UM-DAE Centre for Excellence in Basic Sciences

Outline, Credits and Syllabus of the course for the M. Sc. (Integrated)

Biology stream

(P: Physics, M: Mathematics, C: Chemistry, B: Biology, G: General, H: Humanities
CB: ChemistryBiology, PCB: PhysicsChemistryBiology)

FIRST YEAR

SEMESTER –I

Subject Code	Subject	Contact hrs/per week Theory + Tutorials	Credits
B 101	Biology I (Introductory Biology)	[2 +1]	3
C 101	Chemistry I (Structures & Bonding)	[2 +1]	3
P 101	Physics I (Classical Physics)	[2 +1]	3
M 101/M100	Mathematics I	[2 +1]	3
G 101	Computer Basics	[2 +1]	3
H 101	Communication Skills	[2 +0]	2
		Contact hrs/per week Lab	**Credits**
BL101	Biology Laboratory	[4]	2
CL 101	Chemistry Laboratory	[4]	2
PL 101	Physics Laboratory	[4]	2
GL 101	Computer Laboratory	[4]	2
			25

M100: Mathematics – 1

The idea of derivative of a function, polynomials, slope and tangent line, derivatives of trigonometric functions, product and quotient rules. Notion of limits and continuous functions.

Elementary results pertaining to limits of functions: product and quotient rules. Higher order derivatives, examples. Maxima and minima, curve tracing, Conic sections: circle, ellipse, hyperbola and parabola; equations, focus, directrix, latus rectum. Generalised conic section equation, exponential and logarithmic functions and their derivatives.

Application of derivatives to root finding: Newton's method (to be supplemented by an introduction to iterative processes). Mean value theorem of differential calculus, Rolle's theorem, applications. l'Hôpital's rule. The chain rule of differentiation, Implicit differentiation, Inverse functions and their derivatives, Inverse trigonometric functions, Applications.

Concept of infinite series, Geometric series, convergence tests; Taylor series, Maclaurin series for elementary functions, power series, simple applications.

Notion of an integral, integral as limit of sums; anti-derivatives, area under a curve, definite

integrals, indefinite integrals. Rules of integration: integration by parts, integration by substitution. Properties of definite integrals including mean value theorem for integral calculus. Fundamental theorem of integral calculus. Integrals involving polynomial, exponential, logarithmic, trigonometric, inverse trigonometric functions. Application of integrals to areas, length of a plane curve, volumes of solids of revolution.

Complex numbers: real and imaginary parts, The complex plane, Complex algebra (complex conjugate, absolute value, complex equations, graphs, physical applications). Elementary functions of complex numbers, Euler's formula, Powers and roots of complex numbers. The exponential and trigonometric functions, Hyperbolic functions, Logarithms, Complex roots and powers, Inverse trigonometric and hyperbolic functions, Some applications.

Separable equations, Linear first order equations, Other methods for first order equations, Second order linear equations with constant coefficients and both zero and non-zero right hand side, Other second order equations.

Suggested Texts and References:

1) Calculus: Gilbert Strang (MIT Courseware)

2) Calculus: M. Weir, J. Hass and F. R. Giordano (Pearson Education)

M101: Mathematics I (Calculus)

1. Review of real numbers, their completeness with respect to order, the Archimedean property.
2. Sequences and series, tests for their convergence and basic properties of their limits and sums, radius of convergence.
3. Functions of one real variable and their graphs, limits, continuity and their basic properties, continuity of standard functions.
4. Differentiation, interpretation of the derivative as slope, velocity and rate of change, derivatives of sums and products, the chain rule, derivative of the inverse of a function, derivatives of standard functions.
5. Rolle's and Mean value theorems, their geometric interpretations.
6. Higher order derivatives, application of derivatives to finding maxima and minima and to curve sketching.
7. The integral as the limit of the lower and upper Riemann sums and as an area, connection with an anti-derivative and the Fundamental Theorem of Calculus.
8. Applications of integration.
9. Brief description of limits and continuity of functions of several variables, partial derivatives and directional derivatives, extreme values and saddle points, iterated integration.
10. Vector fields, gradient, divergence and curl: definitions, properties and physical interpretations.

References:

1. Inder K. Rana, Calculus@iitb, Concepts and Examples, Version 1.2, math4all 2009.

2. G. B. Thomas and R.L. Finney, Calculus and Analytic Geometry, 9th ed., Addison-Wesley/Narosa, 1998.

3. James Steward, Calculus, Thomson Press, 2006.

Physics I (Classical Physics) P101

1. Concepts of energy and mass, Linear kinematics and dynamics. Concept of force: Conservative and non-conservative forces, Friction. Conservation of momentum, energy, and angular momentum. Work-energy theorem, Centre of mass, moment of inertia. Rotational kinematics and dynamics, Rigid body motion. Impulse and collisions, Central forces, Kinetic theory of gases, Equipartition of energy.
2. Free oscillations in one, two, and many degrees of freedom. Linearity and superposition principle. Normal modes; Transverse and longitudinal modes. General notion of a continuous string; Resonance; Coupled pendula and oscillators, Normal coordinates.

3. Probability (chance, fluctuations, random walk, probability distribution, uncertainty principle); Curvilinear Coordinates, Vector calculus (differentiation and integration, gradient, divergence, curl, Green's theorem, Gauss' theorem, Stokes' theorem); Fourier series (an introduction).

References:

1. "The Feynman lectures in Physics" volume 1, by R. P. Feynman, R. B. Leighton, M. Sands.
2. "An introduction to mechanics", by D. Kleppner and R. Kolenkow.
3. “Mechanics”, by Charles Kittel, Walter D. Knight and Malvin A. Ruderman, Berkeley Physics Course Volume 1.
4. "Waves", by F. S. Crawford, Berkeley Physics Course Volume 3.

C 101: Structure Bonding and reactivity: Revisited (30 + 15 = 45 hrs.)

a. Structure and Properties of atoms: (4 + 2 = 6 hrs.)

i) Atomic spectra, Bohr’s theory of atomic structure, Sommerfeld’s theory for complex electron spin and magnetic quantum number, Pauli exclusion principle, Hund’s rule, electron configuration of elements, Sequence of energy levels and Periodic Table.

ii) Size of atoms and ions, ionization energy, electron affinity, electronegativity – values by Pauling, Mulliken and Allred-Rochow, Metallic character, variable valency and oxidation states, horizontal, vertical and diagonal relationships in the periodic table.

iii) Atomic Nucleus: Fundamental particles, classification of nuclides, nuclear stability, the neutron to proton ratio N/Z, nuclear potential, binding energy, exchange force. Radioactivity and radioactive elements, radioactive decay and decay kinetics.

b. Types of Chemical Bonds (14+ 7 = 18 hrs.)

(i) The covalent bond - the Lewis theory, Octet rule and its limitations. Shapes of the molecules – Sidgwick – powel theory. Valence shell electron pair (VSEPR) theory, effect of lone pair and electronegativity, isoelectronic principle, examples to apply VSEPR theory. Valence bond theory. Hybridization. Bond length, bond angle & dihedral angle, d-orbital participation in molecular bonding, sigma and pi bonding. Molecular orbital method – Linear combination of atomic orbitals (LCAO), MO treatment for di- and tri-atomic molecules and involving delocalized pi-bonding. Conjugation & aromaticity.

(ii) Metallic and organometallic bonds – general properties.

(iii) Coordinate bond- coordination complexes.

(iv) Physical properties and molecular structures – polaizability and dipole moments, melting point, solubility and acid-base properties, Intermolecular forces (dipole-dipole interaction) Hydrogen bonding and vander Waals’s forces.

c. Reactivity & Mechanism: (12 + 6= 18 hrs)

(i)Inductive and field effects and bond dissociation energy. pπ-dπ bonding.

Delocalization –cross conjugation, resonance. Aromaticity and Huckel’s rule – systems of 4n and 4n+2 electrons, antiaromaticity . Resonance and Hyperconjugation.

(ii) Reaction mechanism: Types of mechanisms, Arhenius theory, collision theory, types of reactions, redox reactions, displacement and addition reactions, thermodynamic and kinetic requirements, Hammond postulate, Curtin-Hammett principle, transition states and intermediates, carbocations, carbanions, free radicals, methods of determining mechanisms, isotopic effects.

(iii)General concepts: Oxidation number and oxidation states, Oxidation – reduction reactions and the use of reduction potential, Bronsted acids and bases, gas phase vs. solution acidity, solvent levelling effects, hardness and softness, surface acidity.

Reference Books:

1. J.D.Lee, Concise Inorganic Chemistry, 4th Edition, ELBS, 1991.
2. P.W.Atkins, Physical Chemistry, Oxford University Press, 7th Edition, 2006.
3. G.M.Barrow, Physical Chemistry, 5th Edition, Tata McGraw-Hill, New Delhi, 1992.
4. R. T. Morrison and R. N. Boyd, Organic Chemistry, Prentice Hall of India.
5. Peter sykes

6. G.W. Castellan, Physical Chemistry, 3rd Ed. Addison - Wesley/Narosa Publishing House, 1993.

B101 Biology I (Introduction to Biology)

1. Life: History and origin of life, Concepts of biological evolution, natural selection, speciation.
2. Classification of living things: Classification and domains of life, Prokaryotes and Eukaryotes, Taxonomy of plants, animals and microorganisms.
3. Ecology & Ecosystem: Concept of ecology and ecosystem, ecological succession, ecosystem dynamics, flow of ecology and matter, biogeochemical cycling, ecosystem changes, biotic and biotic factors and stresses, food web, adaptation of individual organism to the environment through genetic changes.
4. Cell Biology: Discovery of cell, cell theory, classification of cell types, cell membrane, cell-cell interactions, energy and metabolism, respiration, photosynthesis, sexual reproduction.
5. Cell Division and System Development: cell cycle, mitosis, meiosis, mechanism of development (stem cells), formation of tissues.
6. Physiology- Body Systems: Digestive system, circulatory system, Lymphatic system, nervous system, respiratory system, sensory system, homeostasis.

Recommended reading:

a. Biology with Mastering Biology (8th Edition) by Neil A. Campbell and Jane B. Reece (Hardcover - Dec. 7, 2007).

b. Biology: Concepts and Connections with my biology" (6th Edition) by Neil A. Campbell, Jane B. Reece, Martha R. Taylor, and Eric J. Simon (Hardcover - Feb. 28, 2008).

c. On the Origin of Species by Charles Darwin (Kindle Edition - Mar. 3, 2008) - Kindle Book.

d. Essential Cell Biology by Bruce Alberts, Dennis Bray, Karen Hopkin, and Alexander D Johnson (Hardcover - Mar. 27, 2009).

e. Molecular and Cell Biology For Dummies by René Fester Kratz (Paperback - June 2, 2009).

f. Darwin's Black Box: The Biochemical Challenge to Evolution by Michael J. Behe (Paperback - Mar. 7, 2006).

g. Biology: A Self-Teaching Guide, 2nd edition by Steven D. Garber (Paperback - Aug. 15, 2002).

G101: Computer Basics

Introducing LINUX: getting started; FORTRAN programming (roughly half of the course); LaTeX introduction (sufficient to make small documents); gnuplot - graph plotting and data fitting; xfig - simple drafting tool; MATHEMATICA - algebraic computations.

