Course Structure: Four Years B.Sc. (Life Sciences with Computer Applications)

Semester I

Basic Concepts of Biology (24-CIR-C-101) (Major) 4 credits

Unit I: An overview of cells [12 L]

History, Cell theory, Overview of Prokaryotic and Eukaryotic Cells, Plant and Animal cells, exceptions to cell theory, Cell size and shape; Phages, Virioids, Mycoplasmas, Viruses, Prions, hierarchy in cell structure and cell molecules.

Unit II: Cell organelles [15 L]

Cell Organelles, composition and function. Mitochondria: structure, function, mitochondrial biogenesis; semiautonomous nature; mitochondrial DNA. Chloroplast: structure, function, semiautonomous nature, chloroplast DNA. Endoplasmic reticulum (rough and smooth): structure and function. Golgi complex: post translation modifications, cell secretion. Lysosomes, Peroxisomes and Glyoxisomes: structures, and functions.

Unit III: Nucleus and cell cycle [14 L]

Nucleus: nuclear envelope, nuclear pore complex, nuclear transport. Chromatin: molecular organization, euchromatin and heterochromatin, DNA packaging in eukaryotes, chromosomes, human karyotype, nucleolus. Cell Cycle: Role of cell cycle, Interphase. Cell division: Mitosis and Meiosis: different stages of cell division, cell cycle check points. Cytoskeleton: microfilaments, microtubules and intermediate filaments.

Unit IV- Membrane transport and cell signalling [15 L]

Cell membrane: structure, models, fluidity, selective permeability, functions, membrane transport: active and passive transport, ion channels, ion pumps. Cell wall structure and function. Cell signalling, signalling molecules, cell surface receptors, introduction to signalling pathways.

Recommended Books:

1. The Cell: A Molecular Approach. by Geoffrey M. Cooper. Eighth edition, 2018. Sinauer Associates Inc.
2. Campbell Biology by Lisa Urry, Michael Cain, Steven Wasserman, Peter Minorsky, Jane Reece. Eleventh Edition, 2017. Pearson Education, Inc.
3. De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.

Chemistry I (24-CIR-C-102) (Major) 4 credits

Unit 1: Stereochemistry [14 L]

Writing of Fischer projection, Newmann and Sawhorse projection and Wedge formulae. Relative stability of different conformations in terms of energy. *Geometrical Isomerism*: Cis- Trans and E/ Z notation along with CIP rules for geometrical isomers. *Optical Isomerism:* enantiomerism, diastereoisomerism, racemic mixtures and their resolution by salt formation method. *Relative and absolute configuration:* D / L nomenclature system for configuration of carbohydrates (difference between d/l and D/L notations). Threo and Erythro designation. R- and S- configuration (upto two chiral centres).

Unit 2: Addition reactions and substitution reactions [14 L]

Alkenes and Alkynes: Hydrogenation, addition of halogens, Hydrohalogenation, hydration, hydroxylation (cis and trans), oxymercuration-demercuration, hydroboration-oxidation, ozonolysis. Aldehydes and ketones. Addition of sodium bisulphite, hydrogen cyanide and alcohols. Addition- elimination reactions with ammonia. Aldol, Claisen, Knoevengel, Cannizzaro. Free radical substitution reactions: Halogenation of alkanes, allylic compounds and alkyl benzenes. Nucleophilic substitution reactions. Mechanism of S_N1 and S_N2 reactions. Replacement of diazo group. Alcohols, amines and phenols: Substitution of active hydrogen, replacement of hydroxyl group in alcohols (using PCl_5, $SOCl_2$ and HI). Carboxylic acid derivatives: Hydrolysis Ethers: Cleavage by HI.

Unit 3: Elimination and electrophilic substitution reactions [14 L]

Alkyl halides (dehydrohalogenation, Saytzeff's rule), vicinal dihalides (dehalogenation), alcohols (dehydration), Quaternary ammonium salts (Hofmann's elimination). Mechanism of $E_1$and E_2 reactions (nature of substrate and base), elimination vs substitution General mechanism of electrophilic substitution reactions (nitration, halogenation, sulphonation, Friedel Crafts alkylation and acylation), directive influence of substituents.

Unit 4: Oxidation and reductions [14 L]

Aromatic side chain: Oxidation with potassium permanganate, potassium dichromate Alcohols. catalytic dehydrogenation and Oppenauer oxidation. Oxidation of 1,2–diols with periodic acid and lead tetraacetate. Aldehydes. iodoform reaction and Baeyer–Villiger oxidation Aldehydes and Ketones: Catalytic hydrogenation, reduction with sodium borohydride, lithium aluminium hydride, Clemmensen, Wolff-Kishner Carboxylic acids and their derivatives: sodium-ethanol and Rosenmund reduction. Nitro compounds: Acidic, alkaline and neutral reducing agents.

Recommended Books:

1. L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
2. R. T. Morrison & R. N. Boyd: Organic Chemistry, Pearson Education.
3. Arun Bahl and B. S. Bahl : Advanced Organic Chemistry, S. Chand
4. Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
5. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London, 1994.
6. T. W. Graham Solomon's Organic Chemistry, John Wiley and Sons.
7. P.S. Kalsi, Stereochemistry, Conformation and Mechanism, John Wiley and Sons.

Science Laboratory I (24-CIR-C-103) (Major) 4 credits

1. Introduction to Biology Lab and general rules and regulations.
2. Glass wares and lab wares.
3. Study of the compound microscope.
4. Study of permanent slides of different stages of mitosis.
5. Study of permanent slides of different stages of meiosis.
6. Study of animal and plant cells using models and charts.
7. Study of prokaryotic cell using charts.
8. To prepare temporary mount of onion root tip to study different stages of mitosis.
9. To prepare temporary mount of a plant cell.
10. To study electron micrographs of different viruses.
11. To prepare temporary mount of human cheek cell.
12. Purification of organic compounds by crystallization using the following solvents:
    a. Water
    b. Alcohol
13. Determination of the melting points of organic compounds (by the Kjeldahl method andelectrically heated melting point apparatus).
14. Organic preparations: Carry out the following preparations using 0.5 - 1 g of starting compound. Recrystallize the product and determine the melting point of the recrystallized sample.
15. To prepare acetanilide by the acetylation of aniline.
16. Benzolyation of aniline or β-naphthol by Schotten-Baumann reaction
17. Semicarbazone derivative of one the following compounds: acetone, ethyl methylketone, diethylketone, cyclohexanone, benzaldehyde

Recommended Practical Books

1. Cell Biology: Practical Manual, 2018 by Dr. Renu Gupta, Dr. Seema Makhija, Dr. Ravi Toteja, Prestige Publishers
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012).
3. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Longman, London & NewYork.
4. Ahluwalia, V.K.; Dhingra, S. & Gulati, A. *College Practical Chemistry,* UniversitiesPress.

Concepts of Programming (24-CIR-M-104) (Minor) 4 credits

Unit-I: Programming concepts [14 L]

Basic concepts of programming languages: High-level and Low-level Languages, Language translators: Assemblers, Compilers, Interpreter and Editor; Concepts of flowcharting, algorithm, Program Compilation, Running of a Program; Header files, Preprocessor directives.

Unit-II: Basic elements and operators [14 L]

Basic elements: Identifiers, keywords, Variables and Constants, Variables/Identifiers declaration; Expressions, Statements, Basic data types of C. Operators and Expressions: Arithmetic Operators, Unary Operators, Relational and Logical Operators, Assignment and Conditional Operator, Expression Evaluation); Data Input/Output statements.

Unit-III: Control structures and functions [14 L]

Control Structures: Branching- if, if else, switch-case, Looping-for, while, do-while; break, continue. Functions: A Brief Overview, Library Functions, User defined functions, declaration, definition & scope, Accessing a Function, Function Prototypes, Passing Arguments to a Function: call by value, call by reference.

Unit-IV: Arrays and pointers [14 L]

Defining an Array: One- and two-dimensional arrays, declaration, initialization and processing; Passing Arrays to Functions, Strings, String Handling functions; Pointers: The & and * Operators, pointer declaration, assignment and arithmetic, array & pointer relationship, dynamic memory allocation, pointer to arrays, array of pointers.

Recommended Books:

1. Deitel and Deitel: How to Program C, Addison Wesley, Pearson Education Asia, 7th Edition.
2. Programming with C, Byron Gottfried (Schaum's Outlines) 4th edition, McGraw Hill International.
3. Let Us C: Authentic guide to C programming language - 19th Edition, BPB Publications.

Basic of Mathematics (24-CIR-T-105) (Multidisciplinary) 3 credits

Unit-I: Algebra-I [14 L]

Set and their representations, finite and infinite sets, subsets, type of sets, operations on sets and their algebraic properties, Venn diagram, ordered pair, Cartesian product & relation. Concept of functions and Relation in biological terminology, its domain and range, Types and classification of function, graphs of some well-known functions, even and odd functions, periodic functions, algebra of functions, composite functions, inverse of a function. Logarithms; exponential and trigonometric functions. Complex numbers; Cartesian System of Rectangular Coordinates; Straight lines and Family; Three-Dimensional Geometry.

Unit-II: Algebra-II [10 L]

Vectors; Basic operation of vector, scalar and vector product of vector, projection vector; Definition and examples of matrices, types of matrices, basic operations, equality of matrices, addition and scalar multiplication of matrices, properties of addition and scalar multiplication, transpose of a matrix, symmetric and skew symmetric matrices and their properties, matrix. multiplication in general and its properties. Definition of Determinant, minors and cofactors of an element of a determinant, singular and non-singular matrices, multiplicative inverse of a matrix and its properties, Applications.

Unit-III: Calculus-I [9 L]

Limits left hand and right-hand limits, algebra of limits, continuity of a function at a point, over an open/closed interval, differentiability of a function at a point, left hand and right-hand differentiability, relation between continuity and differentiability, Derivative of a function, its geometrical and physical significance, Applications.

Unit-IV: Calculus-II [9 L]

Introduction of indefinite integral, anti-derivative or primitive function, standard formulae, and fundamental laws of integrations, methods of integration: by substitution, by parts.
Definition of definite integral as the limit of sum, The fundamental theorem of calculus (without proof), evaluation of definite integral, transformation of definite integral by substitution, by parts. Properties of definite integral and problems based on these properties, Applications.

Recommended Books:

1. Differential Calculus by Shanti Narayan, P K Mittal, S Chand Publication.
2. Integral Calculus by Shanti Narayan, P K Mittal, S Chand Publication.
3. Textbook of Integral Calculus and Differential Equations, Khalil Ahmad, Anamaya Publication.
4. M. J. Strauss, G. L. Bradley and K. J. Smith, Calculus (3rd Edition), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.
5. H. Anton, I. Bivens and S. Davis, Calculus (7th Edition), John Wiley and Sons (Asia) Pte. Ltd., Singapore, 2002.
6. Schaum's Outline of Matrix Operations (Schaum's Outlines) by Richard Bronson.
7. Linear Algebra, by Seymour Lipschutz, Marc Lars Lipson. McGraw Hill Pub.

Ecology (24-CIR-V-106) (VAC) 2 credits

Unit-I: Ecosystem ecology, adaptation and succession [14 L]

Structure and function of ecosystem; Flow of energy and biogeochemical cycling of materials; Trophic levels, pyramids and food webs; Ecosystem types and diversity; Alterations of ecosystem function: acid rain, nuclear winter, greenhouse gases global warming and ozone hole; Ecological succession; Ecological adaptations of the plant and animal species: hydrophytes, mesophytes and xerophytes.

Unit-II: Ecology of population, community and waste management [14 L]

Populations and communities; Birth, death, population size, and age structure; Intraspecific and Interspecific interactions; Species diversity, community stability and disturbance, Brief idea about communicable and non-communicable diseases; Waste Management: Biomedical waste, e-waste management, hazardous waste, solid waste management.

Recommended Books:

1. Peter Stiling 2015. Ecology: Global Insights & Investigations 2nd Edition. McGraw-Hill international edition
2. Dash MC and Mishra PC, Man and Environment, McMillan Publishers , London.
3. Smith, TM and Smith RL 2015. Elements of Ecology, Pearson Education, India.
4. Cunningham, W.P. & Cunningham, M.A. 2003. Principles of environmental science, inquiry and applications. Tata McGraw-Hill Publ. Co. Ltd.
5. Odum, E. P. (2004). Fundamentals of Ecology, Oxford and IBH Publishing Co. Pvt. Ltd.
6. Chapman, J.L.& M.J. Reiss. 1998. Ecology: Principles and Applications. Cambridge Univ. press. 2 nd edition.
7. Sharma, P.D. Ecology and Environment, Rastogi publications,India
8. Archibold, O.W. 1995. Ecology of World Vegetation. Chapman & Hall, London.
9. John H. Vandermeer Deborah E. Goldberg (2013) Population Ecology: First Principles (Second Edition). Princeton University Press, ISBN: 978-0691160313.

