

COURSES OF STUDY
M.Sc Bioinformatics (Self Financing)
(2023-2025)



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

PEOs

PEO1: Understand the nature and basic concepts of subjects relating to the M.Sc. in Bioinformatics

PEO2: Analyse the relationships among different concepts

PEO3: Perform procedures as laid down in the areas of study

PEO4: Apply the Basic Concepts learned to execute them

POs

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 entrepreneur

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

COs

CO-1: Remember and understand the basic concepts/principles of subjects

CO-2: Analyse 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

COURSE AT A GLANCE

Subject: Bioinformatics

Academic session: 2023-25

First Semester- December, 2023

| Course Number | Course Title | Credit Hours | Mark Distribution (ET+MT+HA) | Maximum Mark |
|---------------|--|--------------|------------------------------|--------------|
| BI-411 | (A) Physical Sciences (B) Foundation Biology | 4 | 80+10+10 | 100 |
| BI-412 | Chemistry of Biomolecules | 4 | 80+10+10 | 100 |
| BI-413 | Genetics and Biostatistics | 4 | 80+10+10 | 100 |
| BI-414 | Microbiology | 4 | 80+10+10 | 100 |
| BI-415 | Molecular Biology-I | 4 | 80+10+10 | 100 |
| BI-416 | Practical-I | 2 | 50 | 50 |
| ESDMS-419 | Environmental Science and Disaster Management (Coordinated by Dept of Env. Sc.) | 2 | 40+05+05 | 50 |

Second Semester- April, 2024

| Course Number | Course Title | Credit Hours | Mark Distribution (ET+MT+HA) | Maximum Mark |
|---------------|--|--------------|------------------------------|--------------|
| BI-421 | Molecular Biology-II | 4 | 80+10+10 | 100 |
| BI-422 | Bioenergetics and Metabolism | 4 | 80+10+10 | 100 |
| BI-423 | Instrumentation and Techniques | 4 | 80+10+10 | 100 |
| BI-424 | Operating System and Basic Programming | 4 | 80+10+10 | 100 |
| BI-425 | Practical -II | 2 | 50 | 50 |
| IDCBT-426 | Biotechnology and its Applications (Interdepartmental Course) | 3 | 40+05+05 | 50 |
| | Participation in NCC or NSS or other non-credit course | | | |

Third Semester- December- 2024

| Course Number | Course Title | Credit Hours | Mark Distribution (ET+MT+HA) | Maximum Mark |
|---------------|--|--------------|------------------------------|--------------|
| BI-531 | Recombinant DNA Technology, IPRs and Biosafety | 4 | 80+10+10 | 100 |
| BI-532 | Immunology | 4 | 80+10+10 | 100 |
| BI-533 | Computational Biology | 4 | 80+10+10 | 100 |
| BI-534 | Python Programming | 4 | 80+10+10 | 100 |
| BI-535 | Practical- III | 2 | 50 | 50 |
| | MOOCs Course | 3 | 40+05+05 | 50 |
| EDPS-439 | Entrepreneurship Development Programme | 2 | 40+05+05 | 50 |

Fourth Semester- April, 2025

| Course Number | Course Title | Credit Hour | Mark Distribution (ET+MT+HA) | Maximum Mark |
|--|--|-------------|------------------------------|--------------|
| BI-541 | Genomics, Proteomics and Metabolomics | 4 | 80+10+10 | 100 |
| BI-542 | Molecular Modeling and Drug Design | 4 | 80+10+10 | 100 |
| BI-543 | Data Warehouse and Database Management | 4 | 80+10+10 | 100 |
| BI-544 Elective Paper (Any one) | (A) Systems Biology | 4 | 80+10+10 | 100 |
| | (B) Clinical Informatics | | | |
| | (C) NGS and Microarray Data Analysis | | | |
| | (D) Big Data analysis | | | |
| BI-545 | Project work and Viva voce | 4 | 100 | 100 |
| BI-536 | Seminar | 2 | 50 | 50 |

ET: End Term Examination, MT: Mid Term Examination, HA: Home Assignment

| LIST OF MOOCS: | |
|-----------------------|---|
| 1 | Operating System Fundamentals |
| 2 | Fundamentals of Protein Chemistry |
| 3 | Introduction to Proteogenomics |
| 4 | Drug Delivery: Principles and Engineering |
| 5 | Environmental Biotechnology |
| 6 | Introduction to Machine Learning |
| 7 | Programming In Java |

FIRST SEMESTER

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| BI-411(A) | PHYSICAL SCIENCES | 4 CH | 100 MARKS |
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| 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, Maxima and Minima. 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 impedance diodes, photoresistors, Semiconductors, transistors, integrated circuits and chips.

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), Buffers and pH.

Unit IV

Basics of computer: types, basic organization of computers, computer languages, hardware and software, generation of computers, operating systems, bit, byte, word, computer memory – types, data processing and storage, information storage devices, ROM and RAM, methods of computing (workstation, server, grid computing, parallel computing, cloud computing), application of computer software in biostatistics and data management.