Besides regular lab work there should be a project which needs all tools developed/learnt during the course. Some of the projects done by the students are listed below.

a. Predator-prey problem
b. Harmonic oscillator with friction
c. Coupled pendulum
d. Testing random number generator
e. Brownian motion as a random walk problem
f. Sorting function and its application to making ranked lists
g. SUDOKU solver

H101: Communication Skills

An interactive session (with examples) on what is communication, communication in the natural and civilized worlds, types of human communication: visual / non-verbal / verbal, written / spoken, etc. An overview of mass media; a brief discussion of their types (with examples). The concepts of facilitating factors, barriers, and filters in communication; the seven C's of effective communication. Verbal communication: How to speak / listen effectively (in interpersonal communication), types of public speaking, tips for effective public speaking, how to make effective presentations. The role of written text

in communication, types of writing (academic/creative/general; formal/informal etc.) with examples of good/bad writing and their analysis. Introduction to letter writing, with stress on formal correspondence; email do's and don'ts.
Academic writing- an overview; explanation of various terms used in academic writing; parts of a paper/thesis; aspects such as formal language, grammatical accuracy, etc. Common grammatical/punctuation errors and how to avoid them (example-based instruction)

GL101 Computer Laboratory

History of computers; hardware basics. Concept of operating system; basic Unix/Linux commands; Office suite, including spreadsheets. Flowcharts; computer arithmetic. Simple FORTRAN programming - mathematical operators, input, output from keyboard, library functions. Conditional statements - If-then-else, Case, Go-to. Loops- Do loops, cycle, exit, nested loops. Arrays- 1 dimensional and multi-dimensional. Formatting - input and output. Input and output from file. Functions and Subroutines. Creating HTML pages. Plotting utilities like GNU Plot.
References:
1. Computer Oriented Numerical Methods - V. Rajaraman

PL101: Physics Laboratory I

Introduction to experimental physics – conceptual and procedural understanding, planning of experiments; Plots (normal, semi-log, log-log); uncertainty / error in measurements and uncertainty / error analysis. Introduction to measuring instruments – concepts of standards and calibration; determination of time periods in simple pendulum and coupled strip oscillator system with emphasis on uncertainty in the measurements and accuracy requirements; study of projectile motion – understand the timing requirements; determination of surface tension of a liquid from the study of liquid drops formed under the surface of a glass surface; determination of Young's modulus of a strip of metal by double cantilever method (use of traveling microscope); study of combination of lenses and nodal points and correspondence to a thick lens; study of thermal expansion of metal – use of thermistor as a thermometer; measurement of small resistance of a wire using Carey-Fosterbridge and determine electrical resistivity of the wire; study of time dependence of charging and discharging of capacitor using digital multimeter – use of semi-log plot.
References:
1. Advanced Practical Physics for Students – Worsnop and Flint

BL 101 Biology laboratory

1) Introduction to Biology laboratory
2) Taxonomy
3) Methods of Classification
    Dichotomous key
    Hierarchical Classification
    Phylogenetic Classification
4) Natural Selelction
5) Natural Selection using Daphnia
6) Concept of pH & Buffers:
    Hydrogen ion concentration in solutions
    Inorganic ion concentration in solutions
    Inorganic Buffers and Biological fluids
    Henderson-Hesselbach equation
7) Media Preparation:
    Preparing and inoculating solid and liquid nutrient media for culturing microorganisms
    Pouring nutrient agar plates and streaking bacterial culture on solid media
    Inoculating nutrient broth with bacterial culture

Preparing nutrient media

8) Introduction to Research Laboratory

Different kinds of microbial plates, liquid growth media for microbes, Laminar air flow system, stem cells laboratory, Centrifuges, Spectrophotometer, Sonicator, PCR and Real-time PCR, Gel Documentation system, *Chlamydomonas* and *Drosophila* incubation systems, Stereomicroscope and various Incubators

9) Growth Curve:

Generating a bacterial growth curve under various pH and environmental conditions (steady and shaking)

Calculations of Growth rate constant (μ)

Calculation of generation time

10) Enzyme Kinetics: To study an enzyme catalyzed reaction using hydroquinone as a substrate and peroxidase extracted from cabbage.

11) Introduction to Light Microscopy: Observing cells in a leaf peel using a compound microscope and To study the morphological characteristics of *Saccharomyces cerevesiae*.

12) Dye exclusion method of differentiating dead v/s live cells: To use a vital stain to distinguish dead and live yeast cells.

13) Staining and Observing human cheek cells: To carry out staining of epithelial cells from the mouth using acetocarmine and methylene blue stains.

14) Staining human blood cells: To observe human blood cell types by differential staining.

15) Plant anatomy: Relationship between plant anatomy and habitat.

16) Micrometry: Measuring size of a microscopic specimen.

17) Haemocytometer

18) Gram Staining: To differentiate bacteria cells by Gram staining.

CL101: Chemistry Laboratory

Calibrations of pipette, burette, standard flasks etc., acid base titrations, recystallization, thin layer chromatography, identification of organic functional groups, complexometric titrations based on EDTA complexation with metals, Synthesis of benzoic acid, diazotization etc.

Suggested text and references:

(1) Vogel's Textbook of Quantitative Chemical Analysis (5th Edition; Longmann)

(2) Vogel's Qualitative Inorganic Analysis (7th Edition)

(3) ACS Journal of Chemical Education

SEMESTER –II

Subject Code	Subject	Contact hrs/per week Theory + Tutorials	Credits
B 201	Biology II (Introduction to Macromolecules)	[2 +1]	3
C 201	Chemistry II (Chemical thermodynamics)	[2 +1]	3
P 201	Physics II (Electricity, Magnetism & Optics)	[2 +1]	3
M 201/M200	Mathematics II (Linear Algebra, Calculus of several variables)	[2 +1]	3
G 201	Electronics & Instrumentation	[2 +1]	3
G 202	Glimpses of Contemporary Science	[2 +1]	3
		Contact hrs/per week Lab	**Credits**
BL 201	Biology Laboratory	[4]	2
CL 201	Chemistry Laboratory	[4]	2
PL 201	Physics Laboratory	[4]	2
GL 201	Electronics Laboratory	[4]	2
			26

M200: Mathematics – II

1) Functions of several variables, partial derivatives, geometric interpretation, properties of partial derivatives, chain rule, applications.
2) Elementary discussion on scalars and vectors, norm of a vector, dot product, projections. Linear equations and matrices, matrix operations. Concept of a determinant, its properties, evaluation of a determinant, cross product as a determinant, lines and planes. Elementary ideas of tensors.
3) Vector functions. Gradient of a function, geometric interpretation, properties and applications; divergence and curl of a vector function, geometric interpretation, properties and applications; higher derivatives, Laplacian.
4) Line integrals. Double and triple integrals, their properties and applications to areas, volumes, etc.
5) Gradient theorem, Green's theorem, Stokes' theorem, divergence theorem, applications. Proofs of Stokes' and divergence theorems through physical examples (such as circulation in a 2 dimensional plane and accumulation of fluid in a given volume).
6) Curvilinear coordinate systems, spherical and cylindrical coordinates, area and volume elements, illustrations. Gradient, divergence and curl in curvilinear coordinate systems.
7) Introduction to linear algebra. Vector spaces, linear dependence and independence, notion of basis, and dimension, subspaces. Examples.
8) More on matrices: special kinds of matrices, their properties. Eignevalues and eigenvectors, secular determinant, characteristic polynomial. Eigenvalues and eigenvectors of a real symmetric matrix.
9) Illustrative examples.
10) Applications of linear algebra.

Suggested Texts and References (for M100 and M200)
1) Calculus: Gilbert Strang (MIT Courseware)
2) Calculus: Thomas
3) Elementary Linear Algebra: Howard Anton and Chris Rorres
4) Introduction to Linear Algebra: Gilbert Strang (MIT Courseware)
5) Mathematical Methods for Scientists and Engineers: George B. Arfken and Hans J. Weber (for curvilinear coordinates, beta and gamma functions only)

M201: Mathematics II (Linear Algebra and Calculus of Several Variables)

1. Algebra of matrices (mainly over the field of real numbers, but mention other fields also), special matrices (scalar, diagonal, upper and lower triangular, etc).
2. Linear equations and their matrix representations, row-echelon form, Gauss-Jordan elimination, general and particular solutions, homogeneous equations.
3. Invertible matrices and elementary matrices, computation of inverse using elementary row operations.
4. Determinants and their properties, minors and cofactors, determinant of a product of matrices, adjoint of a matrix, invertible matrices and determinants. Cramer's rule
5. Rank of a matrix, rank and invertibility.
6. Vector spaces (mainly over the field of real numbers, but mention other fields also), examples including the space of polynomials, the space of functions, the solution space of a system of homogeneous linear equations, and row and column spaces of a matrix.
7. Span, linear independence, basis, dimension and its uniqueness (without proof).
8. Linear transformations, isomorphisms, kernel and image, the dimension formula.
9. Eigenvalues and eigenvectors of a square matrix or a linear operator, computation of eigenvalues and eigenvectors, characteristic polynomial, sums and products of eigenvalues, similar matrices, diagonalization. (Most of the results to be discussed without proof)
10. Review of geometric properties of vectors in r^2 and r^3, dot, cross and scalar triple products, their properties and their geometric interpretation.
11. Vector fields, review of definitions and basic properties of gradient, divergence, directional derivatives, divergence, curl and the Laplace operator.
12. Paths and curves in r^2 and r^3, tangent, velocity, acceleration and force vectors, arc length.
13. A brief overview of differentials.
14. Double integrals as limits of Riemann sums and as volumes, their computation as iterated integrals, elementary regions.
15. Triple integrals as limits of Riemann sums, their computation as iterated integrals, elementary regions.
16. Change of variables, the Jacobian determinant, spherical and cylindrical coordinates.
17. Application of double and triple integrals to finding volume, centre of mass, etc.
18. Line integrals, their dependence on parametrization, their computation, work done.
19. Parametrized surfaces, normal to a surface, surface area, surface integrals and their dependence on parametrization, their computation.
20. Oriented surfaces, statement of Green's theorem and its application to computing the area of a region, statements of Stokes' theorem, and Gauss' divergence theorem.
21. Conservative vector fields.

References:

1. D.J.S. Robinson, A Course in Linear Algebra with Applications, World Scientific.
2. G. B. Thomas and R.L. Finney, Calculus and Analytic Geometry, 9th ed., Addison-Wesley/Narosa, 1998.
3. J. Marsden, A. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer.
4. Inder K. Rana, Calculus@iitb, Concepts and Examples, Version 1.2, math4all 2009.

P201: Physics – II: Electricity, Magnetism and Optics

Electricity and Magnetism

Electrostatics: Coulomb's law and Gauss' law; Electrostatic potential, uniqueness theorem, method of images; Electrostatic fields in matter; Conductors and insulators; Capacitors and capacitance; Electric current. Magnetostatics: Biot – Savart law, Ampere's law; Electromagnetic induction; Mutual inductance and self inductance; Magnetic fields in matter.