Computational Laboratory I (24-CIR-S-107) (SEC) 3 credits

1. C program to swap two numbers.
2. C program to check whether the given number is
   (i) even or odd
   (ii) prime or not
3. C program to check leap year.
4. C program to calculate percentage and grade of n subjects.
5. C program to find LCM of two numbers.
6. C program to check whether the number is Palindrome.
7. C program to make Simple Calculator for addition, subtraction, multiplication and division using switch-case in C programming.
8. C program to find multiplication table using for loop.
9. C program to print pyramids and patterns.
10. C program to differentiate call by value and call by reference in functions.
11. C program to calculate factorials of n numbers using function.
12. C program to generate a Fibonacci series between 1 to N using a function.
13. C Program to find the length of a protein sequence entered by user.
14. C Program to append DNA sequence in the existing file.
15. C Program to store and concatenate two protein sequences.
16. C program to count number of unique words in a protein sequence.
17. C program to find the frequency of a subsequence in a protein sequence.
18. C Program to find the number of elements in an array
19. C Program to find smallest element in Array.
20. C program to access array elements using pointers.

Recommended Practical Books:

1. Yashavant P. Kanetkar, “Let Us C”, 16th Edition, 2019, BPB Publications, ISBN: 978- 93- 8728-449-4.

General English I (A) (AEC) 2 credits

Semester II

Biochemistry (24-CIR-C-151) (Major) 4 credits

Unit-I: Introduction to Biochemistry [16 L]

Structure of atoms, molecules and chemical bonds. Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.). Principles of biophysical chemistry. Physico-chemical properties of water. Dissociation of water. Henderson Hasselbalch equation and its usefulness: pKa, degree of dissociation and its dependence on pH, determination of pKa. Bronsted-Lowry acid and base. Buffers (definition, preparation of buffers, characteristics of buffers).

Unit-II: Carbohydrates and lipids [12 L]

Composition, structure and function of carbohydrates; introduction, classification, types, optical isomerism, mutarotation, basic structure and functions of monosaccharides, oligosaccharides, polysaccharides, examples-starch, glycogen, cellulose, hemicellulose, and chitin. Bioenergetics, glycolysis, oxidative phosphorylation, coupled reaction, group transfer, biological energy transducers.

Composition, structure and function of lipids, triglycerides, phospholipids, glycolipids, sphingolipids, sterols, cerebrosides, steroids, prostaglandins, glycolipids and proteoglycans.

Unit-III: Amino acids and protein [16 L]

Composition, structure and function of proteins and amino acids; Conformation of proteins (Ramachandran plot, secondary structure, domains, motif and folds). Principles of catalysis, enzymes and enzyme kinetics, enzyme regulation, mechanism of enzyme catalysis, isozymes. Stability of proteins. Composition, structure and function of vitamins.

Unit-IV: Nucleic acids [12 L]

Composition, structure and function of nucleic acids, nucleosides and nucleotides. Conformation of nucleic acids (helix (A, B, Z), t-RNA, micro-RNA). Stability of nucleic acids. Stereochemistry: nucleoside, torsion angles, sugar conformation. NMR study. DNA structure: different types of DNA and their structure, DNA motifs, DNA repeats and their significance, function and stability. Spectroscopic study of DNA: dye binding, interaction, denaturation, and renaturation of DNA, thermal denaturation and T_m value. Vitamins, coenzymes and other small molecules.

Recommended Books:

1. Lehninger Principles of Biochemistry (7th edition) NELSON, L. COX, M.M W.H. Freeman and Company, New York, 2017.
2. Biochemistry (2015) Eighth edition by Jeremy M. Berg, Lubert Stryer, John L. Tymoczko, Gregory J. Gatto. W. H. Freeman and Company, New York.
3. Fundamentals of Biochemistry: Life at the Molecular Level, 5th Edition. Donald Voet, Judith G. Voet, Charlotte W. Pratt. Wiley International.

Chemistry II (24-CIR-C-152) (Major) 4 credits

Unit 1: The covalent bond and the structure of molecules [14 L]

Valence bond approach, Concept of resonance in various organic and inorganic compounds, Hybridization and structure, equivalent and non-equivalent hybrid orbitals, Bent's rule and its applications, VSEPR model for predicting shapes of molecules and ions containing lone pairs, sigma and pi bonds. Molecular Orbital Approach: LCAO method, symmetry and overlap for s-s, s-p and p-p combinations, MO treatment of homonuclear diatomic molecules of 2nd period (B_2, C_2, N_2, O_2, F_2) and heteronuclear di-atomicmolecules (CO, NO) and their ions.

Unit 2: Transition elements (3*d* series) [14 L]

General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu. Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

Unit 3: Coordination Chemistry [14 L]

Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6. Drawbacks of VBT. IUPAC system of nomenclature. Coordination compounds in biological systems: Fe, Cu, Co, Mn, Ni, Zn and heavy metal ions.

Unit 4: Crystal field theory [14 L]

Crystal field effect, octahedral symmetry. Crystal field stabilization energy (CFSE), Crystalfield effects for weak and strong fields. Tetrahedral symmetry. Factors affecting the magnitude of D. Spectrochemical series. Comparison of CFSE for O_h and T_d complexes, Tetragonal distortion of octahedral geometry. Jahn-Teller distortion, Square planar coordination.

Recommended Books:

1. James E. Huheey, *"Inorganic Chemistry: Principles of structure and reactivity"*,Prentice Hall, IV Edition.
2. D. S. Shriver and P.A. Atkins, *"Inorganic Chemistry"*, Oxford University Press, IVEdition.
3. Alan G. Sharpe, "*Inorganic Chemistry"*, University of Cambridge, III Edition.
4. J. D. Lee, *"A New Concise Inorganic Chemistry"*, ELBS IV Edition
5. Grey L. Miessler and Donald A. Tarr, *"Inorganic Chemistry"*, Prentice Hall, III Edition.
6. B. Douglas, D. H. McDaniel and J. J. Alexander, *"Concepts and Models of Inorganic Chemistry", John Wiley and Sons, III Edition.*
7. Rodgers, G.E. *Inorganic & Solid State Chemistry*, Cengage Learning India Ltd., 2008.

Science Laboratory II (24-CIR-C-153) (Major) 4 credits

1. To determine the concentration of glucose in the given sample by Anthrone's/ Fehling' solution Method.
2. Estimation of cholesterol in the given sample.
3. To determine total lipid profile from human serum.
4. To determine the saponification value of mustard oil
5. To determine the activity of acid phosphatase and alkaline phosphatase.
6. To estimate the concentration of given protein using biochemical assays.

Acids-Bases:

7. Principles of acid-base titrations, Principle behind selection of an appropriate indicator.

a) Standardization of NaOH solution (standard solution of oxalic acid to be prepared)

b) Determination of concentration of carbonate and hydroxide present in a mixture.

Titrations involving redox reactions:

8. Concept of electrode potential, principle behind selection of an appropriate indicator.

a) Standardization of $KMnO_4$ solution (standard solution of Mohr's salt to be prepared).

b) Determination of concentration of Fe (II) in Mohr's salt and/or K2Cr2O7 using diphenylamine/ phenylanthranilic acid as internal indicator (standard solution of K2Cr2O7 and /or Mohr's salt to be prepared).

Complexometric Titrations

9. Principles of complexometric titrations

a) Determination of concentration of Mg (II) & Zn (II) by titrimetric method using EDTA.

b) Determination of concentration of Ca/Mg in drugs or in food samples.

Recommended Practical Books

1. Practical Biochemistry, 2016 by Damodaran Geetha K. Jaypee Brothers Medical Publishers.
2. Molecular Cloning: A Laboratory Manual (Fourth Edition), Volume 1, 2 & 3, 4th Edition. Green and Sambrook. Cold Spring Harbor Laboratory Press, 2012.
3. Vogel, A.I. *A Textbook of Quantitative Inorganic Analysis*, ELBS.
4. Harris, D.C. & Freeman, W.H. & Co. *Quantitative Chemical Analysis 7th Ed.,* New York.

Programming with Python (24-CIR-M-154) (Minor) 4 credits

Unit I: Basic Concepts [14 L]

Basic Concepts: IDE Interpreter for Python, Variables and Keywords, Operators and Expressions, I/O Functions; Data types: List, Tuple, Dictionary, Arrays, and Strings: Accessing, working, operations, related functions and methods.

Unit II: Control structures and functions [14 L]

Control structures, if-else conditional statement; Looping statements: for and while, break, continue and pass, Built-in Functions, Function Definition and Call, Arguments and Parameters; Importing user-defined modules.

Unit III: Python Classes and Objects [14 L]

Creating Class, Python objects, attributes and methods, accessing class attributes using objects, Data abstraction and Encapsulation, Python constructors, Parameterized constructors Instance methods, Operator overloading

Unit IV: Inheritance and polymorphism [14 L]

Concept of Inheritance, Types of Inheritance: single, multi-level, hierarchical, multiple; Polymorphism, Method overloading, dynamic binding, Packages: defining package list, package installation.

Recommended Books:

1. Taneja & Kumar: Python Programming: A Modular Approach, Pearson
2. Mark Lutz, Learning Python, O'Reilly Media, Inc.,
3. Kenneth & Lambert: Fundamental of Python. Course Technology

Physics I (24-CIR-T-155) (Multidisciplinary) 3 credits

Unit 1: Electrostatics and magnetostatics [12 L]
Coulomb's law, Electric field, Potential, Dipoles, Bio-Savart Law, magnetic field, Ampere circuital law, Magnetic dipole, current carrying conductor, Lenz's law, Faraday law, self and mutual inductance, electromagnetic induction and emf.

Unit II- Electrical circuit [10 L]
Voltage, current, power, effect of ac and dc on resistor, capacitor, inductor, RMS and average values, Kirchoff's rule, series and parallel circuit, impedance, voltage and current phase, LCR circuits, conditions in LCR circuits, resonance.

Unit III- Semiconductors and transistors [10 L]
Conductor, insulator, semiconductor, p and n type semiconductor, diode, half and full wave rectifiers, transistors, characteristic curve of transistors, Operational amplifiers, inverting and non-inverting amplifiers, adder, subtractor, differentiator, integrator.

Unit IV- Digital electronics [10 L]
Number system (binary, octal, hexa decimal), bits bytes, addition, subtraction, 1's compliment, 2's compliment, Boolean algebra, gates (AND, NAND, OR, XOR, NOT, GATES), De Morgan's theorem, truth tables, AD and DA convertors.

Recommended Books:

1. Digital Principles and applications, A.P. Malvino, D.P. Leach and Saha, 7th Ed., 2011, Tata McGraw Hill.
2. Digital circuit and systems, Venugopal 2011, Tata McGraw Hill.
3. Digital electronics, S.K. Mandal, 2010, Tata McGraw Hill,
4. Electronics: Fundamentals and applications, J.D. Ryder, 2004, Prentice Hall.
5. Electronic devices and circuits, S. Salivahanan and N.S. Kumar, 2012, Tata McGraw Hill.

Environmental Sciences (24-CIR-V-156) (VAC) 2 credits

Unit I: Environmental Science, Natural resources, biodiversity and conservation [14 L]
Environmental Science: An overview; Scopes and Objective of Environmental Science; Management and conservation of wildlife; Soil erosion and conservation; Brief idea of Environmental Laws: Water Act, 1974, Air Act, 1981, The Wildlife (Protection) Act, 1972, Environment Protection, 1986, Natural Disasters and their Management, Biodiversity hotspots ,Loss of biodiversity and its causes; Biodiversity conservation tools and strategies; In-situ methods, Ex-situ Methods ; IUCN and IUCN Red List, an overview of biodiversity convention and protocols.

Unit–II: Environmental pollution, Problems and Global environmental issues [14 L]
Environment Pollution, types and control;Environmental Problems and Global Environmental Issues: Climate change and its causes; Inter-governmental panel on climate change; UNFCC, KYOTO Protocol, IPCC Reports, Environment issues and health effects; Environmental movements in India, Brief idea of International organizations and conventions.