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, Reema Thareja. Oxford University Press (2015). ISBN-13: 978-0199452729.

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| BI-411(B) | FOUNDATION BIOLOGY | 4 CH | 100 MARKS |
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| 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

Plant and animal tissue system and function; Physiology of locomotion, respiration, digestion, circulation, excretion in animals; hormonal regulation in animals; Photosynthesis, respiration, transportation in plants.

Unit IV

Physiology of reproduction in plants and animals; Genetics- science of heredity: chromosome number and structure, cell division- meiosis and mitosis, mendelian principle of heredity; monohybrid and dihybrid cross (examples).

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, Shalesha 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.

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| BI-412 | CHEMISTRY OF BIOMOLECULES | 4 CH | 100 MARKS |
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| 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

DNA structures: Nucleotides and nucleosides, DNA double helix, DNA structure (Z-DNA, B-DNA, A-DNA), triple helix DNA, tetraplex DNA, DNA binding proteins, Protein – DNA interactions, RNA secondary and tertiary structures. Isolation, purification and quantification methods for DNA and RNA.

Unit II

Biomolecules: Carbohydrates (monosaccharides, disaccharides, and polysaccharides); Biological importance of Carbohydrates: Cell wall structure and its diversity. Commercial importance of carbohydrates: synthesis and applications of fibers made from cellulose, chitin, chitosan, and keratin. Purification of carbohydrates.

Structure and functions of lipids (fatty acids, storage lipids, structural lipids, structural lipids); Lipids as signals, cofactors and pigments; Isolation of lipids.

Unit III

Protein structure: Chemical building blocks, Peptide bond, Torsion angles, Ramachandran map, Protein structures (Primary, Secondary Super-secondary, Tertiary, Quaternary), Protein folding, Protein Motifs and domains; Protein structure determination; Purification of proteins, Crystallization of proteins.

Unit IV

Engineering and design of protein structure, Homologous protein, Protein sequencing, Protein flexibility and stability, Engineering of protein structure and applications (case studies). Membrane proteins and its function, Metalloproteins, Carbohydrate binding proteins, Glycosylation and its importance. 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, Lubert Stryer, 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.

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| BI-413 | GENETICS AND BIOSTATISTICS | 4 CH | 100 MARKS |
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| CO-1 | Remember and understand the basic concepts/principles of Genetics 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

Mendelian principle: dominance, segregation and independent assortment; extensions of Mendelian principle: co-dominance, Incomplete dominance, gene interactions, supplementary genes, complementary genes, duplicate genes, epistasis, pleiotropy, 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.

Unit-II

Concept of gene: allele, multiple alleles, 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; Population genetics: gene pool, gene frequency, Hardy Weinberg genetic equilibrium; Gene flow and Genetic drift.

Unit III

Concepts from probability: probability rules, probability distributions, binomial distribution, Poisson distribution, Systematic organization of data; populations, samples, types of data, frequency tables and histograms; 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; skewness and kurtosis.

Unit IV

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; Analysis of variance: One-way analysis of variance, two-way analysis of variance.

Suggested readings:

1. Genetics, Monroe W Strickberger. 3rd Edition. Prentice Hall India Learning Private Limited (2015). ISBN-13: 978-9332555105.
2. Genetics, B.D. Singh, Kalyani Publishers / LyallBk Depot (2016). ISBN-13: 978-8127248673.
3. Principles of Population Genetics, Andrew G. Clark, Daniel L. Hartl, 4th Ed., Sunderland: Sinauer Associates (2007). ISBN-13: 978-0878933082.
4. Principles of Genetics, Robert H. Tamarin, 7th Edition, Tata McGraw-Hill Edition. ISBN-0-07-048667-0.
5. Introductory Biostatistics for the Health Sciences, Michael R. Chernick, Robert H. Friis, Wiley-Interscience Publications (2003). ISBN-13: 9780471411376.
6. Statistics: Concepts and Applications, Nabendu Pal, Sahadeb Sarkar, Prentice-Hall of India Pvt Ltd (2009). ISBN-13: 9788120334458.
7. 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.

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| BI-414 | MICROBIOLOGY | 4 CH | 100 MARKS |
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| 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 |

UnitI

Microbial world (Bacteria, Archaea, Eukaryote). Classification of Archaea and Eubacteria as per Bergey's manual; Microbial phylogeny. Structural organization of prokaryotic cell (bacterial wall, capsule, flagella, pili, pronucleus, ribosomes, plasmid).

UnitII

Bacterial nutrition and nutritional category; Bacterial culture: Types of media, synchronous and asynchronous culture, continuous culture and chemostat; Bacterial growth: mathematical expression of growth, generation time, specific growth rate; Diauxic growth.

UnitIII

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

UnitIV

Virus: general properties, 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 (persistent, latent and slow virus infection). Plant virus and their transmission. Anti-viral agents; M-13, Lambda, HIV, Influenza virus, Viroids 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, 8th Edition, 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.

