HTML; using web services: XML, JSON, APIs; Object-Oriented programming using Python: creating objects, encapsulation, inheritance; using databases and SQL: database concepts using SQLite, creation of tables, SQL querying, JOIN operator; BioPython and applications: various classes in Python, applications to sequence and structure files.

Unit III:

R Programming: Introduction, Installing R; R basics, graphics; simple plotting, advanced plotting, using color in plots, using subscripts and superscripts in graph labels, interactive graphics, saving graphical output, loops. Working with data sets: data structures, moving to and from files, statistical distributions.

Suggested readings:

1. Python for everybody: Exploring Data Using Python 3, Charles R. Severance, Shroff Publishers & Distributors (2016). ISBN-13: 9789352136278.
2. R Programming for Bioinformatics, Robert Gentleman, Taylor and Francis (2008). ISBN-13: 9781498797733.
3. R in Action: Data analysis and graphics with R, Rob Kabacoff, 2nd Ed., Manning Publications (2015). ISBN-13: 9789351198079.
4. Bioinformatics with Python Cookbook, Tiago Antao, O Relly Publication. ISBN-13: 9781782175117.
5. Bioinformatics with R Cookbook, Paurush Praveen Sinha, Packt Publishing (2014). ISBN-13: 9781783283132.
6. Beginning Python, James Payne, Wiley Publishing, Inc (2011). ISBN-13: 9788126525638.
7. Programming Python, Mark Lutz, Laura Lewin and Frank Willison, O'Reilly Publication (2015). ISBN-13: 9789350232873.

BI-427	**Practical (Immunology and Molecular Biology)**	**2 CH**	**50 marks**

BI-428	**Practical (Bioinformatics Resources and Programming)**	**2 CH**	**50 marks**

THIRD SEMESTER

BI-531 RECOMBINANT DNA TECHNOLOGY 3 CH 50 marks

Objective: The objective of the course is to familiarize the students with the techniques and applications of recombinant DNA technology from a academic and industrial perspective.

CO-1	Remember and understand the basic concepts/Principles of Recombinant DNA Technology
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit-I

DNA isolation and purification; restriction endonuclease, ligase and other modifying enzymes; DNA & RNA markers, linker, adapter and MCS; gene cloning vectors- plasmid, bacteriophage, cosmid, BAC, YAC; expression vectors: bacteria and yeast based expression vector; gene library- genomic and c-DNA, contig library; PCR, blotting techniques: Southern, Northern, Western, Dot and Slot; Nucleic acid hybridization.

Unit-II

Concept of gene cloning; cloning of interacting gene: two hybrid and three hybrid assay; cloning of differentially expressed gene, gene regulation analysis-DNA transfection, Primer extension, SI mapping, RNase protection assay, reporter assay and phage display; DNA microarrays and chips- principle and process; DNA finger printing and DNA foot printing; DNA sequencing; site directed mutagenesis; expression of heterologous gene; *In vitro* transcription and translation; gene knock out strategies; RNA interference: antisense RNA, siRNA, mi RNA; Ribozyme Technology.

Unit-III

Molecular markers- types (RFLP, RAPD, AFLP, SCAR, SSR, SNP, EST), principle and methodology; application of molecular markers: in diagnostics, gene tagging, gene mapping, physical mapping, map based cloning of gene and cloning of QTLs. Gene therapy and its applications; DNA vaccines and rDNA products; Genetic engineering regulations and safety guidelines.

Suggested readings:

1. Principle of gene manipulation and Genomics, S.B Primrose, R.M Twyman, 6th Ed., Blackwell Science Ltd (2014). ISBN-13: 9788126548392
2. From Genes to Genomes: Concepts and Applications of DNA Technology, Jeremy W. Dale, Malcolm von Schantz, Wiley, John & Sons (2007) ISBN-13: 9780470017340.
3. Biotechnology: Expanding Horizons, BD Singh, Kalyani Publishers / Lyall Bk Depot (2016). ISBN-13: 9789327222982.
4. Elements of Biotechnology, P K Gupta, Rastogi Publication (2015). ISBN-13: 9788171339372.
5. Recombinant DNA: A Short Course, Amy A. Caudy, James D. Watson, Jan A. Witkowski, Richard M. Myers, WH Freeman (2006), ISBN-13: 9780716728665.