Recommended Books:

1. Dash MC and Mishra PC, Man and Environment, McMillan Publishers, London.
2. Cunningham, W.P. & Cunningham, M.A. 2003. Principles of environmental science, inquiry and applications. Tata McGraw-Hill Publ. Co. Ltd.
3. Odum, E. P. (2004). Fundamentals of Ecology, Oxford and IBH Publishing Co. Pvt. Ltd.
4. Sharma, P.D. Ecology and Environment, Rastogi Publications, India
5. APHA, 2012. Standard Methods for the Examination of Water and Waste water (21st ed). APHA.

Computational Laboratory II (24-CIR-S-157) (SEC) 3 credits

1. Write a program for checking the given number is even or odd.
2. Implement Python Script to print sum of N natural numbers.
3. Finding the sum and average of given numbers using lists.
4. Write a program that takes a DNA sequence (string) as input and calculates the percentage of each nucleotide (A, T, C, G) in the sequence.
5. Implement Python Script to check given string is palindrome or not.
6. Define a function max_of_three() that takes three numbers as arguments and returns the largest of them.
7. Implement a python script to check the element is in the list or not by using Linear search & Binary search.
8. Write a program to check if the substring is present in a given string or not.
9. Create a class Protein that has methods to calculate the molecular weight based on the amino acid composition of the protein. Use a dictionary to store the molecular weights of each amino acid.
10. Write a program to create tuples (name, age, address, college) for at least two members and concatenate the tuples and print the concatenated tuples.
11. Write a program that displays which letters are present in both strings.
12. Write a Python class named Person with attributes name, age, weight (kgs), height (ft) and takes them through the constructor and exposes a method get_bmi_result() which returns one of "underweight", "healthy", "obese".
13. Write a Python class named Circle constructed by a radius and two methods which will compute the area and the perimeter of a circle.
14. Write a program to create, display, append, insert and reverse the order of the items in the array.
15. Write a program to add, transpose and multiply two matrices.
16. Create a base class called Animal with attributes like name and species. Then create a derived class Dog that inherits from Animal and has an additional attribute breed. Write methods to display information about the animal and the dog.
17. Create a class called Book that has attributes for title, author, and price. Implement methods to display book information and apply a discount to the price.
18. Create a base class Employee and another class Freelancer. Implement a derived class Contractor that inherits from both classes. Add a method to display the contractor's details.
19. Define a base class Shape with a method area(). Create derived classes Rectangle, Circle, and Triangle, each implementing the area() method. Write a function that takes a list of shapes and prints their areas.
20. Use matplotlib to create a scatter plot that represents the relationship between two variables, such as temperature and enzyme activity in a given experiment.

Recommended Practical Books:

1. Taneja & Kumar: Python Programming: A Modular Approach, Pearson
2. Mark Lutz, Learning Python, O'Reilly Media, Inc.,
3. Kenneth & Lambert: Fundamental of Python. Course Technology

General English II (A) (AEC) 2 credits

Internship (24-CIR-I-158) 4 credits
(only for those who exit after Ist year)

Semester III

Molecular Biology (24-CIR-C-201) (Major) 4 credits

Unit I: Nucleic acid as genetic material [14 L]

Basic understanding and Central dogma of molecular biology, Nucleotides as a structural and functional unit of nucleic acid, Definition and significance of gene, Structure of nucleoside, nucleotide and nucleic acids-The nature of chemical bonds; Nomenclature system to designate nucleoside and nucleotides. Polymerization of nucleotides, structure of DNA and RNA, Deviations in DNA structure and their significance, DNA as a genetic material of bacteria (Avery-MacLeod-McCarty experiment), Virus (Hershey-Chase experiment).

Unit II: DNA replication [14 L]

Fidelity of DNA replication, Base pair geometry, Semi conservative nature, Meselson-Stahl experiment, Types and functions of DNA polymerases in E. coli, Proof reading activity, Requirements for DNA polymerase activity, Polymerization rate and processivity, Klenow fragment, Replication of DNA in prokaryotic system, Origin of replication, Replication fork, Initiation, elongation and termination processes in DNA replication, Regulation of DNA replication, DNA ligase, Special function of DNA polymerase I and Nick translation.

Unit III: RNA transcription [14 L]

DNA dependent synthesis of RNA, RNA Polymerases, promoters and initiation of RNA synthesis in *E. coli*, Prerequisites for RNA polymerase activity, Elongation and termination of transcription, Transcription factors, Transcription in eukaryotes, Differences with DNA polymerase activity, RNA processing, RNA splicing, Splicing mechanisms of Group I and Group II introns, RNA-dependent synthesis of RNA and DNA. Post transcriptional modifications.

Unit IV: Protein translation [14 L]

Genetic code, mRNA and reading frame, Protein synthesis, Activation of amino acids, tRNA, Aminoacyl-tRNA synthetases, Initiation, elongation and termination of Polypeptide synthesis in *E. coli*. Overview of translation in eukaryotes, Prosthetic groups. Post translational modifications.

Recommended Books:

1. Lehninger Principles of Biochemistry (4th Ed.) Nelson, D., and Cox, M.; W.H. Freeman and Company, New York, 2005.
2. Lehninger Principles of Biochemistry (7th edition) NELSON, L. COX, M.M W.H. Freeman and Company, New York, 2017.
3. Biochemistry (2015) Eighth edition by Jeremy M. Berg, Lubert Stryer, John L. Tymoczko, Gregory J. Gatto. W. H. Freeman and Company, New York.

Chemistry III (24-CIR-C-202) (Major) 4 credits

Unit-1: Biological membranes [14 L]

Colloidal solution, Micelles, reverse micelles, bilayers, liposomes, phase transitions of lipids, active, passive and facilitated transport of solutes and ions, Fick's Laws, Nernst Planck Equations, Diffusion, Osmosis, Donnan effect, permeability coefficient. Ionophores, transport equation, membrane potential, water potential. Intermolecular interactions (van der Waals forces, Hydrogen bonding, and its applications, effects of these forces on meltingpoint, boiling point, and solubility.

Unit-2: Conductance [14 L]

Unit 3: Conductance Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes, Kohlrausch Law of independent migration of ions, transference number and its experimental determination using Hittorf and moving boundary methods, Ionic mobility, applications of conductance measurements: determination of degree of ionization of weak electrolytes, solubility and solubility Page 14 of 96 B.Sc. Physical Science products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base).

Unit 3: Electrochemistry [14 L]

Electrochemistry Reversible and irreversible cells, concept of EMF of a cell, measurement of EMF of a cell, Nernst equation and its importance, types of electrodes, standard electrode potential, electrochemical series. thermodynamics of a reversible cell, calculation of thermodynamic properties: G, H and S from EMF data. Calculation of equilibrium constant from EMF data, concentration cells with transference and without transference, liquid junction potential and salt bridge, pH determination using hydrogen electrode and quinhydrone electrode, Potentiometric titrations-qualitative treatment (acid-base and oxidation-reduction only).

Unit-4: Theory of Quantitative Analysis [14 L]

Principle of Volumetric Analysis- introduction, standard solutions, indicators, end point, titration curves, Types of titrations) neutralization titration- principle, titration curves and selection of indicators- strong acid - strong base, strong acid –weak base, weak acid- strong base and weak acid –weak base. ii) Redox titrations- principal, detection of end point, redox indicators. iii) Precipitation titrations, principle, detection of end point, indicators. iv) Complexation titrations principle, metal ion indicators. Principle of Gravimetric analysis-nucleation, precipitation, growth of precipitate, filtration and washing, drying and incineration of precipitate, coprecipitation and post precipitation.

Recommended Books:

1. Castellan, G.W. (2004), Physical Chemistry, Narosa.
2. Kapoor, K.L. (2015), A Textbook of Physical Chemistry, Vol 1, 6th Edition, McGraw Hill Education.
3. Kapoor, K.L. (2013), A Textbook of Physical Chemistry, Vol 3, 3rd Edition, McGraw Hill Education.
4. B.R.Puri, L.R.Sharma, M.S. Pathania, (2017), Principles of Physical Chemistry, Vishal Publishing Co.

Science Laboratory III (24-CIR-C-203) (Major) 4 credits

1. Preparation and sterilization of reagents.
2. Bacterial DNA extraction.
3. Whole blood DNA extraction.
4. Estimation of DNA concentration and purity.
5. Agarose gel electrophoresis.
6. Total RNA extraction.

Conductance

7. Determination of cell constant.
8. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
9. Perform the following conductometric titrations: a) Strong acid vs strong base b) Weak acid vs strong base.
10. Potentiometry
11. Perform the potentiometric titrations of (i) Strong acid vs strong base and (ii) Weak acid vs strong base.
12. Determination of optical activity by using a polarimeter.

Recommended Practical Books

1. Molecular Cloning: A Laboratory Manual (Fourth Edition), Volume 1, 2 & 3, 4th Edition. Green and Sambrook. Cold Spring Harbor Laboratory Press, 2012.
2. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), Senior Practical Physical Chemistry, R. Chand & Co.

Database Management System (24-CIR-M-204) (Minor) 4 credits

Unit I: Database systems [14 L]

Database & Database systems Concepts, Characteristics of Database, Database System Environment, Database System Versus File Systems, Workers on and behind the Scene Advantages of Using the DBMS Approach, Database Applications, When Not to Use a DBMS.

Unit II: Concepts and architecture [14 L]

Data Models, Schemas, and Instances, Three-Schema Architecture and Data Independence, Database Languages and Interfaces, Database System Component Modules, Utilities and Tools, Centralized and Client/Server Architectures for DBMSs, Classification of Database Management Systems.

Unit III: Conceptual data modelling and database design [14 L]

Using High-Level Conceptual Data Models for Database Design, A Sample Database Application, Entity Types, Entity Sets, Attributes, and Keys, Relationship Types, Relationship Sets, Roles, and Structural Constraint, Weak Entity Types, ER Diagrams.

Unit IV: Relational data model and SQL [14 L]

Relational Data Model and Relational Database Constraints, Relational Model Concepts, and Relational Database Schemas, Update Operations, Transactions, and Dealing with Constraint Violations; Basic SQL, Data Definition and Data Types, Specifying Constraints in SQL, Basic Retrieval Queries in SQL, INSERT, DELETE, and UPDATE Statements in SQL.

Reference Books:

1. Elmasari and Navathe, “Fundamentals of Database Systems”, Seventh Edition, Pearson Publications.
2. Silberschats, Korth, Sudarshan, “Database System Concepts”, Fifth edition., McGraw Hill.
3. I. Bayross, “SQL, PL/SQL: the programming language of oracle”, Second Edition, BPB Publications

Physics II (24-CIR-T-205) (Multidisciplinary) 3 credits

Unit I: Simple harmonic motion [14 L]

Periodic motion, Simple harmonic motion, Displacement equation for SHM, Phase, propagation constant, velocity and acceleration in a progressive wave, Superposition of waves, longitudinal and transverse wave and their propagation.

Unit II: Electromagnetic spectrum [14 L]

Photoelectric effect, Compton effect, Wave particle duality, Davisson Germer experiment, de Broglie wave, Uncertainty principle, electromagnetic spectrum; microwave, infra-red, ultraviolet sand visible light, x-ray, gamma ray, lasers and their applications.

Unit III: Wave optics [10 L]

Huygens principle, Wavefront, Young's double slit experiment, concept of path difference and dark and bright fringes, interference in thin films (parallel and wedge shape), diffraction (Fraunhoffer and Fresnel): single slit, double slit, multiple slit, grating, theory of zone plates.

Unit IV: Electromagnetic theory [10 L]

Electromagnetic waves generation and equations, wave velocity and propagation constant, wave in free space, dielectrics and conductors (skin depth), poynting vector, plane wave reflection and refraction.

Recommended Books:

1. The physic of waves and oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
2. Waves: Berkley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw Hill.
3. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McgRAW Hill.
4. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill.
5. Introduction to electrodynamics, D.J. Griffiths, 1998, Benjamin Cummings.

Scientific Writing and Presentation (24-CIR-V-206) (VAC) 2 credits

Unit I: Scientific writing [14 L]

Types of academic writing: Essays, reviews, research paper, report, term paper, review article, thesis, dissertation, comment paper, short communication, case study, etc.; Stages in scientific writing : Collecting information, conducting a review of the literature ,listing key words, noting selected references ,preparing references at the time of review of the literature, preparing a working bibliography; Types of bibliographies: Annotated bibliography; End notes and footnotes; Language of Research Writing :Appropriate tone, diction and style ; Definition and forms of plagiarism.