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| BI-415 | MOLECULAR BIOLOGY-I | 4 CH | 100 MARKS |
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| CO-1 | Remember and understand the basic concepts/principles of Molecular Biology- I |
| 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 |

UnitI

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.

UnitII

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.

UnitIII

DNA replication: Models of DNA replication, Enzymes involved in DNA replication, Process of DNA replication (initiation, elongation, termination), DNA replication at 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).

UnitIV

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).

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.

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| BI-416 | PRACTICAL - I | 2 CH | 50 MARKS |
| ESDMS-419 | Environmental Science and Disaster Management | 2 CH | 50 MARKS |

SECOND SEMESTER

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| BI-421 | MOLECULAR BIOLOGY - II | 4 CH | 100 MARKS |
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| 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, transcriptional 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; operon concept (lac, ara, trp and his); Regulation of gene expression in prokaryotes and eukaryotes.

Unit III

Structure & function of cytoskeleton and its role in motility; Biomembrane composition dynamics and function; Endocytosis, budding and fusion reaction; Membrane carbohydrates and their role in cellular recognition. Transport across the membrane: Carriers and channels, Mechanism of transport through Gluts, Na⁺-K⁺ pump, Na⁺ -Glucose co-transporter, Acetylcholine receptor, K⁺ Channel, Aquaporin, Protein trafficking: mechanism of sorting and regulation of intracellular transport.

Unit IV

Bio signaling: Ion channel, Receptor enzymes, and G protein mediated signaling; Ras/MAPK pathway, JAK-STAT pathway, BMP pathway, Hedgehog pathway; Quorum Sensing, Cell cycle and its regulation; Genetics of cancer (proto-oncogenes, tumor suppressor genes); Virus-induced cancer, metastasis; Therapeutic interventions of uncontrolled cell growth.

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.

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| BI-422 | BIOENERGETICS AND METABOLISM | 4 CH | 100 MARKS |
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|------|--|
| 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 (Competitive, Non-competitive, Uncompetitive), Allosteric enzymes and regulation, 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 pathway and its physiological significance); Coordinated regulation of glycogen synthesis and breakdown; Citric acid cycle, Regulation of citric acid cycle, glyoxylate cycle; Electron transport in mitochondria.

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, Amino acid degradation), Biosynthesis of amino acids, Biosynthesis of nucleotides (purines and pyrimidines), Metabolic disorders, Inborn error due to metabolism, Hormonal regulation of metabolism.

Unit IV

Photosynthesis: Light harvesting complexes; mechanisms of electron transport in chloroplast; photoprotective mechanisms; CO₂fixation-C₃, C₄and CAM pathways. Alternate oxidase; photorespiratory pathway; Biosynthesis, storage, breakdown and transport of plant hormones; Physiological effects and mechanisms of action plant hormones; Endocrine glands of animals: Overview, Mechanism of hormone action (Peptide and Second messenger concept); Biological Nitrogen fixation; Nitrate and ammonium assimilation.

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.

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| BI-423 | INSTRUMENTATION AND TECHNIQUES | 4 CH | 100 MARKS |
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| CO-1 | Remember and understand the basic concepts/principles of Instrumentation and Techniques |
| 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 |

UnitI

Laws of absorption of light: Beer-Lambert's Law, factors affecting the absorption properties of chromophores; Principle, instrumentation and application: Spectrophotometer and fluorimeter; Principle, instrumentation and application: Chromatography (Paper, Thin layer, Affinity, Ion-exchange, Size exclusion chromatography, GLC, and HPLC).

UnitII

Principle, instrumentation and application of Infrared spectroscopy, atomic absorption spectroscopy, Mass spectroscopy (LC-MS, GC-MS, MALDI-TOF, Fluorescent spectroscopy, FTIR; Circular dichroism, NMR and ESR spectroscopy, Structure determination using X-ray diffraction and NMR; Analysis using light scattering and surface plasmon resonance methods.

UnitIII

Centrifugation – Principles and types (Density gradient and differential centrifugation); Radioactivity; Principle and application of G.M. counter and Liquid Scintillation Counter, Microscopy (Compound, Phase contrast, Fluorescence, Confocal); Electron microscopy (TEM, SEM), Different fixation and staining techniques (freeze-etch and freeze-fracture methods for EM), Image processing methods in microscopy.

UnitIV

Principle, instrumentation and application of pH meter, Flame photometer, Electrophoresis (Agarose, PAGE, SDS-PAGE and IEF). Principle and application of Blotting (Southern, Northern) techniques. Electrophysiological methods:PET, MRI, fMRI, CAT.

Suggested readings:

1. Biochemical Techniques Theory and Practice, John F Robyt, CBS Publishers & Distributors (2015). ISBN-13: 978-8123926605.
2. An Introduction to Practical Biochemistry, David T Plummer, Tata McGraw Hill Publishing Co Ltd (2015). ISBN-13: 978-0070994874.
3. Analytical Chemistry, Gary D. Christian, John Wiley & Sons Inc (2013). ISBN-13: 978-0470887578.
4. Principle and Techniques of Biochemistry and Molecular Biology, Keith Wilson, John Walker, 7th Ed., Cambridge University Press (2010). ISBN-13: 978-0521731676.