BI-532 COMPUTATIONAL BIOLOGY 3 CH 50 MARKS

Objective: To develop the ability to implement various algorithms and use of bioinformatics tools to annotate the sequences of DNA, RNA and proteins.

CO-1	Remember and understand the basic concepts/Principles of Computational Biology
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit I

Introduction of computational biology: sequence similarity, homology, sequence alignment; different scoring models, Substitution matrices (PAM and BLOSUM), pairwise sequence alignment: concept of global and local alignment, dot matrix method, dynamic programming (Needleman-Wunch algorithm, Smith-Waterman algorithm), BLAST and FASTA, FASTA and BLAST algorithms, multiple sequence alignment:(methods, scoring of MSA, profile, BLOCK analysis and pattern searching).

Unit II

Markov chains and HMM: frequent words in DNA, consensus word analysis, transaction and emission matrix, development of training set, CpG island prediction using HMM and its application; artificial neural network and its application; phylogenetic analysis: concepts and terminology, phylogenetic tree prediction algorithms: distance-based methods (UPGMA, NJ), character-based methods (Maximum parsimony, Maximum likelihood), bootstrapping; protein sequence analysis (compute pI/MW, RADAR, hydrophobic cluster analysis, ExPAsy).

Unit III

DNA sequencing & human genome project, dinucleotide abundance, codon biases, GC reach prediction and relationship to gene density, GC and AT skewness and prediction of Ori and Ter site, pattern searches, primer design for PCR, promoter analysis using PSSM, methods for gene finding; RNA structure analysis: RNA secondary structure prediction: Nussinov folding algorithm, energy minimization and Zuker folding algorithm.

Suggested readings:

1. Bioinformatics: Sequence and Genome Analysis, David Mount, CBS Publishers & Distributors. ISBN-13: 9788123912417.
2. Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids, Durbin R., Eddy S., Krogh A. and Mitchison G., Cambridge University Press (2012). ISBN-13: 9780521540797.
3. Bioinformatics and Functional Genomics, Jonathan Pevsner, Wiley-Blackwell (2015) ISBN-13: 9781118581780.
4. Bioinformatics – A practical guide to the Analysis of Genes and Proteins, Andreas D Baxevanis, Bf Francis Ouellette, Wiley India Pvt.Ltd (2014). ISBN-13: 9788126521920.
5. Nucleic Acid and Protein Sequence Analysis: A Practical Approach (The Practical Approach Series), M. J. Bishop, C. J. Rawlings, Oxford University Press. ISBN-13: 9781852210069.

BI-533 MOLECULAR MODELING AND SIMULATION 3 CH 50 MARKS

Objective: To develop the ability to model and analyze computationally the structure and function of target proteins.

CO-1	Remember and understand the basic concepts/Principles of Molecular Modeling and Simulation
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit I

Protein structure prediction: computational methods for protein secondary structure prediction (Chou-Fasmann, GOR and Neural Networks) and reliability (Q3 value and SOV score), tertiary structure prediction methods: homology, fold recognition method, validation of protein structure (Ramachandran plot analysis, ERRAT score, VERIFY3D), analysis of 3D structures: secondary structure assignment, assignment of hydrogen bonds, coulomb hydrogen bond calculation, empirical hydrogen bond calculation, assignment methods of secondary structure (DSSP, STRIDE, DEFINE, P-Curve).