UNIT III Data collection and presentation [14 L]

Sampling and methods of data collection: observation, interview, questionnaire, and case study; Types of Data presentation, editing, coding, tabulation, and graphical representation of data; Preparation of tables, Requisites of a good table; Basic statistics, correlation, and regression; Testing of hypothesis; Introduction to data analysis tool pack in Microsoft Excel; Citation databases: Web of Science, Scopus, etc.,

Recommended Books

1. Kothari, C.R. Research Methodology: Methods and Techniques, New Age International Private Limited, New Delhi.
2. Day, R. and Castel, B. (2012). How to Write and Publish a Scientific Paper (7th) Cambridge: Cambridge University Press
3. Swales, J. M. and Feak, C. B. (2000). English in Today's Research World: A Writing Guide. Michigan: University of Michigan.
4. Allan Bluman (2009) Introductory Statistics. A step-by-step approach (7th edition). McGraw-Hill.
5. Strunk, W. and E.B. White. The Elements of Style. 2000. Pearson Education, Inc.

Computational Laboratory III (24-CIR-A-207) (AEC) 2 credits

1. **Create and use the following database schema to answer the given queries.**
   STUDENT Schema
   Field Type NULL KEY
   DEFAULT
   SnoChar (3) NO PRI NIL
   SnameVarchar (50) NO NIL
   course_typeVarchar (50) NO NIL
   department Char (3) Yes FK NIL
   admission_date Date NO NIL
   Dno Integer YES FK NIL
   fees Decimal (7,2) NO NIL
   DEPARTMENT Schema
   Field Type NULL KEY
   DEFAULT
   Dno Integer No PRI NULL
   DnameVarchar (50) Yes NULL
   Location Varchar (50) Yes New Delhi

2. **Query List**
   Query to display student Name, course, admission Date, student Number; for each student with the student Number appearing first.
   Query to display unique course from the Student Table.
   Query to display student Name concatenated by a course separated by a comma.
   Query to display all the data from the Student Table. Separate each Column by a comma and name the said column as THE_OUTPUT.
   Query to display the Student Name and fees of all the student fees more than Rs2850.
   Query to display Student Name and Department Number for the Student No= 0011.

Recommended Practical Books:

1. A Silberschatz, H Korth, S Sudarshan, “Database System and Concepts”, fifth Edition McGraw-Hill, Rob, Coronel, “Database Systems”, Seventh Edition, Cengage Learning.

Semester IV

Recombinant DNA Technology (24-CIR-C-251) (Major) 4 credits

Unit I: Nucleic acid isolation and analysis [14 L]

Principles of DNA isolation; Nucleic acid isolation and purification methods from bacterial cells, whole blood and plant cells; Preparation of plasmid DNA, separation of plasmid DNA on the basis of size and conformation; Assessment of quality of purified DNA, Quantification of DNA, Agarose gel electrophoresis; RNA extraction and analysis.

Unit II: Nucleic acid amplification and sequencing [14 L]

Nucleic acid amplification principle and techniques, Signal amplification and target amplification, Polymerase Chain Reaction (PCR) and analysis of amplicons, Applications of PCR; Real time PCR and applications, Principle and methods of DNA sequencing. Applications of DNA sequencing.

Unit III: Enzymes in recombinant DNA technology [14 L]

DNA and RNA polymerases, Endonucleases and Exonucleases, Methylases, DNAases and RNAases, DNA ligases, Principle and methods of Restriction enzyme digestion, analysis of restriction enzyme digested products. DNA fingerprinting and DNA foot printing- principles, methods and applications.

Unit IV: Gene cloning [14 L]

Vectors, Linkers, adaptors and TA cloning vector; Basic requirements for a suitable cloning vector, Phage DNA as cloning vector; Cloning and expression vectors; Preparation of competent cells; Recombinant DNA; Transformation, selection of transformants; Cloning and selection of recombinants.

Recommended Books:

1. Gene Cloning and DNA Analysis: An Introduction, 8th Edition, T. A. Brown, ISBN: 978-1-119-64078-3, November 2020, Wiley-Blackwell.
2. Gene Cloning and DNA Analysis, 5th Edition. T. A. Brown. Blackwell Publishing. 2006
3. Recombinant DNA Techniques: A Textbook Paperback – 1 January 2011 by Monika Jain (Author), Publisher: Narosa.

Plant and Animal Physiology (24-CIR-C-252) (Major) 4 credits

Unit I: Plant-water relationship, Transpiration, Mineral Nutrition and Translocation [14 L]

Water Potential and its components, Transpiration, Root pressure and guttation; Photosynthesis: Photochemical reactions, mechanism of electron transport in Photosystem I and II, Calvin cycle, C_3 , C_4 and CAM Pathway, Photorespiration; Respiration: Glycolysis, Oxidative phosphorylation, mitochondrial ETS; Nitrogen metabolism, role of nitrogenase in N_2 fixation.

Unit II: Photosynthesis and Lipid metabolism [14 L]

Photoperiodism: photoperiodic responses and classification of plants; Photomorphogenesis; Plant growth regulators; Mineral nutrition: essential, macro and micronutrients, transport of ions across membrane, active and passive transport, channels and pumps; Mechanism of enzyme action and enzyme inhibition; Dormancy.

Unit III: Nerve and Muscle Systems [14L]

Structure of neuron, resting membrane potential, Origin of action potential and its propagation across the myelinated and non-myelinated nerve fibers; Types of synapse, Synaptic transmission and Neuromuscular junction; Reflex action, Physiology of hearing and vision. Histology of different types of muscle; Ultra structure of skeletal muscle, Physiology of skeletal muscle contraction.

Unit IV: Endocrinology [14 L]

Endocrine glands- Structure and Function of Pituitary, Thyroid, Parathyroid, Adrenal glands and pancreas. Neuroendocrine System, Anatomy of male and female reproductive system, Hormonal regulation of reproduction, Placental hormones.

Recommended Books:

1. Hopkins, W.G. & Guner, A.(2008). Introduction to Plant Physiology. John Wiley& Sons. U. S.A.4th ed.
2. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.
3. Salisbury,F.B and Ross,C.W. Plant Physiology, Wadsworth Publishing Company Ltd.
4. Tortora, G.J.& Derrickson, B.H. (2009). Principles of Anatomy and Physiology, 12th edn., John Wiley & Sons, Inc.
5. Widmaier, E.P., Raff, H. & Strang, K.T. (2008) Vander's Human Physiology, 11th ed, McGraw Hill.
6. Guyton, A.C. & Hall, J.E. (2011) Textbook of Medical Physiology, 12th ed, Harcourt Asia Pvt. Ltd/ W.B. Saunders Company
7. Veer Bal Rastogi, Textbook of Animal Physiology

Chemistry IV (24-CIR-C-253) (Major) 4 credits

Unit 1: Chemical energetics [14 L]

Review of the Laws of Thermodynamics.

Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formation, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchhoff's equation. Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

Unit 2: Chemical and ionic equilibrium [14 L]

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG^{o}, Le Chatelier's principle. Relationships between K_p, K_c and K_x for reactions involving ideal gases. Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts – applications of solubility product principal.

Unit 3: Chemical kinetics [14 L]

The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero and first order reactions. Half–life of a reaction. General methods for determination oforder of a reaction. Concept of activation energy and its calculation from Arrhenius equation. Enzyme kinetics.

Unit 4: Photochemistry [14 L]

Laws of photochemistry. Fluorescence and phosphorescence. Quantum efficiency and reasons for high and low quantum yields. Primary and secondary processes in photochemical reactions. Photochemical and thermal reactions.

Recommended Books:

1. Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry* 9th Ed., Oxford UniversityPress (2011).
2. Ball, D. W. *Physical Chemistry* Thomson Press, India (2007).
3. Castellan, G. W. *Physical Chemistry* 4th Ed. Narosa (2004).
4. Mortimer, R. G. *Physical Chemistry* 3rd Ed. Elsevier: NOIDA, UP (2009).
5. Chang, R. *Physical Chemistry for the Biosciences.* University Science Books (2005).

Science Laboratory IV (24-CIR-C-254) (Major) 4 credits

1. Plasmid DNA isolation and confirmation.
2. Restriction digestion and its confirmation.
3. Restriction mapping and analysis.
4. Ligation to form the recombinant plasmid.
5. Competent cells preparation.
6. Transformation and its confirmation.
7. Determination of osmotic potential of plant cell sap by plasmolytic method.
8. Experiment to measure the rate of transpiration by using Farmer's Potometer.
9. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte.
10. Separation of photosynthetic pigments by paper chromatography.
11. Study of permanent slides of mammalian skin, cartilage, bone, spinal cord, nerve cell, lung, stomach, small intestine, large intestine, pituitary, pancreas, testis, ovary, adrenal, thyroid and parathyroid.
12. Estimation of haemoglobin from human blood and determination of blood clotting time.
13. Calculation of body mass index (BMI), estimation of erythrocyte sedimentation rate (ESR) and measurement of blood pressure (BP).

pH-metric and potentiometric measurements

14. Preparation of sodium acetate-acetic acid buffer solutions and measurement of their pH.
15. Determination of dissociation constant of a weak acid.

Study the kinetics of the following reactions:

16. **Initial rate method:** Iodide-persulphate reacdevelopmental biologtion
17. **Integrated rate method:**
    (A) Acid hydrolysis of methyl acetate with hydrochloric acid.
    (B) Saponification of ethyl acetate

Colourimetry

18. Verification of Lambert-Beer's Law for potassium dichromate/ potassium permanganatesolution.
19. Determination of pK (indicator) for phenolphthalein.

Recommended Practical Books

1. Molecular Cloning: A Laboratory Manual (Fourth Edition), Volume 1, 2 & 3, 4th Edition. Green and Sambrook. Cold Spring Harbor Laboratory Press, 2012.
2. Bajracharya D. (1999). Experiments in Plant Physiology-A Laboratory Manual. Narosa, Publishing House, New Delhi.
3. Animal Micro techniques by Humason (1962).
4. Animal cell culture a practical approach by R.W. Masters (2000).
5. Arey, L.B. (1974). Human Histology. IV Edition. W.B. Saunders
6. Khosla, B.D.; Garg, V.C.; Gulati, A. & Chand, R. Senior Practical Physical Chemistry, New Delhi.

Computational Statistics (24-CIR-M-255) (Minor) 4 credits

Unit 1: Descriptive statistics and distribution [14 L]

Measures of dispersion; Mean Deviation for grouped and ungrouped data; Variance and Standard Deviation; and Analysis of Frequency Distribution. Measures of location and spread; symmetry of data (moments, skewness and kurtosis). Probability, law of probability, conditional probability, Baye's Rule and Screening Tests; ROC curves, Prevalence and Incidents. Random variable, probability distribution, binomial, poission and normal distributions.

Unit 2: Hypothesis testing [14 L]

Hypothesis, z-test, t-test, One-sample hypothesis: hypothesis concerning the mean, confidence limit for population mean, sample size and estimation of population mean, hypothesis limit for the population variance, hypothesis concerning the variance. **Two-**sample hypothesis: difference between two mean, testing for difference between two variance. Pair-sample hypothesis: mean comparison of pair sample. Multiple hypotheses: mean comparison more than two groups (ANOVA).

Unit 3: Non-parametric methods and category data analysis [14 L]

Nonparametric statistics, The Sign Test, Wilcoxon Signed-Rank Test, The Wilcoxon Ranks-Sum Test, two sample test for binomial properties, Fisher's Exact Test, McNemar's Test, $R \times C$ Contingency tables, chi-square goodness of fit test, Data Transformation, clustering analysis.

Unit 4: Regression and correlation methods [14 L]

Fitting regression line- method of least squares, inference about parameters from regression lines, interval estimation for linear regression, assessing the goodness for fit of linear regression lines, correlation coefficient, inference of correlation coefficient, and multiple regressions, partial and multiple correlation and rank correlation.