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| BI-424 | OPERATING SYSTEM AND BASIC PROGRAMMING | 4 CH | 100 MARKS |
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| CO-1 | Remember and understand the basic concepts/principles of Operating System and Basic 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

Basic structure of computer: CPU, I/O devices, memory, secondary storage devices; Data representation: overview of binary, octal and hexadecimal number system; Classification of computers (mainframes, mini computers, microcomputers, special purpose computers); Application programs: basic concept of word processing, spreadsheet, presentation and other application software.

Unit II

Operating system concepts; Windows, UNIX, Linux operating systems and their inter-operability; Command line operations in windows; Basic commands in windows OS; Creating command scripts in windows; Text editors in windows and Linux environment; WYSIWIG and WYSWYM editors; Notepad, TextEdit, VI, emacs, gedit; Other GNU tools.

Unit III

Linux environment, salient features of UNIX and GNU/Linux; UNIX shells, UNIX file system, file and directory commands, basic commands, I/O redirection and piping, simple and advanced filters, sed command, archives and file compression; Processes: background processes and schedule processes, Alias and environmental variables; Shell scripting.

Unit IV

Programming languages. Low- and high-level languages. C-programming: constants, variables, data types in C, operators, managing I/O operations, decision control and looping statements in C, array; Functions and passing parameters to the function; string operation and pointers; concepts of structure and union.

Suggested readings:

1. Fundamentals of Computers, Reema Thareja. 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, M.G Venkatesh Murthy, Pearson Education Limited (2016). ISBN-13: 978-8177587456.
5. Introduction to UNIX, David I Schwartz, Pearson Education Limited (2016). ISBN-13: 978-8131722343.

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| BI-425 | PRACTICAL - II | 2 CH | 50 MARKS |
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| IDCBT-426 | BIOTECHNOLOGY AND ITS APPLICATION | 3 CH | 50 MARKS |
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| CO-1 | Remember and understand the basic concepts/principles of Biotechnology and Applications |
| 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 |

UnitI

Fundamentals of Biotechnology: Structure of DNA and RNA; DNA as the genetic material (experimental evidences); Central dogma of molecular biology. Genetic organization of prokaryotes and eukaryotes; Nucleosome concept.

UnitII

Concept of gene cloning: DNA isolation techniques; Restriction endonucleases, DNA polymerase, Ligase; Cloning vectors- plasmid, bacteriophage, cosmid, BAC, YAC; Expression vectors: Bacteria and yeast-based expression vector; Introduction of recombinant DNA into host cells, Screening of recombinants; c-DNA library and genomic library.

UnitIII

Biotechnological applications in agriculture: Pest resistant plants Bt Cotton; Biotechnological applications in medicine; Gene Therapy; DNA finger printing; Therapeutic proteins and peptides (Insulin, STH, Erythropoietin).

UnitIV

Transgenic animal production: Induction of superovulation, Embryo collection and evaluation, Embryo splitting, Embryo sexing, Embryo transfer, Advantages of embryo transfer in farm animals, *In vitro* fertilization, Embryo cloning. Applications of transgenic animals. Ethical Issues: Public concerns on GMOs and LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC ethics in clinical trials, genetic testing.

Suggested readings:

1. Elements of Biotechnology, P K Gupta, Rastogi Publication (2015). ISBN-13: 9788171339372.
2. Recombinant DNA: A Short Course, Amy A. Caudy, James D. Watson, Jan A. Witkowski, Richard M. Myers, WH Freeman (2006), ISBN-13: 9780716728665.

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| | PARTICIPATION IN NCC OR NSS OR ANY OTHER NON-CREDIT COURSE | 2 CH | 50 marks |
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*Interdisciplinary Value Aided Course with total intake of 60 students from other departments

THIRD SEMESTER

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| BI-531 | RECOMBINANT DNA TECHNOLOGY, IPRs AND BIOSAFETY | 4 CH | 100 MARKS |
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| CO-1 | Remember and understand the basic concepts/principles of Recombinant DNA Technology, IPRs and Biosafety |
| 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

Restriction endonuclease, ligases; DNA and RNA markers, linker, adapter and MCS; Cloning vectors- plasmid, bacteriophage, cosmid, BAC, YAC; Expression vectors: bacteria and yeast-based expression vector; Gene library: Genomic and c-DNA, contig library; PCR and its variants (RT-PCR); 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

Intellectual property rights and its types: Patents, trademarks, copyright and related rights, Industrial design, Traditional knowledge, Geographical indications, Protection of new GMOs; Process patent vs product patent; Basic requirement of a patentable invention; Indian Patent Act 1970 and recent amendments; Procedure for filing a patent, international patenting-Requirement, Patent infringement: meaning, scope, litigation, remedies; Case studies and examples: Rice, Neem *etc.*

Unit IV

Introduction to biosafety regulations; Primary containment for biohazards and biosafety levels; Biosafety guidelines - government of India; Definition of GMOs and LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC; Bioethics; Public concerns on human genome research and transgenics- Genetic testing and screening, Ethics in clinical trials and GCP, ELSI and Human genome project; Ethics in human cloning (case study).