Displacement current; Maxwell's equations; Alternating current circuits; Electric and magnetic properties of matter; Plane electromagnetic waves in vacuum; Polarisation; Energy and momentum in electromagnetic waves; electromagnetic radiation (qualitative); Dipole radiation formula; Larmor's formula for radiation due to accelerated charge (without proof); Synchrotron radiation (descriptive).

Optics

Interference of two beams and involving multiple reflections; Young's experiment, Fresnel's biprism, Lloyd's mirror, Optical instruments; Telescope and microscopes; Magnifying power and resolving power. Sources of light and spectra; Dispersion, polarization, double refraction; Optical activity.

Suggested texts and References:

1) Electricity and Magnetism, Berkeley Vol. 2: Edward M. Purcell
2) Feynman Lectures Vol. 2
3) Waves, Berkeley Vol. 3: Frank S. Crawford
4) Fundamentals of Optics: Jenkins and White

C 201: Chemistry II (Thermodynamics & Equilibrium) (30 + 15 = 45 hrs.)

(i) Classification of system, intensive and extensive properties, equilibrium and
(ii) Heat, work and energy, irreversible and reversible expansion work of an ideal
(iii) First law of thermodynamics, heat content or enthalpy of a system, molar
(iv) Thermochemistry – Enthalpy of a reaction, exothermic and endothermic
(v) Second law of thermodynamics, Carnot cycle, entropy, entropy change and
(vi) Free energy functions and Maxwell's relations, Gibb's Helmholtz relations, nonequilibrium states, reversible and irreversible processes. gas, internal energy in a cyclic process. heat capacities, Joule-Thomson effect, Adiabatic expansion of an ideal gas and work done. reactions, thermochemical equation, Kirchoff's equation, heat of reaction and flame temperature, heat of combustion, heat of solution, heat of neutralization, heat of fusion, heat of vaporization, Bond energy and dissociation energy, Hess's law and its applications. irreversible processes and Clausius inequality, entropy and available work. criteria of spontaneity and conditions of equilibrium, Heat capacity relations (Cp/Cv and Cp – Cv), change of phase and Clapeyron equation, Trouton's rule.
(vii) Electrode potential and free energy, electrochemical series.
(viii) Nernst heat Theorem and third law of thermodynamics, experimental
(ix) Elements of statistical thermodynamics
(x) Chemical equilibrium and chemical potential (μ): chemical potential of an determination of entropy. ideal gas and gas mixture, Gibbs free energy and entropy of mixing,Chemical
(xi) Phase equilibrium in simple systems: Equilibrium condition, stability of the
(xii) Ideal solutions and colligative properties: ideal solutions, chemical potential equilibrium in a mixture of ideal gases and real gases, Equilibrium constants – Kx and Kc between ideal gases and pure condensed phase. Lechatelier principle and applications. phases of a pure substance, pressure dependence of μ vs. T curves, Clapeyron equatons, Phase equilibrium: solid- liquid, liquid-gas, solid-gas, phase diagram – water, carbondioxide, sulphur, Effect of pressure on the vapour pressure, the phase rule. of a solute in a binary ideal solution – Gibbs-Duhem equation, Colligative properties – freezing pointing depression, solubility, elevation of boiling point, Osmotic pressure, Vant Hoff equation.

Reference Books:

1. P.W.Atkins, Physical Chemistry, Oxford University Press, 7th Edition, 2006.
2. G.W. Castellan, Physical Chemistry, 3rd Ed. Addison - Wesley/Narosa Publishing House, 1993.

3. G.N.Lewis and Randall, Thermodynamics, (Revised by K.S.Pitzer and L.Brewer), International Students Edition, McGraw Hill, 1961.
4. K. Denbigh, The principles of Chemical Equilibrium.
5. B. G. Kyle , Chemical & Process Thermodynamics.
6. Prutor and Meson

B201: Introduction to Molecules (35 + 10 = 45 hrs.)

1. Cell – Overview: Cellular organization, Biomembranes, Nucleus, Cytoplasmic organelles, Bacteriophages.
2. Nucleic Acids, Genomes and Proteomics: Building blocks- nucleotides, DNA structure, RNA structure and function, chromatin structure, genome code, genes, repetitive DNA sequences.
3. Gene Transcription: Overview of gene expression, overview of transcription, gene's regulatory elements, transcription mechanisms in prokaryotes and eukaryotes (a comparison).
4. Protein Structure and Function: Building blocks- amino acids, peptides, secondary structure, three dimensional structure, membrane proteins, miscellaneous proteins, enzymes.
5. Cell Signaling: Overview, signaling via hydrophobic molecules, signaling via ion channels, Signaling via G-protein coupled receptors, signaling via cell surface enzymes, intracellular signaling.
6. Biotechnology: DNA cloning, Uses of recombinant DNA technology, Polymerase chain reaction (PCR), Production of recombinant proteins and SDS-PAGE.

Recommended reading:-

a. Molecular Biology of the Cell by Bruce Alberts, Alexander Johnson, Julian Lewis, and Martin Raff.
a. Molecular Biology of the Gene (6th Edition) by James D. Watson, Tania A. Baker, Stephen P. Bell, and Alexander Gann.
b. Molecular Biology of the Cell, Fifth Edition: The Problems Book by John Wilson and Tim Hunt (Paperback - Nov 28, 2007).
c. Genes IX (Lewin, Genes XI) by Benjamin Lewin (Hardcover - Mar 5, 2007).

BL201: Biology Practicals

1. Observing instruments to be used in semester II, their use and maintenance: (a) micro-pipettes, (b) tissue homogenizer, (c) electrophoresis apparatus, (d) centrifuges, (e) ultraviolet and visible (uv-vis) absorption spectrophotometer
2. Centrifugation of the cell contents at varying speeds such that the subcellular fractions separate out based on their density differences
3. Photosynthesis - floating leaf disc experiment under various conditions (light, dark & light - dark)
4. Visit to TIFR
5. Nucleic acid extraction - from plant & animal tissue using ethanol precipitation
6. Agarose gel electrophoresis
7. Analysis of DNA under various conditions – pH and Temperature
8. Protein extraction & separation using polyacrylamide gel electrophoresis (PAGE)
9. Carbohydrate extraction & estimation - extraction of sugars from grapes & estimation of the same by DNSA method
10. Protein extraction & estimation

determination of total protein content in microorganisms by folin-ciocaltaeu method

11. Lipid extraction & separation - Extraction of total lipids from liver tissue & separation by thin layer chromatography
12. Separation of biomolecules using:
    - Adsorption chromatography
    - Partitioning of indicators in various solvent systems.
    - Separation of a mixture of solutes by partitioning
    - Separation of leaf pigments by paper chromatograhy
    - Separation of flower pigments by paper chromatograhy

13. Reverse phase thin layer chromatography (PRTLC) - Separation of photosynthetic pigments

PL201: Physics Laboratory II

Review of uncertainty / error analysis; least squares fit method; introduction to sensors / transducers; determination of 'g' (acceleration due to gravity) by free fall method; study of physical pendulum using a PC interfaced apparatus – study variation of effective 'g ' with change of angle of plane of oscillation - investigation of effect of large angle of oscillation on the motion; study of Newton's laws of motion using a PC interfaced apparatus; study of conservation of linear and angular momentum using 'Maxwell's Wheel' apparatus; study of vibrations of soft massive spring; study of torsional oscillatory system; study of refraction in a prism - double refraction in calcite and quartz; study of equipotential surface using different electrode shapes in a minimal conducting liquid medium; determination of electrical inductance by vector method and study effect of ferromagnetic core and study the effect of non-linearity of inductance with current.

1. Advanced Practical Physics for Students – Worsnop and Flint

G201 & GL201: Electronics & Instrumentation G201 and Electronics Lab GL201

Analog electronics: Introduction to passive electronic components -resistance, capacitance, inductance; Circuit theorems: Thevenin's theorem, Norton's theorem and Maximum power transfer theorem; basic concepts of semiconductor diode and transistor; Principle of DC power supply; half and full wave bridge rectifier, capacitor filter – ripple factor, concept of load and line regulation, concept of constant voltage source and constant current source; concept of short circuit protection and current limit protection; Zener regulator; concept of Switch Mode Power Supply (SMPS), power supply ICs, charge pump ICs for stepping up voltage and for bipolar supply; application of Bipolar Junction Transistor (BJT) - biasing circuits: The CE configuration, fixed base bias, emitter bias, and potential-divider or voltage divider bias; CE amplifier, amplifier as a switch, concept of negative feedback, differential amplifier; Operational Amplifier (OPAMP): principle, basic characteristics and parameters relevant for general use; non-inverting and inverting amplifier, voltage follower, difference amplifier, summing amplifier, voltage controlled current source; OPAMP comparator, Schmidt trigger; Digital to Analog Converter (DAC) with weighted resistance and R-2R ladder network; Anlog to Digital Converter (ADC); filters: low pass, high pass; band pass; Butterworth filter. Digital electronics: Review of basic logic gates; DeMorgan's theorem, Use of NAND / NOR as universal building blocks; arithmetic circuits; binary addition, half adder, full adder, binary subtraction - 1s and 2s complement, controlled inverter, adder / subtracter, parity checker; Flip-Flops (FF): RS-FF, D-FF, JK-FF; counters and shift registers: binary counter, ripple counter.

References:

1. Electronic Principles - Malvino and Bates
2. Electronic Devices and Circuits – David A. Bell
3. Digital Principles and Applications – Leach, Malvino and Saha

G202: Glimpses of Contemporary Science

Physics in life systems: size and scale, diffusion, cell locomotion, force generated by actin growth and flagellum rotatory motion, ion channels, resting potential across the membrane, nerve conduction velocity, action potential, macromoleculaes of life, random walk model of polymer, single molecular experiments, optical tweezers, magnetic tweezers.

Complex systems: dynamical chaos, logistic map, bifurcation, Universality, Feigenbaum constants, Mechanical demonstrations of chaos, Nanomechanical oscillators, Patterns, Reaction-diffusion systems, Nodal patterns, thermodynamics and human population, Falling leaves, Smoke ring physics.

At the turn of 1900: Silver threads, Discovery of the electron, Rutherford's nuclear atom Wien's law, Blackbody radiation and Max Planck's action. Quantum mechanics, atoms : Entanglement

Light-atom interaction, Bringing atoms to rest, Laser tweezers , How bright is laser, Quantum computing.
Astrophysics, Astrochemistry and Astrobiology
Suggested Texts and References:
1) Growth and Forms, Darcy Wentworth Thompson
2) Physical biology of the cell: Rob Phillips
3) Random walks in biology, Harward Berg
4) Physics: Structure and Meaning , L. Cooper
5) The Feynman Lectures on Physics vol. 3,R. P. Feynman, R. B. Leighton, and M. Sands
6) Introduction to the study of stellar structure , S. Chandrasekhar

PL201: Physics Laboratory – II

Review of uncertainty / error analysis; least squares fit method; introduction to sensors / transducers; determination of 'g' (acceleration due to gravity) by free fall method; study of physical pendulum using a PC interfaced apparatus – study variation of effective 'g ' with change of angle of plane of oscillation - investigation of effect of large angle of oscillation on the motion; study of Newton's laws of motion using a PC interfaced apparatus; study of conservation of linear and angular momentum using 'Maxwell's Wheel' apparatus; study of vibrations of soft massive spring; study of torsional oscillatory system; study of refraction in a prism - double refraction in calcite and quartz; study of equipotential surface using different electrode shapes in a minimal conducting liquid medium; determination of electrical inductance by vector method and study effect of ferromagnetic core and study the effect of non-linearity of inductance with current.
Suggested Texts and References:
1. Advanced Practical Physics for Students – Worsnop and Flint

CL 201: Chemistry Laboratory

Colorimetric titrations, Beer Lambert law, Estimation of concentration by colorimetric methods, conductometric methods, estimation of concentraion of acid base bt pH meter, identification of inorganic anions and cations, finding of pka values, short project of 2 weeks based on the experiments available in Journal of Chemical Education.