Recommended Books:

1. B. Rosner, *Fundamentals of biostatistics*. Boston: Brooks/Cole, Cengage Learning, 2011.
2. J. H. Zar, *Biostatistical analysis*, 4th ed. Upper Saddle River, N.J: Prentice Hall, 1999.
3. P. N. Arora, P. K. Malhan, *Biostatistics*, Himalaya Publishing House, 2006.
4. S. C. Gupta, V. K. Kapoor, *Fundamental of mathematical statistics,* Sultan Chand and Sons New Delhi.
5. V. K. Rohatgi, A. K. Md. Ehsanes Saleh, *An introduction to probability and statistics*, 2nd ed., John Wiley and Sons (Asia) Pvt. Ltd.

IPR, Bioethics and Biosafety (24-CIR-V-256) (VAC) 2 credits

Unit I: Bioethics and biosafety [14 L]

Definition of ethics, Ethics in Research; Scientific misconduct: Falsification, fabrication and Plagiarism, Research Design and ethics, concept of bioethics; bioethics and biosafety: ethical issues during and after the scientific study; Animal ethics in experimental research, Role of Institutional ethics committee(IER).

Unit II: IPR and Patents [14 L]

Introduction to Intellectual Property (IP) and Intellectual Property Rights (IPR), Importance of IP, Types of IP; difference between Geographical Indication and Trademark, Concept and Basics of patents, Process of obtaining a patent in India; Brief idea of GATT, WTO and TRIPS agreement, Role of WIPO.

Recommended Books

1. Kankanala C (2007). Genetic Patent Law & Strategy, Ist Edition, Manupatra Information Solution Pvt. Ltd. New Delhi.
2. Goel D & Prashar S (2013). IPR, Biosafety and Bioethics. Pearson
3. Senthil Kumar Sadhasivam and Mohammed Jaabir, M. S. 2008. IPR, Biosafety and Biotechnology Management. Jasen Publications, Tiruchirappalli, India.
4. Biotechnology and Safety Assessment Thomas J.A., Fuch R.L Academic Press 3rd Edition 2002
5. Bioethics & Biosafety R Rallapalli &Geetha Bali APH Publication 2007

Computational Laboratory IV (24-CIR-A-257) (AEC) 2 credits

1. Descriptive statistical analysis using excel (Microsoft Office tool).
2. Understand probability distributions using excel (Microsoft Office tool).
3. Perform hypotheses testing (one-sample) on excel or other compatible software (web-based tools).
4. Perform hypotheses testing (two-sample) on excel or other compatible software (web-based tools).
5. Perform hypotheses testing (ANOVA) on excel or other compatible software (web-based tools).
6. Correlation and regression analysis on excel or other compatible software.

Recommended Practical Books:

1. Statistics for managers using Microsoft Excel by David M. Levine, David F. Stephan, Timothy C. Krehbiel, Mark L. Berenson, 2010

Internship (24-CIR-I-258) 4 credits

(only for those who exit after IInd yr)

Semester V

Molecular Genetics (24-CIR-C-301) (Major) 4 credits

Unit I: Concept of gene and Mendelian genetics [14 L]

Mendelian principles: dominance, segregation and independent assortment, test and back crosses; Classical concept of gene: Allele, multiple alleles, pseudo-allele; Allelic interactions: concept of dominance, incomplete dominance, co-dominance, pleiotropy, genomic imprinting, essential and lethal genes. Non allelic interactions: Interaction producing new phenotype complementary genes, epistasis (dominant and recessive); Linkage and crossing over.

Unit II: Eukaryotic genome organization [14 L]

Eukaryotic nuclear genome nucleotide sequence composition -unique and repetitive DNA, satellite DNA, centromere and telomere DNA sequences, noncoding DNA; Eukaryotic chromosome: morphology, concept of euchromatin and heterochromatin, chromosome banding pattern, karyotype, giant chromosomes, polytene chromosomes, one gene one polypeptide hypothesis, Transposable elements.

Unit III: Prokaryotic genome organization [14 L]

Genetics of bacteria and bacteriophages, bacterial mutants, mutant detection and isolation; conditional mutant; silent mutation; Ames test; extra chromosomal genetic elements in bacteria, Restriction modification system in Bacteria; F factor and conjugation; Transformation; Transduction; Bacteriophages: Nomenclature, structure and assay; Bacteriophages lambda: life cycle and gene regulation; Biology of filamentous phage.

Unit IV: Sex determination, chromosomal aberrations and gene mutation [14 L]

Sex determination and sex linkage: Mechanisms of sex determination, Barr bodies, sex linked diseases and inheritance; Chromosome and gene mutations: Definition and types of mutations, causes of mutations, DNA repair mechanisms; variations in chromosomes structure, chromosomal aberrations in human beings, abnormalities: Aneuploidy (Down, Turner, Klienfelter syndrome) and euploidy, non-disjunction.

Reference books:

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. Principles of Genetics. John Wiley & Sons, 7th Edition, 2016.
2. Klug, W.S., Cummings, M.R., Spencer, C.A. Concepts of Genetics. Pearson Publishers, 12th edition, 2019.
3. Griffiths, A.J.F., Wessler, S,R., Lewontin, R.C. and Carroll, S.B. Introduction to Genetic Analysis, W. H. Freeman & Co, 2007.
4. Human Genetics, Gardener, A., R.T. Howel and T. Davies, published by Vinod Vashistha for Viva Books Private Ltd., 2008.

Diversity in Life Forms and Developmental Biology (24-CIR-C-302) 4 credits (Major)

Unit I: Outline classification of plants, animals & microorganisms [14 L]

Concepts of species and hierarchical taxa, biological nomenclature, levels of organization of Unicellular, colonial and multicellular forms, Levels of organization of tissues, organs & systems, Adaptive modifications, Classification of plants, animals and microorganisms, Important criteria used for classification in each taxon.

Unit II: Organisms of health, agricultural importance and conservation concern [14 L]

Common parasites and pathogens of humans, domestic animals and crops, Rare, endangered species, Conservation strategies, Major habitat types of the subcontinent, migrations of species, Common Indian mammals, birds, phenology of the subcontinent.

Unit III: Basic concepts of development [14 L]

Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; post embryonic development- larval formation, metamorphosis; environmental regulation of normal development.

Unit IV: Gametogenesis, fertilization and early development [14 L]

Production of gametes, spermatogenesis, oogenesis, cell surface molecules in sperm-egg recognition in animals; double fertilization in plants, zygote formation, cleavage, blastula formation, gastrulation and formation of germ layers in animals; embryogenesis, seed formation and germination.

Recommended Books:

1. Developmental Biology (2016) 11th Edition, Gilbert, S. and Barresi, M. Sinauer Associates, USA.
2. Principles of Development (2011) 3rd Edition, Wolpert, L. Smith, J., Jessell, T., Lawrence, P., Robertson, E. and Meyerowitz, E. Oxford University Press.
3. P.S. Verma and V.K. Agarwal, (2009) Chordate Embryology. S. Chand and Co. Ltd., New Delhi.
4. Scott F. Gilbert, (2003) Developmental Biology, 7th Ed., Sinauer Associates, Inc, Sunderlands, Massachusets.
5. The Diversity of Life, (1992) Edward O. Wilson, Harvard University Press.
6. Diversity of life forms, (2022) Edited by Andrea Arcangeli, Intelliz Press.

Biophysical and Biochemical Techniques (24-CIR-C-303) (Major) 4 credits

Unit-I- Introduction to spectroscopy [14 L]

Electromagnetic radiation, fundamental definitions, electromagnetic spectrum, introduction to concepts of absorption and emission spectroscopy, Beer-Lambert law. IR Spectroscopy: Fundamental and non-fundamental molecular vibrations, IR spectrum, fingerprint, and group frequency regions and their significance, Hooke's law, and vibrational frequency. Electronic Spectroscopy: Electronic transitions, singlet and triplet states, dissociation, and predissociation. UV spectroscopy: Types of electronic transitions, Characteristic UV transitions in common functional groups. General applications of UV spectroscopy including the distinction between cis-trans isomers. Woodward rules for calculating λmax.

Unit-II- Introduction to electron microscopy [14 L]

Introduction to Electron Microscopy, Introduction to electron-solid interactions, Introduction of transmission electron microscopy (TEM), and Scanning electron microscopy (SEM). How Atomic force microscopy (AFM) works and what is the Principle of AFM. Basic principle of confocal microscopy.

Unit-III-NMR spectroscopy [14 L]

PMR spectroscopy: Basic principles of NMR spectroscopy, PMR scale, chemical shifts (concept of shielding and deshielding), factors influencing chemical shifts, simple spin-spin couplings, coupling constant, chemical shift equivalence, anisotropic effects in alkenes, alkynes, aldehydes, and aromatics. Interpretation of PMR spectra of simple compounds.

Unit-IV- Separation techniques [14 L]

Solvent extraction: Classification, principle, and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous, and counter-current extractions. Chromatography: Classification, principle, and efficiency of the technique. Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ion-exchange chromatography; Molecular sieve chromatography; Affinity chromatography.

Recommended Books:

1. Jeffery, G.H., Bassett, J., Mendham, J. & Denney, R.C. Vogel's Textbook of Quantitative Chemical Analysis, John Wiley & Sons, 1989.
2. Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. Instrumental Methods of Analysis, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.
3. Christian, G.D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
4. Harris, D. C. Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.
5. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
6. Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed.
7. Mikes, O. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Series on Analytical Chemistry, John Wiley & Sons, 1979.
8. Ditts, R.V. Analytical Chemistry; Methods of Separation, van Nostrand, 197.

Science Laboratory V (24-CIR-C-304) (Major) 4 credits

1. Pour plate and replica plating technique.
2. Karyotype analysis.
3. Effect of physical mutagen (UV) on bacteria.
4. Genetic problem related to probability/Chi-square test.
5. Conjugation in bacteria.
6. Transduction in bacteria.
7. Study of development stages of frog (Whole mounts and sections through permanent slides): Cleavage stages, blastula, gastrula, neurula, tail bud stage, tadpole external and internal gill stages.
8. Study of the different types of placenta- histological sections through permanent slides or photomicrograph.
9. Structure of young anther wall, microsporogenesis, mature anther (permanent slides).
10. Study of plant tissues (parenchyma, collenchyma, sclerenchyma, xylem & phloem) through permanent slides only.
13. Study of following specimens (Non-Chordata):
    Euglena, Noctiluca, Paramecium, Sycon, Physalia, Tubipora, Metridium, Taenia, Ascaris, Nereis, Aphrodite, Leech, Peripatus, Limulus, Hermitcrab, Daphnia, Millipede, Centipede, Beetle, Chiton, Dentalium, Octopus, Asterias, and Antedon.
14. Study of following specimens (Chordata).
    Balanoglossus, Amphioxus, Petromyzon, Pristis, Hippocampus, Labeo, Icthyophis/ Uraeotyphlus, Salamander, Rhacophorus Draco, Uromastix, Naja, Viper, model of Archaeopteryx, any three common birds-(Crow, duck, Owl), Squirrel and Bat.
15. Separation of a mixture of two amino acids by ascending paper chromatography.
16. Separation of a mixture of two sugars by ascending paper chromatography.
17. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography.
18. Determine the concentration of CuSO4/KMnO4/K2Cr2O7 in a solution of unknown concentration. Verify Lambert-Beer's law.
19. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.
20. Identification of simple organic compounds by IR spectroscopy and NMR spectroscopy (Spectra to be provided).

Recommended Practical Books

1. Vogel's Quantitative Chemical Analysis 6th Edition. January 2009. Pearson Education.
2. Pechenik, J. A. (2015) *Biology of the Invertebrates*. VII Edition, McGraw-Hill Education
3. Weichert C.K and William Presch (1970). *Elements of Chordate Anatomy*. Tata McGraw Hills
4. Wolpert, L & Tickle, C (2011) *Principles of Developmental Biology (4th edition)*. Oxford University Press, ISBN: 9780198792918
5. Kardong, K.V.(2005) *Vertebrates' Comparative Anatomy, Function and Evolution*. IV Edition. McGraw-Hill Higher Education.
6. Raven P.H. *et al.* (2006) Biology 7th edition. Tata McGraw Hill Publishers, ND
7. Singh, G. (2004) Plant Systematics: Theory and Practice 2nd edition. Oxford & IBH Publishing Co. Delhi.