Suggested readings:

1. Biotechnology and Intellectual Property Rights, Kshitij Kumar Singh, Springer (2016), ISBN-13: 9788132229759.
2. Intellectual Property and Biotechnology: Biological Inventions, Rimmer Matthew, Edward Elgar, U.K. - Edward Elgar (2009). ISBN-13: 9781845429478.
3. Bioethics and Biosafety, M. K. Sateesh, IK International Pvt Ltd (2014), ISBN-13: 9788190675703.
4. Biosafety and Bioethics, Rajmohan Joshi, Isha Books (2006). ISBN-13: 9788182053779.
5. Principle of gene manipulation and Genomics, S.B Primrose, R.M Twyman, 6th Ed., Blackwell Science Ltd (2014). ISBN-13: 9788126548392
6. Biotechnology: Expanding Horizons, BD Singh, Kalyani Publishers / Lyall Bk Depot (2016). ISBN-13: 9789327222982.
7. Elements of Biotechnology, P K Gupta, Rastogi Publication (2015). ISBN-13: 9788171339372.

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| BI-532 | IMMUNOLOGY | 4 CH | 100 MARKS |
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| 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 |

UnitI

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 antibody diversity; Other B cell receptors. Principles and methods of hybridoma technology; Production and characterization of monoclonal antibodies and their applications.

UnitII

Complement system: Mechanism of activation and its regulations; Major histocompatibility complex proteins; Antigen processing and presentation; T-cell receptors. Cytokines and cytokine receptors: structure, function and therapeutic applications. Immunology of allergy, AIDS, Organ transplantation; Autoimmune diseases. Immunology of cancer cells.

UnitIII

Tools and techniques in immunology: experimental animal models, cell culture. Application of immunological concepts in drug development, vaccines and diagnostics: development of antibodies, antibodies as drugs, designing vaccines for active and passive immunization.; hybridoma technology and application of Mabs, Mabs production.

UnitIV

Immunotechnology: Antigen-antibody interaction (Scatchard equation); Immunodiffusion (SRID and DRID); Immunoelectrophoresis: types and uses; ELISA; RIA; ELISPOT assay; Western blotting; Immunofluorescence; Immunoelectron microscopy; Surface plasmon resonance; 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

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| BI-533 | COMPUTATIONAL BIOLOGY | 4 CH | 100 MARKS |
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| 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

Bioinformatics: origin and applications; Major Bioinformatics resources: NCBI, EBI, ExPASy, RCSB; Nucleic acid sequence databases: GenBank, EMBL, DDBJ; Protein sequence databases: UniProt-KB: SWISS-PROT, TrEMBL, UniParc; Data contents and formats; Genome databases (viral, archea, bacterial and eukaryotic genomes).

Unit II

Structural database: PDB, NDB,, MMDB, CATH, SCOP, FSSP, DALI, protein structural alignment databases, protein-protein interaction database, protein-ligand databases, PubChem, ChEMBL and ZINC databases; Identification and interpretation of patterns in sequences; sequence patterns: InterPro, Prosite, Pfam, ProDom;

Unit III

Sequence alignments algorithms: Scoring matrices and scoring functions (PAM, BLOSUM); Dynamic programming; Pairwise alignment algorithms (local and Global); Multiple sequence alignment; Database search (BLAST, FASTA); Phylogenetic analysis: concepts and terminology; Phylogenetic analysis algorithms: distance-based methods (Fitch–Margoliash method, UPGMA, NJ), character-based methods (Maximum parsimony, Maximum likelihood), bootstrapping.

Unit IV

Markov chains and HMM; CpG island prediction using HMM; dinucleotide abundance, codon biases, GC reach prediction and relationship to gene density, GC and AT skewness and prediction of *Ori* and *Ter* site; RNA structure analysis; RNA secondary structure prediction: Nussinov folding algorithm, energy minimization and Zuker folding algorithm.

Suggested readings:

1. Bioinformatics (Databases, Tools and Algorithms), Orpita Bosu, Simminder Kaur Thukral, Oxford University Press (2007). ISBN-13: 9780195676839.
2. Bioinformatics: Principles and Application, Zhumur Ghosh and Bibekanand Mallick, Oxford Publication (2015). ISBN-13: 9780195692303.
3. Introduction to Bioinformatics, Arthur M. Lesk, Oxford University Press (2014). ISBN-13: 9780198724674
4. Bioinformatics: Sequence and Genome Analysis, David Mount, CBS Publishers & Distributors. ISBN-13: 9788123912417.
5. Fundamental Concepts of Bioinformatics, Dan E Krane, Michael L Raymer, Pearson Education India (2003). ISBN-13: 9788177587579.
6. 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.
7. 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.