Suggested text and references:
(1) Vogel's Textbook of Quantitative Chemical Analysis (5th Edition; Longmann)
(2) Vogel's Qualitative Inorganic Analysis (7th Edition)
(3) ACS Journal of Chemical Education

SECOND YEAR
SEMESTER –III

Subject Code	Subject	Contact hrs/per week Theory + Tutorials	Credits
CB301	Essential Mathematics for Chemistry & Biology	[3 +1]	4
CB 302	Biochemistry – I	[3 +1]	4
B 301	Cell Biology – I	[3 +1]	4
CB 303	Organic Chemistry-I	[3 +1]	4
H 301	World Literature	[2 +0]	2
H302	History & Philosophy of Science	[2 +0]	2
		Contact hrs/per week Lab	**Credits**
BL 301	Biology Laboratory	6	3
GL 301	Applied electronics laboratory	4	2
			25

CB301: Essential Mathematics for Chemistry & Biology

Applications of Taylor series, Euler series.
Review of first order ordinary differential equations, second order ODE's with constant coefficients, solutions by series expansion methods, introduction to partial differential equations, Laplace's equation, separation of variables, Legendere differential equation and Legendere polynomials, important properties of Legendere poynomials, Hermite polynomials, Laguerre polynomials, Fourier series and simple applications, Laplace transforms and applications, convolution.
The matrix Eigen value problems, Secular determinants, Characteristics polynomials,
Eigen values and Eigen functions. Eigen values of real symmetric matrices; Eigen values and
Eigen functions, important properties and examples.
Complex numbers, Analytic functions, Cauchy Riemann equations, Cauchy's integral
formula, Residue theorem and simple applications.
Suggested texts and References:

CB302: Biochemistry-I (45 + 15 = 60 hrs.)

Requisites: Introductory Biology and Basic Chemistry

1) General biochemistry concepts: The concept of pH, dissociation and ionization of acids and bases, pKa, buffers and buffering mechanism, Henderson Hasselbalch equation, dissociation of amino acids and determination of pKa.
2) Major categories of cellular macromolecules:
   - Carbohydrates : sugar -- disaccharide -- polysaccharide -- starch -- glycogen
   - Lipids : fatty acid -- fats -- essential oils -- oils -- waxes -- cholesterol
   - Nucleic acids: DNA--RNA--mRNA--tRNA--rRNA--codon--adenosine--cytosine--guanine--thymine--uracil
   - Proteins: amino acid -- glycine -- arginine -- lysine and peptide--primary structure--secondary structure--tertiary structure--conformation--protein folding

   Chemical properties:

- molecular bond -- covalent bond -- ionic bond -- hydrogen bond -- ester -- ethyl
- molecular charge -- hydrophilic -- hydrophobic -- polar
- pH -- acid -- alkaline -- base
- oxidation -- reduction -- hydrolysis

Structural compounds:

- In cells: flagellin -- peptidoglycan -- myelin -- actin -- myosin
- In animals: chitin -- keratin -- collagen -- silk
- In plants: cellulose -- lignin -- cell wall

Enzymes and enzyme activity:

- enzyme kinetics -- enzyme inhibition
- proteolysis -- ubiquitin -- proteasome
- kinase -- dehydrogenase

Membranes : fluid mosaic model -- diffusion -- osmosis

- phospholipids -- glycolipid -- glycocalyx -- antigen -- isoprene
- ion channel -- proton pump -- electron transport -- ion gradient -- antiporter -- symporter -- quinone -- riboflavin

- Lipids, Vitamins, Hormones

3) Protein structure and function: folding, modification, enzymes, enzyme kinetics, enzyme regulation and inhibition

Recommended Reading:-

a. Lehninger Principles of Biochemistry, Fourth Edition by David L. Nelson & Michael M. Cox.

b. Stryer L (1995) Biochemistry, 4 th edition, W. H. Freeman & company, New York.

c. Energy and Entropy equilibrium to stationary states, Starzak, Michael E. 2010, XI, 303 p.

d. Fundamentals of General Organic and Biological Chemistry (Study Guide) by John McMurry (Paperback - Jan. 1999).

CB 303: Organic Chemistry –I (45 +15 = 60 hrs.)

A. Basic concepts - Recapitulation

Hybridisation, formal charge, inductive and resonance effects and their effect on reactivity and acidity and basicity of organic compounds; polar & non polar covalent bonds; homolytic and heterolytic fission, types of reagents- electrophiles and nucleophiles; curly arrow notation; classification of organic reactions.

B. Chemistry of Aliphatic compounds

IUPAC nomenclature of aliphatic and substituted aliphatic compounds and alicyclic compounds

Preparation, structure, properties and reactions of the following classes of compounds.

i) Hydrocarbons - a) alkanes, Methods of formation Kolbe reaction, Wurtz reaction, Corey House reaction, decarboxylation of carboxylic acids; Mechanism of halogenation of alkanes, orientation, selectivity & reactivity, product ratio.

b) Cycloalkanes - Methods of formation and reactivity ; Baeyer's strain theory and its limitation; theory of strainless rings

c) Alkenes - Elimination reactions ; Saytzeff & Hoffman elimination; Reactions – halogenation reactions-free radical and polar mechanisms. Markownikoff's rule, the peroxide effect, allylic halogenations using NBS; Ozonides/Ozonolysis. epoxidation; hydroboration-oxidation; oxymercuration-demercuration; Oxidation using KMnO4 & OsO4.; polymerization.

d) Dienes - Structure of butadiene and allene ; 1,2 vs 1,4 addition ; Diels Alder reaction.

e) Alkynes - Methods of formation; acidity of alkynes; electrophilic addition to alkynes; hydroboration oxidation ; metal ammonia reductions; hydrogenation using Lindlar's catalyst.

ii) Alkyl halides - Preparation, properties and synthetic applications of alkyl halides ; SN1 & SN2 reactions (mechanism), E1 and E2 reactions(mechanism); Grignard reagent and its applications.

iii) Alcohols - Methods of formation ; acidity ; H-Bonding ; reactions of mono; di & trihydric alcohols; Diols as protecting groups

iv) Ethers and epoxides - Formation & reactions of ethers and epoxides ; ring opening reactions of epoxides under acidic and basic consitions; reaction epoxides with Grignard & organolithium reagents
v) Aldehdyes & ketones - Methods of formation of aldehdyes and ketones; Nucleophilic addition reactions with cyanide, ammonia and derivatives of ammonia; acetal formation; oxidation reduction reactions. Meerwin-Pondroff-Verley reduction, Clemmensen reduction, Wolf-Kishner reduction, Aldol condensation reaction, Cannizzaro reaction, Tischenko reaction, haloform reaction, Baeyer-Villiger oxidation, Wittig reaction; Mannich reaction
vi) Carboxylic acids - Methods of formation of mono and di carboxylic acids; acidity and factors affecting acidity; reactions of carboxylic acids :
vii) Carboxylic acid derivatives - Methods of formation of acid chlorides, amides, anhydrides and esters and their interconversions; relative stabilities of acid derivatives; Rosenmund reaction; Hoffmann rearrangement; saponification.
viii) Nitrogen and sulphur compounds - Nitro alkanes

CB303: Chemistry of Organic Molecules –I (45 +15 = 60 hrs.)

A. Chemistry of aliphatic compounds: preparation, structure, properties and reactions.
1) Hydrocarbons: alkanes, alkenes, alkynes. Preparation, Structures and Reactions – substitution, addition and halogenation reactions. Electrophilic addition: rearrangements. Free radical and polar mechanisms. Markownikoff's rule, the peroxide effect, Lemieux reagent, Grignard reagent, Wurtz reaction,
2) Ozonides/Ozonolysis. Stereoselctive and Stereospecific reactions. (5 hrs.)
3) Monohydric and polyhydric alcohols and ethers (3hrs.)
4) Carbonyl compounds – Oxidation, reduction reactions. Meerwin-Pondroff-Verley reduction, Clemension reduction, Wolf-Kishner reduction, Schmidt reaction, Aldol condensation, Claisen condensation, Claisen-Schmidt reaction, Cannizaro reaction, Tischenko reaction, haloform reaction, Baeyer-Villiger oxidation, Polymer of acetaldehyde, Chloral (5 h).
5) Carboxylic acids and derivatives (4hrs.)
6) Polycarbonyl compounds. Compounds with conjugated double bonds – dienes and enones, a,b-unsaturated compounds – tautomerism. Unsaturated alcohols, ethers, and carbonyl compounds. (5hrs).
7) Nitrogen, sulphur, phosphorous, silicon and boron compounds. Aliphatic diazocompounds. (4hrs.)
B. Chemistry of aromatic compounds – preparation, structure, properties and reactions.
1) Hydrocarbons: monocyclic, polycyclic and condensed systems. Reactivity and orientation. Electrophilic substitution reactions- general methods of preparation of benzene homologues, Hammett and Taft equation, Friedel-Crafts reaction.
2) Polynuclear hydrocarbons and their derivatives.
3) Halogen, nitro, nitroso, amino compounds. Diazonium salts and their related compounds.
4) Aromatic alcohols, Phenols, ethers, aldehydes, ketones, quinones carboxylic and sulfonic acids.
Text / References:
a. I. L. Finar, Organic Chemistry, Vol. 1 & 2, ELBS.
b. R. T. Morrison and R. N. Boyd, Organic Chemistry, Prentice Hall of India.
c. L. G. Wade, Organic Chemistry, Pearson Education
d. G. Solomons and C. Fryhle, Organic Chemistry, John Wiley & Sons (Asia) Pte Ltd.
e. M. J. Sienko and R. A. Plane, Chemical Principles and Applications, McGraw Hill, 1980.
f. D. D. Ebbing, General Chemistry, Houghton Miffin Co., 1984.
g. T.W.G. Solomons, Fundamentals of Organic Chemistry, 5th Ed., John Wiley, 1992.
h. J. March, Advanced Organic Chemistry, 3rd Edn. McGraw Hill,1991.
i. F.J. Carey and R.J. Sundburg, Advanced Organic Chemistry, Part A and Part B, 2nd Edn. Plenum Press, 1983.