Bioinformatics (24-CIR-M-305) (Minor) 4 credits

Unit I: Databases in Life Sciences [14 L]

Exploring data contents, formats, and organization principles, exploration of open-access resources like PubMed, BioMed Central, PloS, and CiteXplore, Nucleic acid sequence databases: GenBank, EMBL, DDBJ, Retrieval techniques for genomic data, Protein Sequence Databases: Uniprot-KB, SWISS-PROT, TrEMBL, and UniParc. Repositories for high throughput genomic sequences, including EST, STS, GSS, etc. Survey of Genome Databases at prominent institutions: NCBI, EBI, TIGR, SANGER, Structure Databases PDB, NDB, Utilization of chemical databases: PubChem, ChemBank, Pubchem, Zinc, etc.

Unit II: Sequence analysis and comparison [14 L]

Various file formats for bio-molecular sequences: GenBank, FASTA, GCG, MSF etc. Basic concepts of sequence similarity, identity and homology, definitions of homologues, orthologues, paralogues and xenologues. BLAST, FASTA, PSI-BLAST. Fundamental concepts of scoring matrices, Matrices for nucleic acid and proteins sequences, PAM and BLOSUM series, Needleman and Wunsch algorithm for global pairwise alignments, Smith and Waterman algorithm for local pairwise alignments, Multiple sequence alignments,

Unit III: Taxonomy and phylogeny [14 L]

Introduction to systematics: organizing biodiversity, Basic principles and definitions in taxonomy and phylogeny. Understanding the molecular basis of evolutionary processes, Examining molecular markers used in phylogenetic studies, Types of data used in taxonomy. and phylogenetics, Comparative analysis of morphological and molecular data. Phylogenetic Trees: Definition and description of phylogenetic trees, Exploring various types of phylogenetic trees. Phylogenetic Analysis Algorithms: Maximum Parsimony: principles and applications, UPGMA, Neighbor-Joining algorithm: principles and applications. Probabilistic Models and Algorithms: Probabilistic models of evolution, Maximum Likelihood algorithm and its applications, Bootstrapping methods for assessing tree reliability. Tools in Phylogenetic Analysis.

Unit IV: Protein structure prediction and analysis [14 L]

Classification and Comparison of Protein Structures: Purpose and concepts of protein structure classification, Algorithms: FSSP, CE, VAST, DALI, and Fold Classes, Databases for structure-based classification: CATH and SCOP. Secondary Structure Prediction: Chou Fasman and GOR methods. Tertiary Structure Prediction. Homology modeling, Fold recognition, Ab-initio structure prediction and AlphaFOLD: principles and applications. 3-D Structure Visualization Tools. Structure analysis tools.

Recommended Books:

1. Discovering Genomics, Proteomics and Bioinformatics (2nd Edition) by A. Malcolm Campbell and Laurie J. Heyer. Published by Cold Spring Harbor Laboratory Press and Benjamin Cummings.
2. Baxevanis Andreas D. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 3rd Edition. Publisher: New York, John Wiley & Sons, Inc. 2002, ISBN: 9814126756.
3. Bourne Philip E., Weissig Helge. Structural Bioinformatics (Methods of Biochemical Analysis, V. 44), 2003. Publisher: Wiley-Liss. ISBN: 0471202002.
4. Bohm, C. and Plant, C. eds., 2010. Database technology for life sciences and medicine (Vol. 6). World Scientific.
5. Carugo. (2010). Data mining techniques for the life sciences (Vol. 609). O. Carugo, & F. Eisenhaber (Eds.). New York: Humana Press.
6. Narayanan, P. Bioinformatics: A primer. New Age International, 2006.

Computational Laboratory V (24-CIR-S-306) (SEC) 3 credits

1. To familiarize students with databases like GenBank, EMBL, UniProt, and PDB. Demonstrate how to search and retrieve genomic and protein data from these databases.
2. To explore chemical databases such as PubChem, ChemBank, and Zinc. Teach students how to search for chemical compounds and retrieve relevant information.
3. Demonstrate to the use of BLAST, FASTA, and PSI-BLAST for sequence alignment. Explain the principles of scoring matrices (PAM and BLOSUM) and perform sequence alignments using different matrices.
4. Demonstrate the construction of phylogenetic trees using methods like Maximum Parsimony, Neighbor-Joining, and Maximum Likelihood. Hands-on exercises use Phylip, Mega, or PAUP software for phylogenetic analysis.
5. Show methods for secondary structure prediction (Chou Fasman, GOR). Demonstrate tertiary structure prediction techniques including homology modeling, fold recognition, and ab initio prediction.
6. Use visualization tools such as PyMol, SPDBV, and VMD to visualize protein structures. Perform practical exercises on structure analysis, including solvent accessibility, surface area calculation, and protein-ligand interactions.

Recommended Practical Books:

1. Ismail, H. D. (2022). Bioinformatics: a practical guide to NCBI databases and sequence alignments. Chapman and Hall/CRC.
2. Fdez-Riverola, F., Mohamad, M.S. and Rocha, M. eds., 2020. Practical Applications of Computational Biology and Bioinformatics, 13th International Conference. Springer International Publishing.

Microbiology (24-CIR-C-351) (Major) 4 credits

Unit I: Diversity, microscopy and staining techniques [14 L]

Brief history of development of microbiology; Diversity of microorganisms and differentiating characteristics of each group of microorganisms; Functional features of cells of microorganisms, Principles of stain and staining, types and significance of bacterial staining; Microscopy- Principles and applications, dark field, bright field, resolving power, numerical aperture, chromatic aberration, phase contrast microscopy, fluorescent microscopy, inverted microscopy, stereo microscopy, electron microscopy, TEM and SEM.

Unit II: Aseptic methods and culture techniques [14 L]

Types of growth media (natural, synthetic, complex, enriched, selective- definition with example), pure culture methods (streak plate, spread plate, pour plate, stab culture, slant culture). Microbial growth phases; Control of microbes- Sterilisation, disinfection, antiseptic, tyndallisation, pasteurization: Physical- dry heat, moist heat, UV light, ionizing radiation, filtration, HEPA filter, Chemical-phenol and phenolic compounds, anionic and cationic detergents.

Unit III: Mycology and applied microbiology [14 L]

Morphology, structure and cultivation of fungus; Cutaneous, Sub cutaneous and Systemic Mycosis; Normal microbial flora of the human body; collection and transport of specimens, processing of clinical specimens for microbiological examination; Nosocomal infection: Introduction and its types, laboratory diagnosis, prevention and control of nosocomial infections.

Unit IV: Virology [14 L]

Virus structure and morphology, virus classification, RNA viruses, DNA viruses. Characteristic features of viral life cycle among RNA and DNA viruses. Prions, virioids, virusoids, oncogenic viruses, persistent and latent viral infections. Human pathogenic viruses. Antiviral strategies; antiviral drugs, interferons, anti-sense RNA and small interfering RNA (siRNA), antiviral vaccines. Gene therapy and significance of viral vectors as gene delivery systems. Diagnostics in virology. Animal cell culture and virus propagation in cell lines.

Recommended Books:

1. Tortora GJ, Funke BR and Case CL. (2008). Microbiology: An Introduction. 9th edition.Pearson Education
2. Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014). Brock Biology of Microorganisms.14th edition. Pearson International Edition
3. Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott's Microbiology. 9th Edition. McGraw Hill International.
4. Atlas RM. (1997). Principles of Microbiology. 2nd edition. WM.T. Brown Publishers.
5. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGraw Hill Book Company.

Immunology (24-CIR-C-352) (Major) 4 credits

Unit I: Cells and organs of the immune system [14 L]

Immune system- Cells of the immune system, Lymphoid cells, Mononuclear phagocytes, granulocytic cells, Mast cells. Dendritic cells and their functions, primary and secondary lymphoid organs (Thymus, bone marrow, lymph nodes, spleen). mucosal and cutaneous associated lymphoid tissue (MALT & CALT), Lymphatic system, Haematopoiesis and differentiation.

Unit II: Antigen-antibody interactions [14 L]

Immunity: Innate and Acquired immunity, Humoral immunity and Cell mediated immunity, Clonal selection theory, Concept of antigen and Antigenicity, Antigens and haptens, Adjuvants, Immunogen and Immunogenicity, Structure and functions of different immunoglobulins. General properties of effector T cells, cytotoxic T cells (Tc), natural killer cells; NKT cells and antibody dependent cellular cytotoxicity (ADCC).

Unit III: Immune disorders [14 L]

Hypersensitivity reactions and its types. IgE mediated (Type I) hypersensitivity, Antibody mediated cytotoxic (Type II) hypersensitivity, immune complex mediated (type III) hypersensitivity and delayed type (Type IV) hypersensitivity, Organ specific and systemic autoimmune diseases, Transplantation and basis of graft rejection, Vaccines - active and passive immunization, types of vaccines.

Unit IV: Immunodiagnostic methods [14 L]

Production of Monoclonal Antibodies and hybridoma technology, Antigen and antibody reactions, Immunodiagnostic methods: Agglutination, precipitations, Complement fixation, Western blotting, Radioimmunoassay (RIA), Enzyme linked immunosorbant assay (ELISA) and its types, Immunohistochemistry, Immunocytochemistry, Fluorescence activated cell sorting (FACS).

REFERENCE BOOKS:

1. Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J (2006). Immunology, VI Edition. W.H. Freeman and Company.
2. David, M., Jonathan, B., David, R. B. and Ivan R. (2006). Immunology, VII Edition, Mosby, Elsevier Publication.
3. Abbas, K. Abul and Lechtman H. Andrew (2003.) Cellular and Molecular Immunology. V Edition. Saunders Publication.
4. Roit, I.M., Delves P.J., Essential Immunology (10th edition), Blackwell Science, Oxford 2001.
5. Immunology by Kuby, J. (8th edition) W.H. Freeman and Company, New York, 2013.

Structural Biology (24-CIR-C-353) (Major) 4 credits

Unit I: Protein preparation methods [14 L]

Overview of expression systems: Expression of protein for crystallization in *E.coli*, yeast and insect cells. Post-translational modifications. Techniques for protein purification: Affinity chromatography, ion exchange chromatography, and size exclusion chromatography. Strategies for optimizing protein yield and purity. Challenges and troubleshooting in protein purification. Protein crystallization. Techniques for obtaining high-quality protein samples for crystallization. Crystallization techniques: Hanging drop, suiting drop, microanalysis, seeding, etc. Strategies to optimize crystallization conditions.

Unit II: Structure determination [14 L]

Protein Structure Determination by X-ray Crystallography: Introduction to protein crystals. Data collection and processing in X-ray crystallography. Electron Density Maps and Model Building: Generation of electron density maps, Model building and refinement in X-ray crystallography, Validation of crystallographic models. Phasing methods: direct methods, molecular replacement, and anomalous dispersion, molecular replacement method and direct method. Intensity estimation and deduction of structure factor amplitudes - Wilson plot - scale and temperature factors - symmetry deduction and determination of space groups - test for centro symmetry.

Unit III: NMR spectroscopy [14 L]

Introduction to NMR Spectroscopy: Historical development and principles of NMR spectroscopy. Overview of NMR instruments and their components, Sample preparation and handling in NMR, NMR Observables and Parameters for Structure Determination: Chemical shift, Spin-spin coupling (J-coupling) and its interpretation, Relaxation times (T1 and T2) and their significance, Selection Rules and Spectral Density Functions, Selection rules governing NMR transitions. Analysis of High-Resolution NMR Spectra. Two-Dimensional NMR Spectroscopy.

Unit IV: Enzymology [14 L]

General concept, Nomenclature and Classification of Enzymes. Enzyme activity- chemical nature of enzymes, Mechanism of enzyme catalysis. Concept of active site and energetics of enzyme substrate complex formation, Enzyme catalysis – general principles of catalysis; Quantitation of enzyme activity and efficiency; Enzyme Kinetic Parameters: Km, Vmax and Kcat. Enzyme specificity. Reversible Inhibition- Competitive, Non-Competitive, Uncompetitive. Analysis of enzyme kinetic data. Lineweaver-Burk and the direct linear plot. Allosteric Regulation, Reversible Covalent Modification and Proteolytic Activation. Organisation of enzymes in the cell.

Recommended Books:

1. Schulz, Georg E., and R. Heiner Schirmer. Principles of protein structure. Springer Science & Business Media, 2013.
2. Finkelstein, Alexei V., and Oleg Ptitsyn. Protein physics: a course of lectures. Elsevier, 2016.
3. Teng, Quincy. Structural biology: practical NMR applications. Springer Science & Business Media, 2012.
4. Glazer, A.M., 2016. Crystallography: A very short introduction (Vol. 469). Oxford University Press.
5. Sands, Donald E. Introduction to crystallography. Courier Corporation, 1993.
6. Günther, Harald. NMR spectroscopy: basic principles, concepts and applications in chemistry. John Wiley & Sons, 2013.
7. McPherson, A. (2011). Introduction to macromolecular crystallography. John Wiley & Sons.