Unit II

Protein structures comparison and alignment: general approach, comparison algorithm and optimization (CE, VAST, DALI), concept of coordinate transformation, RMSD, Z score for structural comparison; identifying structural domains in protein, first and second generation algorithms for domain assignments, domain assignment based on graph theoretical methods, Prediction of binding sites and characterization.

Unit III

Ab initio protein structure prediction: Empirical force field for biomolecular simulations, Potential Energy Function (bond length potential, bond angle potential, torsional potential, van der wals potential and coulomb potential), Classical representations of electrostatics (Poisson-Boltzmann, Generalized Born and Colombic). Energy minimization techniques: Concept of local and global minima, Energy minimization protocol, Energy minimization algorithms (steepest descent, conjugate gradient, Newton Raphson); Molecular Dynamics simulations, Monte Carlo Simulations, Simulated Annealing

Suggested readings:

1. Introduction to Protein Structure, Carl Branden, John Tooze, Garland Publishing (1999), ISBN-13: 9780815323051.
2. Molecular Modelling: Principles and Applications, Andrew R. Leach, Pearson Education Limited (2013), ISBN-13: 9788131728604.
3. Molecular Modeling & Simulations: An Interdisciplinary Guide, Tamar Schlick, Springer Verlag (2010). ISBN-13: 9781441963505.
4. Molecular Modeling: Basic Principle and Application,HdHoltje, Sippl W, Rognan D, 2nd Ed., Wiley Publishers (2003) ISBN-13: 9783527305896.
5. Structural Bioinformatics, Philip E Bourne, HelgeWeissig, Wiley Publishing (2003). ISBN-13: 9780471201991.

BI-534 DATABASE MANAGEMENT SYSTEM 3 CH 50 MARKS

Objective: To develop the ability to rationally design and implement suitable databases for addressing problems relating to storage, retrieval and management of biological data.

CO-1	Remember and understand the basic concepts/Principles of Database Management System
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit I

Database, database concepts, schemas and instances, DBMS architecture and data independence, data models, database languages and interfaces, view of data, database users and administrators, database system structure, database system applications; data models – ER model: keys, constraints, design issues, extended ER features, reductions of ER schema to tables. Relational model: structure, relational algebra, hierarchical model, network model, object oriented model.

Unit II

Structured query language – basic structure, set operations, aggregate functions, null values, nested sub queries, views, integrity: domain constraints, joined relations, data-definition language; relational database and storage-pitfalls in relational design database, functional dependencies, decomposition normal forms – 1NF, 2NF, 3NF and Boyce-Codd NF, data storage- ordered indices, hashing concepts- security and authorization.

Unit III

Concurrency control techniques and information retrieval – transactions: properties of transactions: concurrency problems, serialisability and locking techniques, data items – database system architecture and information retrieval: centralized and client- server architecture.

Suggested readings:

1. Database system Concepts, Abraham Silberschatz, Henry F Korth, Sudarshan S, 4thEd., McGraw Hill Publishers (2016). ISBN-13: 9789332901384.
2. An introduction to Database systems, Cj Date, Kannan A, Swamynathan S, Pearson Education Limited (2013). ISBN-13: 9788177585568.
3. Fundamentals of Database systems, RamezElmasri, Shamkant B Navathe, Pearson Education Limited (2015). ISBN-13: 9788131758984.
4. Principles of Database systems, Jeffrey D Ullman, 2ndEd., Galgotia Publications(2014). ISBN-13: 9788175155459.

BI-535 DATA WAREHOUSE AND DATA MINING 3 CH 50 MARKS

Objective: To develop the data warehouse for the electronic repository of multidimensional clinical data and analysis using data mining techniques.

CO-1	Remember and understand the basic concepts/Principles of Data Warehouse and Data Mining
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit I: DATA WAREHOUSE

Introduction to data warehousing, evolution of decision support systems, Modeling a data warehouse, OLAP vs OLTP, granularity in the data warehouse, Concept hierarchy, Data warehouse life cycle, building a data warehouse, Data Warehousing Components and Architecture, Data warehouse schema, Data Warehouse design: Top down and bottom up, ETL: Design, meta data management, Development and Application, Application in clinical data management.