B301: Cell Biology-I

Requisites: Introductory Biology, Basic Molecular Biology

1) Cell biology - An Overview: Universal features of cells, Diversity of their genomes, Overview of cell chemistry (important atoms and their properties, pH, acids, bases, and buffers in cells, formation and functions of proteins, DNA, sugars, and fats in cells), Visualization of cell (Basic principles of light microscopy, Different microscopic techniques for imaging cells).
2) Membrane system: The cell membrane and its structure, Models of the biomembrane: Charles Overton's "Lipid Membrane", Lipid monolayer model of Irwing Langmuir, Lipid bilayer model by Gorter and Grendel, Protein-containing lipid bilayer model of Daveson and Danielly, David Roertson's direct observation of the membrane, Fluid Mosaic model of Singer and Nicholson, Constituents and fluidity of plasma membrane, Transport across membrane, Ion channels.
3) Cellular organelles and their functions: Mitochondria: Structure of mitochondria, Different enzymes and their location, Electron transport complexes, ATP synthase, Mitochondrial DNA, Structure of chloroplast, Protein complexes and photosynthetic electron transport chain, DNA of the chloroplast, Bioenergetics, Structure and functions of the ribosomes, Endoplasmic reticulum, Golgi body, Lysosomes, and Nucleus. Protein sorting, Vesicular traffic inside the cells, targeting & degradation
4) Cytoskeleton, cilia and flagella: Structure and functions of Microtubules, Actin, and Intermediate filaments. Interplay between different cytoskeletal components. Molecular motors. Cilia and flagella: structure and functions. Diseases associated with the cytoskeleton, cilia, and flagella.
5) Organization, Replication, and Maintenance of the genome: Complexity of eukaryotic genomes, Chromosomes and chromatin, DNA replication, DNA repair, DNA rearrangements

H301: Introduction to World Literature

What is Literature? - a discussion; Introduction to literary terms, genres, and forms of various periods, countries, languages, etc. The Novel: Class study of 'Brave New World' by Aldous Huxley; Group discussions and student presentations on other genres such as the graphic novel, detective fiction, children's literature, etc. Plays: Introduction to the history of theatre, class study of (mainly) two plays: 'Pygmalion' by G. B. Shaw and 'Fire and Rain' by Girish Karnad, the setting up of play – reading group through which the students can be introduced to several other plays. Poetry: Brief introduction; Study of poetic genres, forms, topics, figures of speech, poetic language etc. by analysing various poems from around the world. Short stories, essays and other types of writing by various authors. Screening of films based on literary works, such as Pygmalion (My Fair Lady), Fire and Rain (Agnivarsha), Persepolis (a graphic novel) and a few others.

H302: History and Philosophy of Science

History of Science:

Genesis of systematic ideas: Science in ancient Greece; against mythological explanations to natural phenomena; Early atomism, mathematical atomism, against atomism; Method of analysis and synthesis; Beginning of mathematical sciences; multicultural origins of science. Renaissance and scientific revolution: Galilean ideas; mechanisation of world picture; From alchemy to chemistry, from natural history to evolutionary history, from natural numbers to complex numbers, from physiology to cell biology. Rise of experimental science: Discussion of some of the crucial experiments with an emphasis on the analysis of conceptual changes rather than the technical details.

Suggested Texts and References

1. Cambridge Illustrated History of Science by Colin Ronan
2.Great Scientific Experiments: 20 Experiments that Changed our View of the World by Rom Harre

History of Indian Science

Comprehensive idea about Sanskrit literature in relation to scientific writing: Vedic and Classical literature – aim and perspective; Brief overview of the contemporary cultural development elsewhere in the world; Indus Civilisation: progress of art, architecture, science and technology, role of geometry in art and architecture; Study of ancient Indian linguistic techniques and their relation with modern programming languages; Overview of Paninian style and techniques; Precision of

Sanskrit in expressing technical terms; History of number naming and writing in India; Sulbasutra and Vedanga Jyotisha – geometrical constructions and astronomical calculations; Jain literature on mathematics and astronomy; Linguistic techniques used in Aryabhatiya; Works of Brahmagupta in opposition of Aryabhata; Contribution of Kerala school of mathematics to development of mathematical ideas.

Suggested Texts and References:

1. Geometry in Ancient and Medieval India by Dr. T. A. Saraswati Amma, MLBD
2. Mathematics in India by Kim Plofker (Princeton Univ. Press)

Philosophy of Science

Introduction to epistemology; Possible criteria of demarcation between science and folklore; Non–science and metaphysics; Introduction to logical positivism and the "standard view"; Criticism of "standard view".

Suggested Texts and References:

1. Philosophy of Science – A Very Short Introduction by Samir Okasha (Oxford Univ. Press, 2002)
2. The Golem – What Everyone should Know about Science by Henry Collins and Trevor Pinch (Cambridge Uni. Press, 1996)
3. What is this thing called Science? By Alan Chalmers

BL301: Biology Laboratory (Biochemistry + Cell Biology)

1. Biochemical calculation
2. Amino acid titration:
   Determine the pka value of the provided amino acid solutions using titration curve.
   Identify the amino acids using the reference table on the basis of pka values obtained
3. Carbohydrate identification & estimation by anthrone method
   Extraction of carbohydrates from various sources.
   Identification by dichotomous key & estimation by anthrone method
4. Estimation of total free amino acids
   Extraction of total free amino acids from plant sample estimation by ninhydrin reagent
5. Acid value - Acid number is a measure of the amount of carboxylic acid groups a fatty acid
6. Iodine number
   Iodine numbers are often used to determine the amount of unsaturation in fatty acids
7. Saponification value
   Measure of the average molecular weight (or chain length) of all the fatty acids present
8. Peroxide value - Gives the evidence of rancidity in unsaturated fats and oils
9. Potato starch - isolation of starch
10. Enzyme kinetics
    Enzymatic reaction using potato starch and salivary amylase.
    Determine Vmax and Km for individuals salivary amylase.
11. pH and temperature effect on enzyme kinetics
    Effect of pH and temperature on salivary amylase action on starch
12. Effect of inhibitors on enzyme kinetics
13. Carbohydrate identification by thin layer chromatography
    Extraction of carbohydrates from various fruit sample and identification by separating using tlc
14. Chromatography

Paper chromatography

2 – dimensional chromatography of a mixture of amino acids

Circular chromatography

Separation utilizing gel filtration and ion-exchange chromatography, S. Russo and A. Radcliffe, *J. Chem. Educ*. **68**, 168-171 (1991).

Isolation of lactoferrin by immobilized metal ion affinity chromatography (IMAC), A. Calvo and F. Batista-Viere, *Biochem. Educ.* **22**, 50-52 (1994).

Rapid microscale isolation and purification of yeast alcohol dehydrogenase using Cibacron blue affinity chromatography, C. Morgan and N. Moir, *J.Chem. Educ.* **73**, 1040-1041 (1996).

Chromatographic separation of two proteins, J. Szeberenyi, *Biochem. Mol. Biol. Educ.* **35**, 71-72 (2007).

15. Electrophoresis

SDS-agarose gel electrophoresis in a simple procedure for determining high molecular weight protein oligomerization, M. Brownleader et al., *Biochem.Educ.* **22**, 155-158 (1994).

Capillary electrophoresis: a fast and simple method for the determination of the amino acid composition of proteins, P. Weber and D. Buck, *J. Chem. Educ.* **71**, 609-611 (1994).

Determination of the subunit molecular mass and composition of alcohol dehydrogenase by SDS-PAGE, B. Nash, *J. Chem. Educ.* **84**, 1508-1511 (2007).

Metal-catalyzed cleavage of tRNA-Phe, S. Kirk et al., *J. Chem. Educ*. **85**, 676-678 (2008).

Introducing proteomics in the undergraduate curriculum: A simple 2D gel electrophoresis exercise with serum proteins, T. Kim and P. Craig, *Biochem. Mol. Biol. Educ.* **38**, 29-34 (2010).

16. Isolation and Characterization of Enzymes

Testing the á-amylase inhibitor of the common bean, J. Moreno et al., *J. Chem. Educ.* 71, 350-352 (1994). A rapid and inexpensive procedure for the determination of amylase activity, V. Mulimani and J. Lalitha, *Biochem. Educ.* 24, 234-235 (1996).

A rapid and inexpensive procedure for the determination of proteolytic activity, S. Castro and A. Cantera, *Biochem. Educ.* 23, 41-43 (1995).

Zymography of extracellular matrix proteases, A. Quesada et al., *Biochem. Educ.* 24, 170-171 (1996).

The thermodynamic stability and catalytic activity of yeast alcohol dehydrogenase at different pH values, R. Tabor and J. Ladwig, *Biochem. Educ.* 25, 169-170 (1997).

The competitive inhibition of yeast alcohol dehydrogenase by 2,2,2-trifluoroethanol, R. Tabor, *Biochem. Educ.* 26, 239-242 (1998).

From egg to crystal: a practical on purification, characterization, and crystallization of lysozyme for bachelor students, V. Olieric et al. *Biochem. Mol. Biol. Educ.* **35**, 280-286 (2007).

Lactate dehydrogenase kinetics and inhibition using a microplate reader, J. Powers et al. *Biochem. Mol. Biol. Educ.* **35**, 287-292 (2007).

17. Cell biology

Cell staining – i (capsule, cell wall, lipid granules)

Cell staining – ii (metachromatic granules, endospores)

Cell motility

Subcellular fractionation of mouse liver tissue, page & wester blotting

Immunoflourescence of cytoskeleton & nuclear proteins

Meosis using lily anthers

SEMESTER –IV

Subject Code	Subject	Contact hrs/per week Theory + Tutorials	Credits
B 401	Cell Biology – II	[3 +1]	4
B 402	Biochemistry – II	[3 +1]	4
CB 401	Introductory Spectroscopy (UV-vis, fluorescence, IR, Raman, NMR)	[3 +1]	4
PCB 401	Physical & Chemical kinetics	[3 +1]	4
G 401	Statistical techniques and Applications	[3 +1]	4
		Contact hrs/per week Lab	**Credits**
BL 401	Biology Laboratory	6	3
GL 401	Computational laboratory and Numerical Methods	4	2
			25

PCB401: Physical & Chemical Kinetics: (45 + 15 = 60 hrs.)

1) Basic Concepts: Rate, order and molecularity of a reaction, First, second and third order reactions – effect of concentration on reaction rate, rate expressions and integrated form, pseudo-unimolecular and second order autocatalytic reactions, nth order reaction of a single component, effect of temperature on reaction rate – Arrhenius equation and activation energy.

2) Complex Reactions: parallel first order reactions, series first order reactions – determination of rate constants by graphical method and the time ratio method. The stationary state, radioactive decay, general first order series and parallel reactions. Competitive, consecutive second order reactions, reversible reactions, equilibrium from the kinetic view point, complex mechanisms involving equilibria.

3) Kinetic Measurements: Experimental determination of reaction rates and order of reactions – correlation of physical properties with concentrations, reactions in the phase, reactions at constant pressure, fractional-life period method, initial rate as a function of initial concentrations.

4) Reactions in Solutions: General Properties, Phenomenological theory of reaction rates, Diffusion limited rate constant, Slow reactions, Effect of ionic strength on reactions between ions, Linear free energy relationships, Relaxation methods for fast reactions.

5) Catalysis: Homogeneous catalysis in gas phase, in solution, basis of catalytic action, catalysis and the equilibrium constant, acid base catalysis, The Bronsted catalysis law, linear free energy changes, general and specific catalysis. Heterogeneous catalysis. Negative catalysis and inhibition, Surface reactions – effect of temperature and nature of surface. Industrial catalysis.