Machine Learning and Artificial Intelligence (24-CIR-M-354) (Minor) 4 credits

Unit I: Concepts of Artificial Intelligence [14 L]

What is Artificial Intelligence? Foundation of Artificial Intelligence, Types of artificial intelligence—weak AI vs. strong AI, The rise of generative models, Future of Artificial Intelligence – Characteristics of Intelligent Agents–Typical Intelligent Agents, Artificial intelligence applications.

Unit II: Knowledge representation [14 L]

Problem solving Methods: Search Strategies- Uninformed, Informed, Heuristics Search Algorithms and Optimization Problems, Searching with Partial Observations Using Predicate Logic, Hill Climbing, Simulated Annealing, Best First Search: OR Graphs, Heuristic Functions Representing Simple Facts in logic.

Unit III: Machine learning [14 L]

Introduction to Learning classifiers, Types of Machine Learning: Supervised Learning: Design a Learning System – Perspectives and Issues in Machine Learning Unsupervised learning: Clustering, mixture models, k-means clustering, hierarchical clustering, distributional clustering, Reinforcement learning; Deep Learning

Unit IV: Machine learning models [14 L]

Parameter Estimation, sufficient statistics, decision trees, neural networks, support vector machines, Bayesian networks, N-gram models; Markov and Hidden Markov models, probabilistic relational models, association rules, nearest neighbor classifiers, ensemble classifiers.

Recommended Books:

1. Stuart Russell, Peter Norvig, Artificial Intelligence: A Modern Approach, 3rd Edition, Pearson,
2. Dan W Patterson, Introduction to Artificial Intelligence and Expert Systems, 1st Edition, PHI.
3. Bishop, C. (2006). Pattern Recognition and Machine Learning. Berlin: Springer-Verlag.
4. Gerhard Weiss, ―Multi Agent Systems‖, Second Edition, MIT Press.
5. I. Bratko, ―Prolog: Programming for Artificial Intelligence, Fourth edition, Addison-Wesley Educational Publishers Inc.

Science Laboratory VI (24-CIR-C-355) (Major) 4 credits

1. Good laboratory practices and biosafety.
2. To study the principle and applications of important instruments (biological safety cabinets, autoclave, incubator, BOD incubator, hot air oven, microscopes, pH meter, centrifuge, spectrophotometer, balance, water bath) used in the microbiology laboratory.
3. Preparation of culture media for different groups of microorganisms.
4. Sterilization and pure culture isolation techniques (pour plate, spread plate and streaking, serial dilution).
5. Stain preparation and staining of different groups of microorganisms; preparation of temporary mounts.
6. Study of electron micrographs of animal viruses (Rhabdo, Influenza, Hepatitis B and Retroviruses), plant viruses (Caulimo, Gemini, Tobacco ring spot, Cucumber mosaic) and bacterial viruses (ϕX 174, T4, λ).
7. RBC /WBC count
8. Single immunodiffusion analysis
9. Double immunodiffusion analysis.
10. Rocket immuno-electrophoresis.
11. Separation of PBMC from the blood sample.
12. Slide and tube agglutination reaction
13. Enzyme-linked immunosorbent assay
14. Set up of crystallization trials using hanging drop, sitting drop, or microanalysis techniques. Optimization of crystallization conditions and analyze crystal quality and homogeneity.
15. Discuss challenges and current trends in protein crystallography through case studies and literature review. Understand Bragg's law, reciprocal lattice, and experimental setup for X-ray crystallography.
16. Process X-ray diffraction data and generate electron density maps. Practice phasing methods such as direct methods and molecular replacement using simulated data.
17. Build and refine crystallographic models using software tools like PyMOL and CCP4. Learn how to analyze crystallographic data and submit structures to databases like the Protein Data Bank (PDB).
18. Demonstration of enzyme activity assays using model substrates and measuring reaction rates.
19. Study of effect of pH, temperature and chemicals on the enzyme activity.

Recommended Practical Books:

1. Cappucino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited.
2. Microbiology: A Laboratory Manual, 12th edition, 2020, Cappuccino, Sherman, Pearson Education.
3. Immunology - By G. Reever & I. Todd, Publ: Blackwell (2000).
4. Immuno diagnostics - By S.C. Rastogi, Publ: New Age (1996).
5. Pal, Subrata. Fundamentals of molecular structural biology. Academic Press, 2019.
6. Nag, N., H. Khan, and T. Tripathi. "Advances in Protein Molecular and Structural Biology Methods." (2022): 1-12.
7. Bisswanger, H., 2019. *Practical enzymology*. John Wiley & Sons.
8. Copeland, Robert A. *Enzymes: a practical introduction to structure, mechanism, and data analysis*. John Wiley & Sons, 2023.

Computational Laboratory VI (24-CIR-M-356) (Minor) 2 credits

1. Extract the data from database using python.
2. Creation and loading different datasets in python.
3. Implement k-nearest neighbours classification using python.
4. Implement the finite words classification system using Back-propagation algorithm.
5. Implement Naïve Bayes theorem to classification.
6. Implement linear regression using python.

Recommended Practical Books:

1. Charles Dierbach, "Introduction to Computer Science Using Python", 1st Edition, Wiley India Pvt Ltd. ISBN-13: 978-8126556014.

Genomics and Proteomics (24-CIR-C-401) (Major) 4 credits

UNIT I: Introduction to Genomics [14 L]

Organization and structure of genomes, Genome size, Sequence complexity, Introns and Exons, Genome structure in viruses and prokaryotes, Isolation of Chromosomes, chromosome microdissection, Retrofitting. Regulation of transcription, transcription factors and the coordination of gene expression. Gene Identification and Expression: Genome annotation, traditional routes of gene identification, detecting open-reading Frames, software programs for finding genes, Identifying the function of a new gene, gene ontology, overview of comparative genomics, Protein structural genomics, determining gene function by sequence comparison, and through conserved protein structure.

UNIT-II: Genomics technology [14 L]

Genome, Annotation, SNPs and TOGA, RAPD, AFLP and RFLP analysis, Arabidopsis KO Strategies, DNA and RNA fingerprinting, Functional Genomics: genome sequence and annotations, ESTs, Digital Northerns, SAGE. Metabolic Reconstruction: The Basic Principles and Methodology, Metabolic Pathway. Metabolic Regulation, Genome-Proteome Connection, Shotgun sequencing and assembly of genomes, Expressed sequenced tags (ESTs), Gene-disease association, diagnostic genes and drug targets, genotyping tools - DNA Chips, diagnostic assays. Interaction Networks - Yeast Genome-wide Interaction Studies. Microarray techniques.

Unit III: Proteomics technology [14 L]

Proteomics: Introduction to Proteomics; Protein Function and Expression. Analysis of proteomes - Two-dimensional polyacrylamide gel electrophoresis, Sample Preparation, Reproducibility of 2-DEDetecting proteins in polyacrylamide gels, Image analysis of 2-DE gels. Analysis of Proteomes: Mass spectrometry-based methods for protein identification-Correlative mass spectrometric-based identification strategies, 2-DE gel electrophoresis coupled with mass spectrometry. Classical technologies for separating and detecting proteins. Protein Chip. Applications of proteome analysis to drug development and toxicology.

Unit IV: Applied Genomics [14 L]

Personal Genomics: Upcoming technologies, likely future directions, Basics of SNPs & their detection. Genetic variation at the nucleotide level. Illumina bead array and array-based SNP detection, Mapping disease genes using whole genome association studies. Interference RNA, RNA silencing, SiRNA. Crispr Cas9. Epigenomics. Next generation sequencing applications. Gene therapy, gene editing, and beyond.

Recommended Books:

1. Mir, Rakeeb Ahmad, Sheikh Mansoor Shafi, and Sajad Majeed Zargar. Principles of Genomics and Proteomics. Elsevier, 2023.
2. Ruchi, Singh. Bioinformatics: genomics and proteomics. Vikas Publishing House, 2015.
3. Arjmand, Babak. Genomics, proteomics, and metabolomics. Springer, Cham, 2019.
4. Walsh, Gary. Proteins: biochemistry and biotechnology. John Wiley & Sons, 2014.
5. Thangadurai, Devarajan, and Jeyabalan Sangeetha, eds. Genomics and Proteomics: Principles, Technologies, and Applications. CRC Press, 2015.
6. Saraswathy, Nachimuthu, and Ponnusamy Ramalingam. Concepts and techniques in genomics and proteomics. Elsevier, 2011.

Advances in Biochemistry and Cellular Metabolism (24-CIR-C-402) 4 credits (Major)

Unit I: Carbohydrate metabolism [14 L]

Overview of metabolism, High energy compounds, Oxidation-reduction reactions, Experimental approaches to study metabolism, Reactions of glycolysis, Fermentation: Anaerobic fate of pyruvate, Regulation of glycolysis, Metabolism of hexoses other than glucose, Pentose phosphate pathway, Glycogen breakdown, Glycogen synthesis, Gluconeogenesis, Pyruvate Dehydrogenase complex.

Unit II: Citric acid cycle, electron transport chain and oxidative phosphorylation [14 L]

Citric acid cycle, Pyruvate dehydrogenase complex, Regulation of Citric acid cycle.
Structure of Mitochondria, Electron transport, Complex I-IV, Oxidative phosphorylation, Chemiosmotic theory, ATP synthesis by flow of protons, Aerobic metabolism, Light reaction, Dark reaction.

Unit III: Lipid metabolism [14 L]

Lipid digestion, absorption and transport, Fatty acid oxidation, Ketone bodies, fatty acid biosynthesis, Regulation of fatty acid metabolism, synthesis of glycerophospholipids, sphingolipids and prostaglandins, Cholesterol metabolism.

Unit IV: Amino acid and nucleotide metabolism [14 L]

Protein degradation, amino acid deamination, Urea cycle, Breakdown of amino acids, amino acids biosynthesis, Biosynthesis of Heme, physiologically active amines and nitric oxide, Nitrogen fixations, Nitrogen assimilation, Synthesis of purine ribonucleotides, Synthesis of pyrimidine ribonucleotides, Formation of deoxyribonucleotides, Nucleotide degradation.

Recommended Books:

1. Lehninger Principles of Biochemistry (7th edition) NELSON, L. COX, M.M W.H. Freeman and Company, New York, 2017.
2. Biochemistry (2015) Eighth edition by Jeremy M. Berg, Lubert Stryer, John L. Tymoczko, Gregory J. Gatto. W. H. Freeman and Company, New York.
3. Fundamentals of Biochemistry: Life at the Molecular Level, 5th Edition. Donald Voet, Judith G. Voet, Charlotte W. Pratt. Wiley International.

Advanced Methods in Biology (24-CIR-C-403) (Major) 4 credits

Unit I: Genetic modifications [14 L]

Site Directed Mutagenesis (SDM), Gene manipulation, Gene editing, Genome editing and CRISPR-Cas9. DNA fingerprinting and DNA footprinting and their applications, Application of molecular biology techniques in forensic sciences, Fluorescent In situ Hybridisation (FISH). Chromatin Immuno precipitation (ChIP) principle and methods.

Unit II: Nucleic acid quantification and mutational analysis [14 L]

Real-time PCR, Principle, method and application of real-time PCR in copy number calculation, DNA and RNA quantification and in diagnostics and gene expression. Analysis of gene mutation, Restriction Fragment Length Polymorphism (RFLP), Single Stranded Conformation Polymorphism (SSCP).

Unit III: Gene therapy and stem cell biology [14 L]

Viral and non-viral vectors for gene therapy, Adenoviral vectors, Lentiviral vectors, Retroviral vectors, Foamy viral vectors, Stem cells- types, nature and characteristic features of stem cells, Relevance of stem cells in gene therapy.

Unit IV: Molecular and viral studies in tissue culture settings [14 L]

Cell culture, cell lines, growth medium, maintenance of cell lines, transfection and infection in cell lines, Principle of siRNA-based inhibition and knockdown, construction of siRNA, targeting genes with siRNA, housekeeping genes and internal control and their significance in transfection experiments, Viral particles preparation from transfected/infected cell culture system, Total RNA extraction from cell culture and normalisation with reference to housekeeping genes.