Unit II: Data mining, Classification

Introduction to Data Mining, Challenges & Issues, Data: Types of data, Data quality, Data preprocessing, Visualization: Introduction, General concepts, Classification: Problem definition, General approach, Decision tree induction, Rule based classifiers, Nearest neighbour classifiers, Bayesian classifiers, Artificial neural networks, Support Vector Machine, Regression, Ensemble methods, Model evaluation.

Unit III: Association Analysis, Cluster analysis and Other Data Mining Techniques

Problem definition, Frequentitemset generation, Rule generation, Interestingness measures. Introduction to cluster analysis, Similarity and distance, Characteristics of clustering algorithms, Center based clustering techniques, Hierarchical clustering, Cluster evaluation. Introduction to Text Mining, Web Mining, Image Mining, and Sequence Mining.

Suggested readings:

1. Data Mining: Concepts and Techniques by Jiawei Han and MichelineKamber, Elsevier publication
2. Introduction to Data Mining by Pang-Ning Tan, Michael Steinbach, and Vipin Kumar
3. Data Warehouse toolkit, 2nd edition, The complete guide to dimensional modeling by Kimball Ralph; Ross, Margy, Johny Wiley and sons
4. Mastering Data Warehouse design-Imhoff C, Galemmo N., Giger J.G.(Wiley Publication)

BI-536 COMPUTER AIDED DRUG DESIGN 3 CH 50 MARKS

Objective: To design potential lead molecules that may be explored further as a potential candidate for the drug.

CO-1	Remember and understand the basic concepts/Principles of Computer Aided Drug Design
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit I

Introduction to chemical informatics, application in pharmaceutical industry; representation of 2D structures; atom lookup and connection tables; SMILES; SD files; fragment codes and fingerprints; 2D chemical database applications, substructure searching with SMARTS, Similarity searching with fingerprints; representing 3D structures. Sources of 3D information; experimental 3D databases; conformational flexibility; distance matrices; estimation of 3D structure; conformational search and minimization; 3D descriptors and fingerprint.

Unit II

Molecular descriptors, kinds of descriptor (2D, 3D descriptors); biological descriptors and their application in ADME/Tox; data verification and manipulation; quantitative structure-property relationships (QSPR): feature selection, model building, examples of QSPR studies and application; QSAR in drug design: QSAR methodology, QSAR applications in drug design, QSAR model selection and validation, CoMFA, 3D and nD-QSAR methods; pharmacophore and drug discovery: pharmacophore generation, query generation and submission, searches in the database, software for pharmacophore generation, application and limitation of pharmacophore concept.

Unit III

High-Throughput chemistry (CombiChem): mix and split synthesis, solid-phase synthesis, solution-phase synthesis, combinatorial biosynthesis, library design, virtual high-throughput screening; de-novo design system: generating the constraints model, finding structure, sorting and selection, synthetic accessibility, experimental validation; computational models for ADME/Tox, application of predictive models to pharmacology and toxicity testing; target identification and characterization, structure based process for designing drug molecules (docking algorithms, MM-GBSA, MM-PBSA, LIE-SGB, free energy perturbation, thermodynamics integration, refinement methods.

Suggested reading:

1. An Introduction to Chemoinformatics,A.R. Leach, V.J. Gillet:, Kluwer Academic Publishers (2009). ISBN-13: 9788184892550.
2. Chemoinformatics: A Textbook, John Gasteiger and Thomas Engel, Wiley Publisher (2003). ISBN-13: 9783527306817.
3. Drug Design: Structure- and Ligand-based Approaches, KMMerz, D Ringe, CHReynolds, Cambridge University Press (2014). ISBN-13: 9780521887236.
4. Guide Book on Modeling in Drug Design,N.Clauden Cohen, Academic Press. ISBN-13: 9788131201695.