6) Chain reactions: general treatment, activation energy, chain length, chain transfer reactions, inhibition, bond dissociation energies, branching chain reactions.

7) The collision theory: Dynamics of bimolecular collisions and rate and rate constant of bimolecular reaction, factors determining effectiveness of collisions, Termolecular reactions, unimolecular reactions. Relation between cross section and rate coefficients.

8) Potential Energy Surfaces: Long range, empirical intermolecular and molecular binding potentials, Internal coordinates and normal modes of vibration, Potential energy surfaces, ab-initio calculation of

potential energy surface, experimental determination of potential energy surfaces, Details of the reaction path, potential energy surface for electronically excited molecule. Molecular beam scattering, State resolved spectroscopic technique, molecular dynamics of H2 + H reaction, state-to-state kinetics of F + H2 reaction.
9) Transition State Theory (TST): Motion on the potential energy surface, Basic postulates and derivation of TST, dynamical derivation of TST, Quantum mechanical effects on TST, Thermodynamic formulation of TST, Application of TST, Microcannonical TST, Variational TST, Experimental observation of TST.
Texts/References
a. K.A. Connors, Chemical Kinetics: A Study of Reaction Rates in Solution, V.C.H. Publications 1990.
b. J.I. Steinfeld, J.S. Francisco and W.L. Hase, Chemical Kinetics and Dynamics, Prentice Hall 1989.
c. K. J. Laidler, Chemical Kinetics, 3rd ed. Harper and Row, 1987.
d. R. D. Levine and R. B. Bernstein, Molecular Reaction Dynamics and Chemical Reactivity, Oxford University Press, 1987.
e. J.W. Moore and R.G. Pearson, Kinetics and Mechanisms, John Wiley and Sons, 1981.
f. Sanjay K. Upadhay, Chemical kinetics and Reaction Dynamics, Springer, 2006

CB401: Introductory Spectroscopy

(i) The electromagnetic spectrum: Nature of electromagnetic radiation. The electromagnetic spectrum and its regions. Frequency, waveno and wavelength: units and conversions. Absorption of electromagnetic radiation. Molecular energy states and quantisation of internal energy. Boltzmann distribution.
(ii) Spectroscopic Processes: Absorption, emission, and scattering of light. Beer-Lambert Law - Quantitative absorption measurements, Jablonski diagram
(iii) Fourier transformation: A mathematical tool to our advantage, basic principle and its relevance in spectroscopy.
(iv) UV-VIS Absorption Spectroscopy: Principles and instrumentation of spectrophotometers. UV-vis spectroscopy to determine conjugation. UV-visible spectroscopy and electronic transitions. Electronic ground states and excited states in organic molecules: n to pi-star and pi to pi-star transitions. band position and band intensities.
(v) Fluorescence Spectroscopy: Principles and instrumentation of fluorimeters. Advantage of fluorimetry compared to absorption spectrophotometry. Luminescence and the fate of excited states: timescale of fluorescence and phosphorescence.Qualitative and Quantitative Fluorimetry.
(vi) IR - Principles and instrumentation of Infrared spectroscopy. nfrared spectroscopy and molecular vibrational transitions. Simple dispersive IR spectrometer and ovewrview of modern instrumentation. Transmittance and absorbance. Vibrational modes and selection rules. Factors governing the position and intensity of IR bands: effects of variation in reduced mass and force constant. Group frequency and fingerprint regions: use of IR for identification by presence/absence of absorptions characteristic of specific bonds/bond groupings. Interpretation of IR spectra.
(vii) Raman Spectroscopy: Raman Effect and molecular polarizability. Technique and instrumentation. Pure rotational Raman spectra, vibrational Rama spectra. Structure determination from Raman and IR.
(viii) Nuclear Magnetic Resonance (NMR): Introduction to Nuclear Magnetic Resonance (NMR) spectroscopy. 1H and 13C NMR, number of signals, integration, chemical shift, splitting of signals. Principles and instrumentation of NMR spectroscopy. Nuclear spin and nuclear magnetism. Energies of nuclear spin states in a magnetic field. Boltzmann population of nuclear spin states and the origin of NMR signals. Applications: Interpretation of simple 1H NMR spectra. Information from: chemical shifts and delta values, peak areas and integration, splitting patterns and spin-spin coupling constants. (n+1) rule and Pascal's triangle. 13C NMR spectra and sensitivity issues. Interpretation of NMR spectra using

examples of organic compounds. Short introduction about application of NMR for proteins.
(ix) Mass spectrometry: Introduction to mass spectroscopy (molecular mass, accurate mass and isotopes) Principles, ionisation methods (including EI, MALDI, ESI). Molecular ions and fragmentation processes under EI. Mass spectrometry for determining the molecular weight/formula of organic compounds and identify the presence of isotopes. Introduction of MS application in protein analysis.

B401: Cell Biology - II (60 hrs.)

Requisites: Introductory Biology, Basic Molecular Biology

1) Cell Junctions, Cell Adhesion, and the Extracellular Matrix: Introduction, Cell Junctions, Cell-Cell Adhesion, The Extracellular Matrix of Animals, Extracellular Matrix Receptors on Animal Cells. Integrins, Selectins, and other proteins involved in intercellular contacts. The Plant Cell Wall

2) Cell signaling: 1. Introduction: Components involved in signaling, Types of signaling, Three Major Classes of Signaling Receptors: Ion Channel-linked, G protein-coupled receptors (GPRs), Enzyme-linked receptors: Tyrosine-Kinase Receptors, other enzyme-linked receptors, Second Messengers: cAMP, cGMP, IP3 and DAG, Ca+2, PIP3. Signaling Cascades. Cell signaling and cancer.

3) Cell cycle and Cell division: Mechanisms and regulations of cell division, Mitosis, Meiosis, and Germ cells, Cell renewal, Uncontrolled cell division and cancer.

4) Types of cell death: Apoptosis, Necrosis, Anoikis, Oncosis.

5) Techniques in Cell biology: Cell fractionation, DNA libraries, DNA transfer into eukaryotic cells and Mammalian embryos, Nucleic acid hybridization, Purification of nucleic acid, Isolation and fractionation of proteins.

Recommended reading:-

a. Molecular biology of the Cell by Alberts *et al*.

b. Essential Cell Biology by Alberts, Bray *et al*, Garland, Publication New York 1997.

c. Molecular Cell Biology by James E. Darnell, Harvey F. Lodish, and David Baltimore (Hardcover - Feb. 1, 1990).

d. The Cell, 2nd edition, A Molecular Approach, by Geoffrey M Cooper.

e. Inside the Cell, an internet-based study of cells (National Institute of General Medical Sciences) http://publications.nigms.nih.gov/insidethecell/index.html.

B402: Biochemistry-II

1) Metabolism and metabolic pathways: Glycolysis, TCA cycle, Oxidative Phosphorylation, Photophosphorylation
2) Biosynthesis of macromolecules: Carbohydrate biosynthesis (Pentose phosphate pathway), Fatty acid synthesis, Cholesterol of steroid biogenesis, Amino acid biosynthesis & degradation, Nucleotide biosynthesis & degradation, Fatty acid degradation
3) Energy pathways :
    - pigments : chlorophyll -- carotenoids -- xanthophyll -- cytochrome -- phycobilin -- bacteriorhodopsin -- hemoglobin -- myoglobin --absorption spectrum -- action spectrum -- fluorescence
    - Photosynthesis : light reaction -- dark reaction
    - Fermentation : Acetyl-CoA -- lactic acid
    - Cellular respiration : Adenosine triphosphate (ATP) -- NADH -- pyruvate -- oxalate -- citrate
    - Chemosynthesis
4) Regulation
    - hormones : auxin
    - signal transduction -- growth factor -- transcription factor -- protein kinase -- SH3 domain
    - Malfunctions : tumor -- oncogene -- tumor suppressor gene
    - Receptors : Integrin -- transmembrane receptor -- ion channel

Recommended Reading:-

a. Lehninger Principles of Biochemistry, Fourth Edition by David L. Nelson (Author), Michael M. Cox (Author).
b. Stryer L (1995) Biochemistry, 4 th edition, W. H. Freeman & company, New York.
c. Energy and Entropy equilibrium to stationary states, Starzak, Michael E. 2010, XI, 303 p.
d. Fundamentals of General Organic and Biological Chemistry (Study Guide) by John McMurry (Paperback - Jan. 1999).

G401: Statistical Techniques and Applications

Purpose of Statistics, Events and Probabilities, Assignments of probabilities to events, Random events and variables, Probability Axioms and Theorems. Probability distributions and properties: Discrete, Continuous and Empirical distributions. Expected values: Mean, Variance, Skewness, Kurtosis, Moments and Characteristics Functions. Types of probability distributions: Binomial, Poisson, Normal, Gamma, Exponential, Chi-squared, Log-Normal, Student's t, F distributions, Central Limit Theorem. Monte Carlo techniques: Methods of generating statistical distributions: Pseudorandom numbers from computers and from probability distributions, Applications. Parameter inference: Given prior discrete hypotheses and continuous parameters, Maximum likelihood method for parameter inference. Error Analysis: Statistical and Systematic Errors, Reporting and using uncertainties, Propagation of errors, Statistical analysis of random uncertainties, Averaging Correlated/ Uncorrelated Measurements. Deconvolution methods, Deconvolution of histograms, binning-free methods. Least-squares fitting: Linear, Polynomial, arbitrary functions: with descriptions of specific methods; Fitting composite curves. Hypothesis tests: Single and composite hypothesis, Goodness of fit tests, P-values, Chi-squared test, Likelihood Ratio, Kolmogorov-Smirnov test, Confidence Interval. Covariance and Correlation, Analysis of Variance and Covariance. Illustration of statistical techniques through hands-on use of computer programs.
Suggested Texts and References:
1. Statistics: A Guide to the Use of Statistical Methods in the Physical Sciences, R.J. Barlow, John Wiley 1989
2. The Statistical Analysis of Experimental Data, John Mandel, Dover Publications 1984
3. Data Reduction and Error Analysis for the Physical Sciences, 3rd Edition, Philip Bevington and Keith Robinson, McGraw Hill 2003

BL401: Biology Laboratory (Biochemistry + Cell Biology)

1. Ligand Binding

a) The binding of coomassie brilliant blue to bovine serum albumin, J. Sohl and A. Splittgerber, *J. Chem. Educ.* **68**, 262-264 (1991).
b) Evaluation of the Hill coefficient from Scatchard and Klotz plots, A. Sabouri and A. Moosavi-Movahedi, *Biochem. Educ.* **22**, 48-49 (1994).
c) The shapes of Scatchard plots for systems with two sets of binding sites, A. Bordbar et al.,*Biochem. Educ.* **24**, 172-175 (1996).

2. Spectroscopy

d) Fluorescence quenching of albumin. A spectrofluorimetric experiment, M. Montero et al, *Biochem Educ.* **18**, 99-101 (1990).
e) Lactate dehydrogenase kinetics and inhibition using a microplate reader, J. Powers et al., *Biochem. Mol. Biol. Educ.* **35**, 287-292 (2007).