Recommended Books:

1. Gene Cloning and DNA Analysis: An Introduction, 8th Edition, T. A. Brown, ISBN: 978-1-119-64078-3, November 2020, Wiley-Blackwell.
2. Gene and Cell Therapy Therapeutic Mechanisms and Strategies, 4th edition, 2015, edited by Nancy Smyth Templeton, Marcell Dekker Inc.
3. Cell culture Technology 2018, editors: Cornelia Kasper, Verena Charwat, Antonina Lavrentieva. Springer publishers.
4. siRNA and miRNA Gene Silencing: From Bench to Bedside (Methods in Molecular Biology, Vol. 487) 2009th Edition by Mouldy Sioud (Editor) Publisher: Humana; 2009th edition (2008)
5. Ribozymes and siRNA protocols Editors: Mouldy Sioud Part of the book series: Methods in Molecular Biology (MIMB, volume 252).
6. SiRNA Delivery Methods: Methods and Protocols 2015, by Kato Shum, John Rossi Publisher: Springer New York
7. Concepts and Applications of Stem Cell Biology A Guide for Students 2020, Editors: Gabriela Rodrigues, Bernard A. J. Roelen. Part of the book series: Learning Materials in Biosciences (LMB), Springer.

AI in Life Sciences (24-CIR-M-404) (Minor) 4 credits

Unit I: Introduction to AI in Life Sciences [14 L]
Overview of AI and its relevance to life sciences, Historical context and current trends, Types of machine learning: supervised, unsupervised, reinforcement learning, Basic algorithms: decision trees, support vector machines, neural network.

Unit II: AI in Data Processing and Drug Discovery [14 L]
Types of data: genomic, proteomic, clinical, imaging, Data preprocessing and management, Predictive modelling for drug candidates, Case studies of successful AI applications in pharmaceuticals.

Unit III: Genomics and Personalized Medicine, Medical Imaging and Diagnostics [14 L]
Installing and loading packages, Downloading and importing data; CSV files, Excel files Binary files, XML files, JSON files: Getting and Setting the Working Directory, Reading, writing and analysing these files; Reading & Writing PDF files, Reading & Writing JPEG files, Saving Data in R.

Unit IV: AI in Clinical Decision Support, Public Health and Epidemiology [14 L]
Predictive analytics for patient outcomes, Natural language processing in electronic health records, AI for disease surveillance and outbreak prediction, Case studies on public health interventions.

Reference Books:

1. Artificial Intelligence for Healthcare: Interdisciplinary Applications" by T. S. M. K. and E. A.
2. Artificial Intelligence in Healthcare" by Parashar Shah and Abhinav S. S.
3. Artificial Intelligence in Medicine" by S. P. P. C.
4. AI in Healthcare: Transforming the Future of Medicine" by A. B. Smith and J. K. Jones
5. Data Science for Healthcare: How AI and Machine Learning Are Transforming Healthcare" by A. K. Gupta
6. Artificial Intelligence for Healthcare: Interdisciplinary Applications" by T. S. M. K. and E. A.

Science Laboratory VII (24-CIR-C-405) (Major) 4 credits

1. Investigate transcriptional regulation by examining transcription factors and gene expression coordination.
2. Use software programs to identify genes and detect open reading frames (ORFs).
3. Perform expression profiling using traditional approaches and analyze RNA expression data.
4. Conduct two-dimensional polyacrylamide gel electrophoresis (2D-PAGE) to analyze protein expression.
5. Investigate protein-protein interactions.
6. Analyze single nucleotide polymorphisms (SNPs) and their impact on protein function.
7. Determination of molar absorption coefficient of the native proteins (RNase-A, -
8. lactalbumin and lysozyme) from the spectra of model compounds (Try and Trp).
9. Determination of no. of Tryptophan and Tyrosine residues in an unknown protein
10. (Lysozyme) by Edelhoch's method.
11. Determination of conformational stability from the guanidine hydrochloride-induced
12. denaturation of a protein.
13. Determination of stability parameters like □G D , □G D 0 , □C P , □H m , and T m , etc. of a protein
14. from analysis of heat-induced transition curve.
15. Determination of secondary structure elements of proteins (RNase-A, -lactalbumin and lysozyme) from their CD spectra.
16. Estimation of hydrodynamic radius of a protein using Dynamic Light Scattering System (DLS).
17. Measure structure of protein using CD, Fluorescence, and UV-vis spectroscopy.
18. To measure effect of temperature on the kinetic parameters of protein.
19. To measure effect of pH on the kinetic parameters of protein.
20. To measure effect of inhibitors and activators on the kinetic parameters of protein
21. PCR amplification of DNA
22. Confirmation of PCR.
23. Gradient PCR.
24. TA cloning.
25. Confirmation of positive clones.
26. In-vitro transcription.

Recommended Practical Books:

1. Thangadurai, Devarajan, and Jeyabalan Sangeetha, eds. Genomics and Proteomics: Principles, Technologies, and Applications. CRC Press, 2015.
2. Dunn, M.J. ed., 2008. From genome to proteome: Advances in the practice and application of proteomics. John Wiley & Sons.
3. Practical Biochemistry, 2016 by Damodaran Geetha K. Jaypee Brothers Medical Publishers.
4. Molecular Cloning: A Laboratory Manual (Fourth Edition), Volume 1, 2 & 3, 4th Edition. Green and Sambrook. Cold Spring Harbor Laboratory Press, 2012.

Computational Laboratory VII (24-CIR-M-406) (Minor) 2 credits

1: Introduction to R and RStudio
Objective: Familiarize students with R and RStudio interface.
Activities:

- Installation of R and RStudio.
- Basic R syntax: variables, data types, and functions.
- Importing datasets (CSV, Excel).
- Basic data manipulation with dplyr.

2: Data Visualization
Objective: Learn to visualize life sciences data.
Activities:

- Introduction to ggplot2 for data visualization.
- Creating scatter plots, box plots, and histograms.
- Customizing visualizations (colors, labels, themes).
- Practical: Visualizing gene expression data.

3: Exploratory Data Analysis (EDA)
Objective: Conduct EDA on life sciences datasets.
Activities:

Summary statistics and data distributions.
Identifying missing values and outliers.
Practical: EDA on a clinical dataset (e.g., patient records).

4: Introduction to Machine Learning with R
Objective: Understand basic machine learning concepts.
Activities:

- Overview of machine learning algorithms (classification and regression).
- Introduction to the caret package for model training.
- Practical: Building a simple classification model (e.g., predicting disease presence).

5: Advanced Machine Learning Techniques
Objective: Implement advanced models.
Activities:

- Introduction to decision trees and random forests using rpart and randomForest.
- Evaluating model performance (accuracy, confusion matrix).
- Practical: Classifying cancer types based on genomic data.

6: Genomic Data Analysis
Objective**:** Analyze genomic data with R.
Activities**:**

- Introduction to Bioconductor for genomic data analysis.
- Performing differential gene expression analysis.
- Practical: Analyzing RNA-seq data and visualizing results with heatmaps.

Recommended Practical Books:

1. "Bioinformatics Data Skills" by Vince Buffalo.
2. "Genomic Data Analysis: Methods and Applications" by Gabriel D. C. Silva.

Gene Regulation and Cell Communication (24-CIR-C-451) (Major) 4 credits

Unit I: Gene regulation in prokaryotes [14 L]

Control of gene expression in prokaryotes, An Operon as a coordinated unit of gene expression, Lactose operon with repressed and induced states, Role of CAP protein, RNA polymerase, and repressor in Lac operon, Arabinose operon and its regulatory genes, Stages of transcription in the lytic growth of lambda phage, Self-regulation by the lambda repressor, Helix-turn-helix motif mediated binding of regulatory proteins, Tryptophan operon and regulatory genes, Attenuation and coupling of transcription and translation.

Unit II: Gene expression in eukaryotes [14 L]

Regulation of gene expression in eukaryotes, Transcriptionally active vs. transcriptionally inactive protein, Role of chromatin in gene expression, chromatin remodelling by acetylation and nucleosomal displacement, Transcriptional activation, Eukaryotic promoters and their regulation, DNA-binding trans activators and coactivators and assembly of general transcription factors, Positive and negative regulation of genes of Galactose metabolism in yeast. Phosphorylation of nuclear transcriptional factors, Translational regulation of eukaryotic mRNA.

Unit III: Cell-cell signalling [14 L]

Cell-cell communication: strategies of cell signalling: cell to cell contact, via signalling molecule (endocrine, paracrine and autocrine). Signalling mediated by intracellular receptors: G protein coupled receptors, receptor tyrosine kinases, non-receptor tyrosine kinases, primary and secondary messengers.

Unit IV: Cell signalling pathways [14 L]

Cell signalling pathways, cAMP pathway, and glycogen metabolism, PI3 kinase/Akt, Ras/Raf, MAP kinase/ERK kinase, mTOR, TGF-β, NF-κB and other pathways. Programmed cell death, caspases, mitochondrial pathway of apoptosis, PI3 kinase/Akt pathway and cell survival.

Recommended Books:

1. Genes XII (Lewin Benjamin), 12th edition, 2017 by Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick, Jones & Bartlett Learning.
2. Lehninger Principles of Biochemistry (7th edition) NELSON, L. COX, M.M W.H. Freeman and Company, New York, 2017.
3. Biochemistry (2015) Eighth edition by Jeremy M. Berg, Lubert Stryer, John L. Tymoczko, Gregory J. Gatto. W. H. Freeman and Company, New York.
4. Fundamentals of Biochemistry: Life at the Molecular Level, 5th Edition, 2018. Donald Voet, Judith G. Voet, Charlotte W. Pratt. Wiley International.

Network and Systems Biology (24-CIR-C-452) (Minor) 4 credits

Unit I: Basics of Network [14 L]

Complex Networks: Node degree, degree distributions and correlations, shortest path lengths, diameter and betweenness, clustering, motifs, Community structures. Topology of real networks. Network model: Random Networks, Scale free Network, Small world networks, BA (Barabási albert) model, ER (Erdos Renyi) model. Weighted networks: Measures for weighted networks, Real weighted networks, Modelling weighted networks. Network drawing tools.

Unit II: Biological Network [14 L]

Type of Biological Networks, Description of Transcriptional networks, hill function, dynamics and response time of gene regulation, metabolic networks, evolving networks and other intra-cellular, inter cellular networks. Characteristic of networks with significance of biology. Definition of Networks motif, Auto regulation: A Network Motif, coherent and in-coherent Feed forward loop, modeling of FFL, motifs in evolving networks, autocatalysis, self-organized networks, Tool, and techniques of finding networks motif.

Unit III: Concepts of mathematical modelling [14 L]

Deterministic and stochastic description of cellular processes, mathematical modelling of chemical reaction networks, Enzyme Kinetics: Michaelis-Menten kinetics, Two-substrate reactions. Regulation of Enzyme Activity: Competitive inhibition, Allosteric regulation. Cooperativity; Compartmental Modelling and Transport; probabilistic picture of molecular interactions: Gillespie's picture, master equation formalism of biochemical networks. Solution of model using some programming and/ or tools.

Unit IV: Modelling analysis techniques [14 L]

Phase Plane Analysis: Direction fields, Nullclines. Stability: Stable and unstable steady states, Linearized stability analysis. Stability criterion and Lyapunov exponent; Limit Cycle Oscillations, Bifurcation Analysis, and Sensitivity Analysis: Local sensitivity analysis, determining local sensitivity coefficients. Parameter Fitting; Draw the above planes and calculations using some programming and/ or tools.

Reference Books: [12L]

1. W. Liu, Introduction to modeling biological cellular control systems, Springer, Milan, 2012.
2. B.P. Ingalls, Mathematical modeling in systems biology: an introduction, MIT Press, Cambridge, Massachusetts, 2013.
3. M. Ullah, Stochastic approaches for systems biology, Springer, New York, 2011.
4. S.H. Strogatz, Nonlinear dynamics and Chaos: with applications to physics, biology, chemistry, and engineering, Addison-Wesley Pub, Reading, Mass, 1994.
5. Uri Alon, an Introduction to System Biology, Chapman & Hall/CRC Mathematical and Computational Biology Series.
6. K. H. Rosen, Discrete Mathematics and its applications, Tata McGraw Hill Publishing Company Ltd.
7. Computational Cell Biology: Edited by: C.P. Fall, E.S. Marland, J.M. Wagner and J. J. Tyson, Springer International, 2006.

Dissertation (24-CIR-D-453) 12 credits