BI-537	**Practical (DBMS, Data Warehouse and Data mining)**	**2 CH**	**50 marks**
BI-538	**Practical (Molecular Modeling and Computer Aided Drug Design)**	**2 CH**	**50 marks**

FOURTH SEMESTER

BI-541 GENOMICS, PROTEOMICS & METABOLOMICS 3 CH 50 MARKS

Objective: To provide thorough understanding on modern techniques of genome sequencing and functional annotation.

CO-1	Remember and understand the basic concepts/Principles of Genomics, Proteomics and Metabolomics
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit I

Concept of genome organization and minimal cell genome; genome sequencing strategies, principles and methodology; genome sequencing projects- microbes, plants and animals; accessing and retrieving genome project information from web; recognition of coding and non-coding sequences and gene annotation.

Reverse genetics- strategies and applications, concept of TILLING, structural genomics, functional genomics and comparative genomics; high throughput screening in genome for drug discovery-identification of gene targets and drug development.

Unit II

Introduction to proteome, protein analysis (includes measurement of concentration, amino-acid composition, N-terminal sequencing); 2-D electrophoresis of proteins; isoelectrofocusing; peptide fingerprinting; LC/MS-MS for identification of proteins and modified proteins; MALDI-TOF; SAGE and differential display proteomics, protein-protein interactions, yeast two hybrid and three hybrid system; protein microarray; structural proteomics; proteomics and drug delivery.

Unit-III

Introduction to metabolomics: metabolome, metabonomics, metabolite profiling, metabolome fingerprinting, role of biomarker in metabolomics, tools of metabolome studies: NMR, MS, GC, LC, IR and its application, metabolome projects of plant and human, future prospective of metabolomics.

Suggested readings:

1. Principle of gene manipulation and Genomics, S.B Primrose, R.M Twyman, 6th Ed., Blackwell Science Ltd (2014). ISBN-13: 9788126548392
2. Discovering Genomics, proteomics & bioinformatics, Malcolm Campbell, Laurie J Heyer, Pearson Education Limited (2013). ISBN-13: 9788131715598.
3. From Genes to Genomes: Concepts and Applications of DNA Technology, Jeremy W. Dale, Malcolm von Schantz, Wiley, John & Sons (2007) ISBN-13: 9780470017340.
4. Molecular Biotechnology: Principles and Applications of Recombinant DNA, Bernard R Glick, Jack J Pasternak, Panima Book Distributors (2002). ISBN-13: 9788186535080.

5. Genetic Engineering,Smita Rastogi, Neelam Pathak, Oxford University Press (2009). ISBN-13: 9780195696578.

BI-542 COMPUTATIONAL GENOMICS & PROTEOMICS 3 CH 50 MARKS

Objective: To develop the skills for functional annotation of the novel DNA sequences and gene expression data.

CO-1	Remember and understand the basic concepts/Principles of Computational Genomics and Proteomics
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit-I

Genome sequencing: genes and genomes, gene sequencing methods (Sanger and Pyro Sequencing), protein sequencing method (EDMAN sequencing), genome sequencing strategies (Shortgun and Clone-by-clone approach), human genome project, sequence assembly and filling gaps, cDNA sequencing and EST, DNA editing, RNA editing, types of RNA editing, identification of various types of RNAs.

Unit-II

Genome analysis: genome structure analysis by genome browser and BLAT, gene sorter, DNA duster, primer design. gene predictions: prokaryotic and eukaryotic genome features for gene prediction, methods of gene prediction, algorithms of gene predictions (GRAIL, FGENESH, GENSCAN, etc), strategies and considerations,c genome analysis: basic concepts and application, BLAST2, MegaBlast PipMarker, AVID, Vista, MUMmer, application of comparative genomics, reconstruction of metabolic pathways.