3. Isolation and Analysis of Biomolecules - Amino acids/peptides/proteins/antibodies

f) Application of gel filtration for fractionation and molecular weight determination of proteins, O. Malhotra and A. Kumar, *Biochem. Educ.* 17, 148-150 (1989).
g) Protein structure and chromatographic behavior: The separation and characterization of four proteins using gel filtration and ion-exchange chromatography and gel electrophoresis, M. Chakravarthy, L. Snyder, T. Vanyo, J. Holbrook, and H. Jakubowski, *J. Chem. Educ.* 73, 268-272 (1996).

4. Isolation and Analysis of Biomolecules - Carbohydrates

h) Changes in carbohydrate content during fruit ripening-a new approach of teaching carbohydrate chemistry in biochemistry course, P. Chaimanee and O. Suntornwat, *Biochem. Educ.* 22, 101-102 (1994).
i) Carbohydrate Analysis: Can we control the ripening of bananas?, S. Deal, C. Farmer, and P. Cerpovicz, *J. Chem. Educ.* **79**, 479-480 (2002).

5. Isolation and Analysis of Biomolecules - Lipids

j) Isolation and spectrophotometric characterization of photosynthetic pigments, R. Boyer, *Biochem. Educ.* **18**, 203-206 (1990), and *Modern Experimental Biochemistry*,3rd ed., p. 333-344, (2000) Benjamin Cummings. (San Francisco).
k) An improved method for the extraction and thin-layer chromatography of chlorophyll a and b from spinach. H. Quach, R. Steeper, and G. Griffin, *J. Chem. Educ.* **81**, 385-387 (2004).

6. Metabolism/Regulation/Transport

l) The energetics of aerobic versus anaerobic respiration, T. Champion and R. Schwenz, *J. Chem. Educ.* 67, 528-530 (1990).
m) Use of DCPIP in a colorimetric method to investigate electron transport in crude heart mitochondrial extracts, A. Myers, *Journal of Biol. Educ.* 24, 123-126 (1990).
n) Mitochondria from rat liver: method for rapid preparation and study, C. Heisler, *Biochem. Educ.* 19, 35-38 (1991).
o) An experiment on glycogen biosynthesis in *E. coli*, A. Lodeiro et al, *Biochem. Educ.* 22, 213-214 (1994).
p) An experiment illustrating catabolite repression in yeast, W. Baker, *Biochem Educ.* 23, 216-217 (1995).
q) A simple experiment demonstrating the allosteric regulation of yeast pyruvate kinase, R. Taber, A. Campbell, and S. Spencer, *Biochem. Educ.* **26**, 73-76 (1998).
r) A simple laboratory exercise illustrating active transport in yeast cells, B. Stambuk, *Biochem. Mol. Biol. Educ.* **28**, 313-317 (2000).
s) The pentose phosphate pathway in the yeasts *Saccharomyces cerevisiae*and *Kloeckera apiculata*,an exercise in comparative metabolism for food and wine science students, C. Steel, P. Grbin, and A. Nichol, *Biochem. Mol. Biol. Educ.* **29**, 245-249 (2001).
t) Kinetic analysis of glucose-6-phosphatase: an investigative approach to carbohydrate metabolism, M. Wallert, J. Foster, D. Scholnick, A. Olmschenk, B. Kuehn, and J. Provost, *Biochem. Mol. Biol. Educ.***29**, 199-203 (2001).
u) Nitrate reductase: A model system for the investigation of enzyme induction in eukaryotes, C. Pike, W. Cohen, and J. Monroe, *Biochem. Mol. Biol. Educ.* **30**, 111-116 (2002).

CELL BIOLOGY

v) Programmed Cell Death DNA Laddering and Cell death assay (quantification by Evans Blue)
w) Post-translational modification of proteins
x) Introducing undergraduate students to real-time PCR, D. Hancock et al., *Biochem. Mol. Biol. Educ.***38**, 309-316 (2010).
y) Caenorhabditis elegans as an undergraduate educational tool for teaching RNAi, J. Andersen et al., *Biochem. Mol. Biol. Educ.* **36**, 417-427 (2008).

GL401: Computational Laboratory and Numerical Methods

This course is primarily a lab course introducing computational techniques used for solving mathematics problems numerically. Vast amount of software for solving these problems exists and has been put together in general purpose packages such as MATHEMATICA, MAXIMA, MAPLE and so on.
Computing special functions (using recurrence relations, Attn: loss of accuracy and its effects), making subroutines/functions for these. Computing derivatives numerically (accuracy issues). Zeros (roots) of functions (single variable, multivariable, complex functions poles as zeros of inverse function). Solving differential equations (single variable, any order), Euler and Runge-Kutta, initial and boundary value problems. Eigenvalue problems as boundary value problems. Numerical

integration: trapizoidal and Simpson rules, Gaussian quadrature rules. Linear equations, inverse of a matrix, determinant using Gauss elimination. Matrix eigenvalue problems, Euler rotations, relaxation methods. Data fitting, χ methods, some simulations minimization. Random number generators, Monte-Carlo methods, some simulations.

The course is to be supplemented by a small project on the lines of projects in first semester.

THIRD YEAR
SEMESTER –V

Subject Code	Subject	Contact hrs/per week Theory + Tutorials	Credits
B 501	Genetics	[3 +1]	4
B 502	Molecular Biology	[3 +1]	4
B 503	Biodiversity	[3 +1]	4
CB 501	Analytical Chemistry	[3 +1]	4
G 501	Earth sciences and Energy & Environmental Sciences	[3 +1]	4
		Contact hrs/per week Lab	**Credits**
BL 501	Biology Laboratory	8	4
			24

CB501 Analytical Chemistry (60 hrs.)

1) Statistics in chemical analysis: Methods of sampling and associated errors, Classification of errors, Propagation of errors, treatment of errors, Normal distribution, Tests of Significance and Confidence Limits.

2) Separation techniques:
   a. Solvent Extraction Technique: Conventional, Liquid Membranes – Bulk, Supported and Emulsified, Solid Phase Extraction (SPE).
   b. Ion Exchange: Conventional, Membranes.
   c. Chromatography: Gas chromatography (GC), High Performance Liquid Chromatography (HPLC), Ion chromatography (IC).

3) Mass Spectrometry: Mass Analysers – Magnetic, Quadrupole, Time of Flight (TOF), Ion Cyclotron Resonance, Features – Resolution, Dispersion, Abundance, Sensitivity , Detectors – Faraday Cup, Channeltron, Daly, Ion Sources –Thermal Ionisation (TI), Electron Impact, ICP, GD, Laser Ablation (LA-ICP), Secondary Ionisation (SI), Resonance Ionisation (RI), Matrix Assisted Laser Desorption and Ionisation (MALDI), Hyphenated Technique – IC-MS, HPLC-MS, GC-MS.

4) Thermal Methods: Thermogravimetric Analysis (TGA), Derivative Thermogravimetric Analysis (DTG), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC), Evolved Gas Analysis (EGA).

5) Electrochemical Methods: Introduction, Potentiometry , Ion Selective Electrodes (ISE), Voltammetry & Polarography , Cyclic, Pulse and Stripping Voltammetry, Coulometry and Amperometry, AC Electrochemical Techniques, Scanning Electrochemical Microscopy.

Analytical Chemistry II

1) Absorption and Emission Spectra - Spectroscope, Spectrograph, Spectrometer. Signal-to-noise ratio, resolving power of the spectrometer, Electromagnetic spectrum. Units of Wavelength, Frequency, Wavenumber and Energy,

2) Detectors - Photomultiplier Tube (PMT), Charge Coupled Device (CCD), Charge Injection Device (CID), Spectrometers – Czerny Turner, Echelle, Sample Introduction Devices – Flame, Electrothermal, Laser Ablation, Direct Sample Insertion Devices, Interferences, detection limits, sensitivity, Absorption Spectrometry – Flame Atomic Absorption Spectrometry, (FAAS), Electrothermal Atomic Absorption

Spectrometry (ETAAS), Optical Emission Spectrometry (OES) with Inductively Coupled Plasma (ICPOES) ,Glow Discharge (GDOES),Fluorescence Spectrometry – Laser Induced Fluorescence (LIF), Recent advances –Continuum Source (CS-AAS), Single Atom Detection.
3) Magnetic resonance spectroscopic techniques – NMR and EPR.
4) X-ray diffraction spectroscopy, Electron microscopy and electron diffraction.
5) Nuclear Methods: Activation Analysis – Neutron Activation Analysis (NAA), Charged Particle Activation Analysis (CPAA), X-ray fluorescence (XRF) spectrometry, Ion Beam Analysis – Backscattering Spectrometry (BS), Particle Induced ı-ray Emission (PIGE), Nuclear Reaction Analysis (NRA), Elastic Recoil Detection Analysis (ERDA), Particle Induced X-ray Emission (PIXE).
Text /References

a. Encyclopaedia of Analytical Chemistry: Applications, Theory and Instrumentation, Editor R. A. Meyers, John Wiley & Sons Ltd. (2000).
b. D.A. Skoog, D. M. West, F. J. Holler, S.R. Crouch, Fundamentals of Analytical Chemistry, 8th Edition, Thomson (2004).
c. D.A. Skoog, F. J. Holler, T. A. Niemann, Principles of Instrumental Analysis, 5th Edition, Saunders College Publishing (1998).
d. A.I. Vogel, A text book of Quantitative Analysis, 5th Edition Revised by G. H. Jeffery, J. Bassett, J. Mendham and R. C. Denney, ELBS (1989).
e. A. K. De, S. M. Khopkar and R. A. Chalmers, Solvent Extraction of Metals, Van Nostrand, Reinhold (1970).
f. F. Helfferich, Ion Exchangers, McGraw Hill (1962).
g. L. R. Snyder and J. J. Kirkland, Introduction to Modern Liquid Chromatography, 2nd Edition, Wiley (1979).
h. Ion Exchange and Solvent Extraction: A Series of Advances, Editors J. A. Marinsky and Y. Marcus, Marcel Dekker Inc. (1998).
i. High Performance Liquid Chromatography : Principles and Methods in Biotechnology, Editor E. D. Katz, John Wiley and Sons, Chichester (1996).
j. A. Metcalfe, Atomic Absorption and Emission Spectroscopy, Wiley (1987).
k. Jose A. C. Broekaert, Analytical Atomic Spectrometry with flames and Plasmas, Wiley-VCH (2002).
l. J. Sneddon, Advances in Atomic Spectroscopy, Jai Press (1992).
m. John Roboz, Introduction to Mass Spectrometry: Instrumentation and Techniques, Interscience (1968).
n. Inductively Coupled Plasma Spectrometry and its Application, Editor Steve J. Hill, Sheffield Academic Press (1998).
o. W. W. Wendlandt, Thermal Methods of Analysis, 2nd Edition, Wiley (1974).
p. T. Daniels, Kogan Page, Thermal Analysis (1973).
q. A. J. Bard and L. R. Faulkner, Electrochemical Methods, 2nd Edition, Wiley (2001).
r. S. P. Kruger, Principles of Activation Analysis, Wiley Interscience (1971).
s. L.C. Feldman, J. W. Meyer, Fundamentals of Surface and Thin Film Analysis, North Holland (1986).
t. J. C. Miller and J. N. Miller, Statistics for Analytical Chemistry, 2nd Edition, Wiley (1998).
u. Day and Underwood "Quantitative Analysis" –, 5th edition, *Prentice-Hall* (1986)

B501: Genetics (60 hrs.)