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| BI-534 | PROGRAMMING IN PYTHON | 4 CH | 100 MARKS |
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| CO-1 | Remember and understand the basic concepts/principles of Programming in Python |
| 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.

Unit II

Data type parsing and manipulation: string structure and function, list: elements and methods, tuple: elements and methods, dictionary: structure and function; file handling: creation, writing, updating, removing files; regular expressions: matching and extraction, RegEx Functions, meta characters, match object, special sequences, sets.

Unit III

Application of Python; networked programs: Retrieval and parsing HTML; using web services: XML, JSON, APIs; Object Oriented Programming in python: concept of class, object and method, constructors in Python, static and instance variable, features of OOPs: data abstraction, encapsulation, inheritance and polymorphism; using databases and SQL: database concepts using SQLite, creation of tables, SQL querying, JOIN operators.

Unit IV

Biopython: Introduction to Biopython, Installation, Inbuilt modules related to sequence objects, sequence annotation objects, sequence analysis, sequence input/output, sequence alignment objects and tools, Overview of Scikit module, Applications of Biopython.

Suggested readings:

1. Python for everybody: Exploring Data Using Python 3, Charles R. Severance, Shroff Publishers & Distributors (2016). ISBN-13: 9789352136278.
2. Bioinformatics with Python Cookbook, Tiago Antao, O Relly Publication. ISBN-13: 9781782175117.
3. Bioinformatics with R Cookbook, Paurush Praveen Sinha, Packt Publishing (2014). ISBN-13: 9781783283132.
4. Beginning Python, James Payne, Wiley Publishing, Inc (2011). ISBN-13: 9788126525638.
5. Programming Python, Mark Lutz, Laura Lewin and Frank Willison, O'Reilly Publication (2015). ISBN-13: 9789350232873.

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| BI-535 | PRACTICAL - III | 2 CH | 50 MARKS |
| | MOOCs COURSE | 2 CH | 50 MARKS |
| EDPS-439 | ENTREPRENEURSHIP DEVELOPMENT PROGRAMME | 2 CH | 50 MARKS |

FOURTH SEMESTER

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| BI-541 | GENOMICS, PROTEOMICS AND METABOLOMICS | 4 CH | 100 MARKS |
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| 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; isoelectric focusing; 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; Structural proteomics; Proteomics and drug delivery.

Unit III

Introduction to metabolomics: Metabolome, metabolomics, 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.

Unit IV

Overview of next generation sequencing technology (Roche/454 FLX, Illumina Genome Analyzer, SOLiD™ sequencing, Ion Torrent™, Nanopore), data processing,

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. 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.

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| BI-542 | MOLECULAR MODELING AND DRUG DESIGN | 4 CH | 100 MARKS |
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| CO-1 | Remember and understand the basic concepts/principles of Molecular Modeling and 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

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

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; domains assignment: first- and second-generation algorithms, graph theoretical methods; Empirical force field for biomolecular simulations: potential energy function; Classical representations of electrostatics (Poisson-Boltzmann, Generalized Born and Columbic). Energy minimization techniques: Concept of local and global minima; Energy minimization algorithms (steepest descent, conjugate gradient, Newton Raphson); Molecular Dynamics simulations, Monte Carlo Simulations; Conformational search: simulated Annealing. Design of novel proteins (case studies).

Unit III

Introduction to chemical informatics; Representation of 2D and 3D 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; Sources of 3D information; experimental 3D databases; conformational flexibility; distance matrices; estimation of 3D structure; conformational search and minimization; 3D descriptors and fingerprint; Molecular descriptors (2D, 3D) and application in ADME/Tox.

Unit IV

Quantitative structure-property relationships (QSPR): feature selection, model building; QSAR methodology, QSAR model selection and validation (CoMFA, 3D methods); QSAR applications in drug design; pharmacophore and drug discovery: pharmacophore generation, query generation and submission, searches in the database; Design of drug library; Computational models for ADME/Tox, application of predictive models to pharmacology and toxicity testing; Structure based designing of drug molecules; Docking algorithms, MM-GBSA, MM-PBSA, LIE-SGB; case studies.

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, Helge Weissig, Wiley Publishing (2003). ISBN-13: 9780471201991.
6. An Introduction to Chemoinformatics, A.R. Leach, V.J. Gillet, Kluwer Academic Publishers (2009). ISBN-13: 9788184892550.
7. Chemoinformatics: A Textbook, John Gasteiger and Thomas Engel, Wiley Publisher (2003). ISBN-13: 9783527306817.
8. Drug Design: Structure- and Ligand-based Approaches, KMMerz, D Ringe, CHReynolds, Cambridge University Press (2014). ISBN-13: 9780521887236.
9. Guide Book on Modeling in Drug Design, N.Clauden Cohen, Academic Press. ISBN-13: 9788131201695.