Unit-IV

MicroRNA and genomewide profiling: miRNA and human disease, significance of miRNA profiling, genomewide profiling of miRNA by microarray. RNAi: what are RNAi and siRNA, discovery of siRNA, RNAi mechanism, siRNA applications, siRNA design, siRNA resources, siRNA information. Proteomic data analysis: analyzing 2DE derived proteomics data, analyzing mass-spectrometry derived data, protein array and analyzing data derived from protein microarray

Suggested Readings:

1. Analysis of Genes and Genomes by Richard J. Reece, Wiley Publishers.
2. Bioinformatics and Functional Genomics by Jonatham Pevsner, Wiley Publishers
3. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins (3rd Ed.) by Andreas D. Baxevanis & B.F. Francis Ouellette, Wiley Publishers.
4. Discovering Genomics, Proteomics and Bioinformatics (2 Ed.) by A Malcolm Campbell, Davidson College and Laurie J. Heyer, Pearson Publishers.
5. Introduction to Proteomics by Daniel C. Liebler and John R. Yates, Humana Press

BT-543 (A) SYSTEM BIOLOGY 3 CH 50 MARKS

Objective: To develop the skills towards system level understanding of biological systems.

CO-1	Remember and understand the basic concepts/Principles of Systems Biology
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit I

Introduction to systems biology, biological knowledge and kinetic modeling, cellular networks: the structure of molecular networks; network motifs and their systems properties and roles they play in biological processes; complexity and robustness of molecular networks; hierarchy and modularity of molecular interaction networks, reconstruction of cellular networks, edinburg pathway editor, static modeling, DBSolve, enzyme kinetics modeling, kinetic modeling of biological pathways, application of the kinetic modeling approach to problems in biotechnology and biomedicine

Unit II

Analysis of biological networks: signal transduction and gene regulation networks, protein interaction networks, metabolic networks, phylogenetic networks, correlation networks; computational system modeling: logic gates, design of biocircuits, blocks, designing, various case studies and applications, gene circuits, Petri Nets, Fuzzy implementation

Unit III

Controlling metabolic networking: metabolic fluxes, metabolic flux analysis, mass/flux balance analysis; BioXML, SBML, CellML and their applications towards modeling and simulation of biological systems, online tools and databases for system biology (STRING, BIND, MINT, IPATH, GeneGo, GYPASI, MetaCYC, etc.); E-cell project

Suggested Readings:

1. Systems Modeling in Cellular Biology, by Zoltan Szallasi, Joerg Stelling, Vipul Periwal, MIT Press,
2. Systems Biology : Properties of Reconstructed Networks, by Bernard Palsson, Cambridge Univ. Press
3. Advances in Systems Biology (Advances in Experimental Medicine and Biology). Opresko, L., Gephart, J., and Mann, M. (eds.), Plenum US, 2005
4. Artificial Intelligence Methods and Tools For Systems Biology, Dubitzky, W. and Azuaje, F. (eds.), Kluwer Academic Publisher
5. Metabolome Analyses: Strategies for Systems Biology, Vaidyanathan, S. et al (eds.), Springer-Verlag
6. Systems Biology in Practice: Concepts, Implementation And Application Klipp, E et al., John Wiley & Sons Inc.

7. Foundations of Systems Biology, Kitano, H.(ed.); The MIT Press

8. Systems Biology, Alberghina L. & Westerhoff, H.V., eds.; Springer Verlag

BI-543 (B) CLINICAL DATA MINING & IMAGE PROCESSING 3 CH 50 MARKS

Objective: To develop the clinical data warehouse for the electronic repository of multidimensional clinical data and analysis using data mining techniques.

CO-1	Remember and understand the basic concepts/Principles of Clinical Data Mining and Image Processing
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit-I

Electronic Health Records - EHR technology; evolution of EHR; EHR adoption and usability; scenario of EHR implementation in India, clinical data management - specialized form of clinical databases; clinical data model and its implementation; clinical data warehouse.