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| BI-543 | DATA WAREHOUSE AND DATABASE MANAGEMENT | 4 CH | 100 MARKS |
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| CO-1 | Remember and understand the basic concepts/principles of Data Warehouse and Database Management |
| 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 data warehouse: concept, component and architecture of data warehouse; Data warehouse design methodologies: top-down, bottom-down and hybrid approach; Data models: dimensional data modeling (star and snowflake schema); relational data modeling: conceptual, physical and logical data model; multidimensional analysis: OLAP and OLTP; building and maintaining data warehouse: ETL design; management of metadata.

Unit II

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.

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 and applications of DBMS, Purpose of data base, Data, Independence, Database System architecture- Levels, Mappings, Database, users and DBA; Database Design Process, ER Diagrams - Entities, Attributes, Relationships, Constraints, keys, extended ER features, Generalization, Specialization, Aggregation, Conceptual design with the ER model.

Unit IV

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.

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

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, 2nd Ed., Galgotia Publications (2014). ISBN-13: 9788175155459.

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| BI-544 (A) | SYSTEMS BIOLOGY | 4 CH | 100 MARKS |
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| CO-1 | Remember and understand the basic concepts/principles of System 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: terms and definitions; Genome regulation, expression, switches and micro-RNA regulations; Biochemical kinetics and pathways; data generation, extraction and experimental accuracy;

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,

Unit II

Classification of enzymes and metabolic Pathways; KEGG database; Comparative genomics and proteomics; Genome annotation through knowledge of metabolic pathways; Organism specific metabolic pathways; Metabolic control analysis and engineering of metabolic pathways.

Unit III

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 bio-circuits, blocks, designing, various case studies and applications, gene circuits, Petri Nets, Fuzzy implementation.

Controlling metabolic networking: metabolic fluxes, metabolic flux analysis, mass/flux balance analysis; and their applications towards modeling and simulation of biological systems,

Unit IV

Software for systems biology, graph and network in biology: BioXML, SBML, CellML; Open-source programs: eCell, Virtual Cell, StochSim, BioNets; Quantitative models for *E. Coli*: lac operon and lambda switch. The chemotactic module in *E. coli*.

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). Opreko, 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. and Westerhoff, H.V., eds.; Springer Verlag

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| BI-544 (B) | CLINICAL INFORMATICS | 4 CH | 100 MARKS |
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| CO-1 | Remember and understand the basic concepts/principles of Clinical Informatics |
| 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 health informatics and its significance; Background disciplines, historical overview and future challenges; Introduction to knowledge hierarchy: Data, information and knowledge; Health care information and its types (internal versus external data); Purpose of maintaining patient electronic records and content; Issues and challenges related to health care data quality, Quality assessment.

Unit II

Medical decision-making process (diagnosis, treatment, monitoring, prognosis), Informatics in clinical decision making, Introduction to evidence-based medicine; Data and information needs for health systems in managing population health; Key health IT tools and strategies for population health management; Concept of precision medicine.

Unit III

Introduction to standard; Need of health informatics standards; Major types of healthcare information standards and the organization that develop or approve them; Importance of healthcare IT standards; Introduction to knowledge management; Roles, responsibilities and major functions of IT department in healthcare organizations; Various ways to organize IT services for healthcare attributes; Role and major functions of data analytics.

Overview mHealth technology and applications; Mobile computing and Application development using Android; Android user interface and data collection; Mobile health: Using

mobile computing for remote monitoring, smart phone and microcontroller communication; Bless and curse: Limitation of mobile and IoT environment.

Unit IV

Introduction to publicly available resources; Retrieval of health data from various public databases; Knowledge discovery, data mining and text mining; Applying various data analysis and visualization tools on health data; Machine learning algorithms for data analysis; Vision-based technologies for human computer interaction; Big data analysis tool and evaluation matrices.

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, Gallemmo 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 (2nd Ed.) by Rafael C Gonzalez and Richard E Woods, Pearson Publisher.

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|-------------------|---|-------------|------------------|
| BI-544 (C) | NGS AND MICROARRAY DATA ANALYSIS | 4 CH | 100 MARKS |
|-------------------|---|-------------|------------------|

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|------|---|
| 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), transcriptome 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.

Unit IV

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 EijaKorpelainen, 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.*

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| BI-544 (D) | BIG DATA ANALYSIS | 4 CH | 100 MARKS |
|-------------------|--------------------------|-------------|------------------|

| | |
|------|---|
| 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

Introduction of Big Data and HADOOP: Big data definition, enterprise/ structures data, social/unstructured data, unstructured data needs for analytics; Big data resources, Industries using Big data, types of Big data, Big data challenges; History of Hadoop, Apache Hadoop; Analyzing data with UNIX tools, Analyzing with Hadoop; Hadoop steaming, eco system, Hadoop commands; IBM Big data strategy.

Unit II

HDFS (Hadoop Distributed File System): Introduction, eco system and stack, components of Hadoop; HDFS, design of HDFS, Java interfaces to HDFS, architecture overview, development environment, eclipse development.

Map reduce anatomy of a map reduce job run, job failures, job rescheduling, shuffle and sort, task execution; Map reduce types and formats; Map reduce features.