Unit-II

Data Mining and CDS - statistical pattern recognition techniques; supervised learning - decision trees, logistic regression, neural networks, nearest neighbor approach, support vector machine, evaluation of classifiers - ROC Graphs, Kolmogorov-Smirnov test; unsupervised learning - cluster analysis; genetic algorithm; temporal mining algorithm.

Unit-III

Introduction to image processing – fundamentals & applications of image processing; human visual perception; components of an image processing system.

Biomedical image processing – macroscopic and microscopic image analysis; biometric pattern recognition, sampling and quantization; binary image; 3-D imaging; image file formats, image segmentation (point and line detection, region growing and object segmentation)

Suggested readings:

1. The Data Warehouse Toolkit, 2nd Edition: The Complete Guide to Dimensional Modeling by Kimball, Ralph; Ross, Margy, John Wiley & Sons Publisher.
2. Building the Data Warehouse by Bill Inmon, Wiley and Sons Publication.
3. Mastering Data Warehouse Design by Imhoff C, Galemmo N, Giger J.G., Wiley Publication.
4. DW 2.0 - Architecture for the Next Generation of Data Warehousing by Bill Inmon, Derek Strauss and Genia Neushloss, Elsevier Press.
5. Data Mining and Analysis: Fundamental Concepts and Algorithms by Zaki, Mohammed J., Cambridge University Press.
6. Data Mining: Concepts and Techniques by Jiawei Han and Micheline Kamber, Morgan Kaufmann Publisher.
7. Digital Image Processing (2^{nd} Ed.) by Rafael C Gonzalez and Richard E Woods, Pearson Publisher.

BI-543 (C) NGS AND MICROARRAY DATA ANALYSIS 3 CH 50 MARKS

Objective:
To enable the students to analyze and infer information from whole genome sequence data and high through put gene expression data of microorganisms, plants and animals.

CO-1	Remember and understand the basic concepts/Principles of NGS and Microarray Data Analysis
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit-I
Overview of next generation sequencing technology (Roche/454 FLX, Illumina Genome Analyzer, SOLiD™ sequencing, Ion Torrent™, Nanopore), data processing, NGS and genetics of complex disease, exome sequencing, RNA-seq experiments and data analysis, differential expression analysis, chip-seq analysis, sequencing mappability.

Unit-II
NGS Data Quality Control methods, NGS Data Structure, Resources and Repositories, genome annotations, haplotyping (concepts and application), SNP technologies (platforms and analysis), trascriptome preparation and annotation, transcriptome abundancy calculation and pathway mapping, pharmacogenomics (concepts and application in healthcare).

Unit-III
Metabolic pathway analysis: macromolecular networks, topology of macromolecular networks, modulatory and dynamics of macromolecular networks, inference of regulatory networks, simulation of molecular networks, simulation of biological processes. DNA and protein microarray: fabrication of microarray, printing of DNA, sample preparation and hybridization, image segmentation and data acquisition, data normalization, data analysis and clustering, case studies, screening of proteins: protein array, antibody array, case studies.

Suggested Readings:

1. Next Generation DNA Sequencing Informatics by Stuart M. Brown, Cold Spring Harbor Laboratory.
2. Network Analysis and Synthesis by Franklin F. Kuo, Wiley Publisher.
3. RNA-seq Data Analysis: A Practical Approach by Eija Korpelainen, CRC Press.
4. Bioinformatics: Genomics and post-genomics, Noah Hardy, John Wiley & Sons, Ltd
5. Microarray Bioinformatics, by Dov Stekel, Cambridge University Press
6. Protein Arrays – Method and Protocols by Fung, Human Press
7. Next-Generation DNA Sequencing Informatics, Stuart M. Brown, *New York University School of Medicine, Cold spring Harbor Laboratory.*

BI-544	**Seminar**	**3 CH**	**50 marks**
BI-545	**Project work and Viva Voce**	**12 CH**	**200 marks**

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