Unit III

Introduction of PIG, execution modes of Pig, Comparison of Pig with databases, grunt shell, Pig Latin, user defined functions, data processing operators; Hive: Hive shell, Hive services, Hive metastore, comparison with traditional databases, HiveQL, Tables, Querying data and user defined functions; Hbase: Hbase basics, concepts, clients, examples of Hbase, storage mechanism of Hbase, commands, Hbase versus RDBMS.

Unit IV

Introduction to data mining; data mining task (classification, clustering, association, regression, forecasting and sequence analysis); Data mining project cycle (data collection, cleaning, transformation; model building, assessment, reporting, prediction and model management); text, image and web mining.

Precision medicine as new approach for healthcare, Difference between personalized and precision medicine; Role of distinct data inputs like clinical, genomic, lifestyle and environmental data in precision medicine; Biomarker discovery using AI in precision medicine; Drug discovery using AI in precision medicine; Big data and AI in clinical trials and drug repurposing; AI and Pharma partnership for precision medicine; Future prospective and challenges in precision medicine using Big data and AI.

Suggested Readings:

1. Big data and Artificial Intelligence for Healthcare Application (Big data from Industry 4.0), CRC press Taylor and Francis (USA). ISBN 978-0367554958, 2021.
2. Saluja, M.K., Agarwal, I., Rani, U. and Saxena, A., 2021. Analysis of diabetes and heart disease in big data using MapReduce framework. In International Conference on Innovative Computing and Communications (pp. 37-51). Springer, Singapore.
3. Nagpal, D., Sood, S., Mohagaonkar, S., Sharma, H. and Saxena, A., 2019, March. Analyzing viral genomic data using Hadoop framework in big data. In 2019 6th International Conference on Computing for Sustainable Global Development (INDIACom) (pp. 680-685). IEEE.
4. Saxena, A., Chandra, S., Grover, A., Anand, L. and Jauhari, S., 2020. Genetic variance study in human on the basis of skin/eye/hair pigmentation using apache spark. In International Conference on Innovative Computing and Communications (pp. 371-379). Springer, Singapore.

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| BI-545 | PROJECT WORK AND VIVA | 4 CH | 100 MARKS |
| BI-536 | SEMINAR | 2 CH | 50 MARKS |

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**DEPT. OF BIOTECHNOLOGY & BIOINFORMATICS
SAMBALPUR UNIVERSITY**

**M.Sc. Biotechnology/Bioinformatics, Semester-I
End Term Examination, December 2023**

Full Marks – 80

BT/BI-411(A): Physical Sciences

Time – 3 hours

Q.1 Answer all the questions (Compulsory). (20 x 1 = 20) From Unit-I to IV

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.
- 8.
- 9.
- 10.
- 11.
- 12.
- 13.
- 14.
- 15.
- 16.
- 17.
- 18.
- 19.
- 20.

Q.2 Answer the following questions. (15) From Unit-I

- (a)
- (b)

OR

Answer the following questions. (15)

- (a)
- (b)

Q.3 Answer the following questions. (15) From Unit-II

- (a)
- (b)

OR

Answer the following questions. (15)

- (a)
- (b)

Q.4 Answer the following questions. (15) From Unit-III

- (a)
- (b)

OR

Answer the following questions. (15)

- (a)
- (b)

Q.5 Answer the following questions. (15) From Unit-IV

- (a)
- (b)

OR

Answer the following questions. (15)

- (a)
- (b)

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DEPT. OF BIOTECHNOLOGY & BIOINFORMATICS
SAMBALPUR UNIVERSITY

M.Sc. Biotechnology/Bioinformatics, Semester-I
End Term Examination, December 2023

Full Marks – 40

IDCB-426: Biotechnology and Its Applications

Time – 2 hours

Answer all the questions (Compulsory)

Q.1 Answer the following questions. (10) From Unit-I

(a).

OR

Answer the following questions. (10)

(a)

(b)

Q.2 Answer the following questions. (10) From Unit-II

(a)

OR

Answer the following questions. (10)

(a)

(b)

Q.3 Answer the following questions. (10) From Unit-III

(a)

OR

Answer the following questions. (10)

(a)

(b)

Q.4 Answer the following questions. (10) From Unit-IV

(a)

OR

Answer the following questions. (10)

(a)

(b)

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**DEPT. OF BIOTECHNOLOGY & BIOINFORMATICS
SAMBALPUR UNIVERSITY**

**M.Sc. Biotechnology/Bioinformatics, Semester-I
End Term Examination, December 2023**

Full Marks – 50

BT/BI-416: Practical-I

Time – 3 hours

Q.1 Answer any one out of the following (to be assigned by the examiner). (20 x 1 = 20)

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.
- 8.
- 9.
- 10.

Q.2 Answer any one out of the following (to be assigned by the examiner). (15 x 1 = 15)

- 1.
- 2.
- 3.
- 4.
- 5.

Q.3 Practical Record (07)

Q.4. Viva-Voce(08)

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