Requisites: Introductory Biology, Basic and Advanced Molecular Biology
1) Introduction and overview of genetics: Information transfer DNA-RNA-Protein/genotype & phenotype, Eukaryotic & Prokaryotic genes, Pseudogenes.
2) Mendelian inheritance (in details): *basics would have been taught*, Cell division- mitosis & meiosis *(revise: would have been taught)*, Deviation from mendelian inheritance, Linkage & Sex-linked inheritance Model genetic systems.

3) Gene regulation: λ phage, Bacterial gene regulation, Eukaryotic gene regulation, Epigenesis, Reverse genetics, genomes and genomics.
4) Human genetics: Elements of human genetics & genetic disorders, Examples from *Drosophila*, yeast, maize and mouse, Immunogenetics.
5) Genes and Evolution: The law of DNA constancy and C-value paradox: Numerical and structural changes in chromosomes; Molecular basis of spontaneous and induced mutations and their role in evolution; Environmental mutagenesis and toxicity testing; Population genetics.
6) Biostatistics: Principles and practice of statistical methods in biological research; samples and populations; Basic statistics – average, statistics of dispersion, coefficient of variation; Standard error; Confidence limits; Probability distributions binomial, Poisson and normal; Tests of statistical significance; Simple correlation of regression; Analysis of variance, Population genetics.
Recommended reading:-

1. Principles of Genetics, by Eldon J. Gardner (Author), D.Peter Snustad (Editor), Michael J. Simmons (Editor)
2. Genetics: From genes to genomes, by: Leland Hartwell, Leroy Hood, Michael Goldberg, Ann Reynolds, Lee Silver, Ruth Veres. Publisher: McGraw-Hill Science/Engineering/Math, published: 2006-10-09.
3. Introduction to genetic analysis: by: Anthony J. F. Griffiths. Publisher: W.H. Freeman & Company, published: 2010-01-30.
4. Intuitive Biostatistics: A Nonmathematical Guide to Statistical Thinking. by: Harvey Motulsky, publisher: Oxford University Press, USA, published: 2010-01-20.
5. Principles of Biostatistics (with CD-ROM) by: Marcello Pagano, Publisher: Duxbury Press, published: 2000-03-09.
6. Genetics for Dummies by T. R. Robinson (Paperback - Sept. 2, 2005).

B502: Advanced Molecular Biology (60 hrs.)

Requisites: Introductory Biology, Basic Molecular Biology
1) Molecular biology an overview: Concept and definition of the gene, complexity of the eukaryotic gene. Structural organization of the DNA in the nuclear material- General properties of histones, nucleosomes and solenoid structure, RNAs and their structure & function.
2) DNA synthesis: The enzymes of DNA replication in prokaryotes and eukaryotes, mechanism of replication in bacteria and viruses, reverse transcriptase, salient features of eukaryotic nuclear and mitochondrial DNA replication.
3) RNA synthesis: The enzymes of transcription in prokaryotes and eukaryotes, mechanism of transcription in bacteria, heteronuclear RNA, post transcriptional processing of RNA, role of ribozymes.
4) Protein synthesis: Concept of the genetic code, structure of t-RNA and t-RNA, enzymes of translation in prokaryotes and eukaryotes, mechanism of protein synthesis, post translational processing of proteins.
5) Gene expression and its characterization: Regulation of gene expression in prokaryotes and eukaryotes, structure and mechanism of different operons, Gene regulation during development, Gene function and phenotype loss of function & gain of function, Gene interaction, suppressors & enhancers redundancy & epistasis.
6) Mutations and their consequences: Definition of mutation, mutagenesis & mutant selection, Alleles, Complementation, Recombination, recombination mapping and mechanism of recombination, Repair of DNA, Transposons & retroposons, Genomic & evolution of diversity.
Recommended reading:-

1. Stryer L (1995) Biochemistry, 4 th edition, W. H. Freeman & company, New York.
2. Watson J. D., Hopkins, N. H., Roberts, J. W., Steitz, J. A. and Weiner, A. M. (1988) Molecular biology of the gene, 4 th edition, The Benjamin/Cummings publishing companies, inc, California.
3. Benjamin Lewin (1999) Genes VII, oxford University Press, Oxford.
4. Weaver R. F. (1999) Molecular biology, WCB McGraw-Hill companies, Inc, New York.
5. Brown T A (1995) Essential molecular biology, vol. I, A practical approach, IRL press, Oxford.

6. Molecular Themes in DNA Replication, by Cox Lynne S (Ed.) 2009 443 p.
7. Cantor, C. R., and Schimmel, P. R. Biophysical Chemistry. San Francisco:
8. W.H. Freeman and Company, 1980. 3 Volumes.

B503: Biodiversity of plants/animals/microbes (60 hrs.)

1) Principles of taxonomy: Concept of species and hierarchical taxa, Biological nomenclature, Taxonomical structure**,** Outline classification of animals**,** important criteria used for classification in each taxon**,** Classification of animals

2) Levels of Structural organizations: Larval forms and their evolutionary significance, Unicellular, colonial, and multicellular forms**,** Levels of organization of tissues, organs, and systems**,** Comparative anatomy

3) Classical and quantitative methods in taxonomy: Biosystematics, Interrelationship among major invertebrate phyla and minor invertebrate phyla; Evolutionary relationship among taxa, Natural History of Indian subcontinent: Major habitat types, Geographical origin and migration of species , Common Indian mammals and birds, Seasonality and Phenology of Indian subcontinent

4) Taxonomy of plants: Plant identification, nomenclature, collecting and documentation, plant phylogeny and systematics.

5) Comparative anatomy and morphology of angiosperms and gymnosperms. Angiosperms: Characteristic features, outline classification, vascular anatomy, leaves, flower, fruits and seeds. Gymnosperms: Characteristic features, outline classification, morphology and anatomy of ovules and female gametophyte, microspore and male gametophyte, seeds, stem and leaves.

6) Concepts and characteristics of biodiversity: The concepts of biodiversity, Comparison of historical and current rate of species extinction, How genetic diversity may change between generations and within population of species, Complexity and functions of ecosystems; predictable and non-predictable features of ecosystem, Importance of preserving biodiversity, Genetic diversity

7) Causes and consequences of biodiversity loss: Address the major threats to biodiversity. The biggest threat is from habitat loss and alteration followed by the introduction of exotic species that become invasive. Chemical alteration of the environment also has a major impact on both natural and managed ecosystems.

a. Habitat Loss and Alteration
b. Exotic Species
c. Chemical Pollutants
d. Loss of Genetic Diversity in Crops

8) Deriving Solutions: Examine the concepts, benefits, and limitations of the different strategies for conserving biodiversity. a. Conservation Strategies, b. Laws and Legal Actions, c. Grassroots Action Program

Recommended reading:-

a. Biology: The Unity and Diversity of Life by Cecie Starr, Ralph Taggart, Christine Evers, and Lisa Starr (Hardcover – Aug 5, 2008).

b. Plant Conservation and Biodiversity. Series: Topics in Biodiversity and Conservation, Vol. 6 Hawksworth, David L.; Bull, Alan T. (Eds.) Reprinted from Biodiversity and Conservation, 16:6, 2007, VIII, 424 p.

c. Plant Biodiversity & Taxonomy By M P Singh.

d. Biodiversity, E.O.Wilson, *Editor*. Frances M. Peter, *Associate Editor*. National Academy Press, Washington, D.C. 1988.

e. Biology of Plants by Peter H. Raven, Ray F. Evert, and Susan E. Eichhorn (Hardcover - Dec. 17, 2004).

G501: Earth Science and Energy & Environmental Sciences

Earth Science

Origin of the earth, type of rocks in different layers, their physical and chemical properties,

mechanism of their formation and destruction. Radioactivity and its role in geochronology, Plate tectonics and geodynamics and the role of mantle plumes in sustaining these processes. Gravity, electrical and magnetic properties of the different layers in the earth. Their variations in different geological terrains. Instrumentation, field procedures used in these studies. Response of the earth to the elastic (Seismic) and electromagnetic waves, use of this phenomena to study the earth's interior. Geodynamo and the internal magnetic field of the earth. Paleomagnetic studies, Polar wandering and reversal, possible theoretical arguments for understanding the phenomena. Seismology and its use in understanding of the different layers in the earth's interior. Utility of the different geophysical techniques (discussed above) in exploration for academic as well as for harnessing resources.
Suggested Texts and references:
1. The magnetic field of the Earth, Merill, R.T. McElhinny, M.W. and McFadden, P.L. International Geophysical Series.
2. Earth Science by Edward J. Tarbuck, E.J. and Lutgens, F.K.
3. Introduction to Applied Geophysics: Exploring the Shallow Subsurface Burger, H.R., Sheehan, A.F., C.H.
4. Mantle Plumes and Their Record in Earth History, Condie, K.C., 2001, Cambridge University Press, Cambridge, UK
5. Applied Geophysics (Paperback) W M Telford, Robert E Sheriff and L P Geldart.

Energy and Environmental Sciences

Introduction to Environmental Science. Natural Environments: Ecosystems and ecology, biodiversity. Socio-cultural environments: demography, population density, human organizations. Land use and its planning. Global climate change and effects on environment. Carbon cycle from human activity, calculation of carbon budgets. Water harvesting, storage and treatment. Natural calamities, hazards, and effects of human activity: Chemical and other technological hazards. Various case studies of natural calamities and human-induced disasters. Causes, effects, forecasting, preparedness, planning measures, technological solutions, social interventions. Concept of sustainability, individual and social, and local and global actions for a sustainable future.
Introduction to energy Sources - evolution of energy sources with time. Power production, per capita consumption in the world, and relation to development index. Energy scenario in India: Various issues related to consumption and demands -energy crisis issues in India. Renewable and non-renewable energy sources - technology and commercialization of energy sources, local (decentralized) versus centralized energy production, constraints and opportunities of renewable energy (hydrocarbon and coal based energy sources). Energy conservation – calculation of energy requirements for typical and home and industrial applications. Alternative to fossil fuels - solar, wind, tidal, geothermal. Bio-based fuels. Hydrogen as a fuel. Energy transport and storages, comparison of energy sources - passage from source to delivery (source, production, transport, delivery) - efficiencies, losses and wastes. Nuclear energy: Power production: Components of a reactor and its working, types of reactors and comparison. India's three stage nuclear program. Nuclear fuel cycle. Thorium based reactors. Regulations on nuclear energy.
Energy and Environmental Sciences
1. Energy in Perspective, J.B.Marion, University of Maryland, Academic Press, (1974)
2. Energy and Environment, Robert A.Ristinen and Jack J. Kraushaar, 2nd Edn., John Wiley and Sons, Inc. (2006).
3. Renewable Energy, Boyle Godfrey, Oxford University Press (2004)
4. Environment, Problems and Solutions, D.K.Asthana and Meera Asthana, S.Chand and Co.(2006)
5.Text Book on Environmental Chemistry, Balaram Pani, I.K.International Publishing House(2007).

BL501: Biology Laboratory (Molecular Biology + Biodiversity + Genetics)

1. BACTERIAL GENETICS

a) *E. coli* Transformation
b) *E. coli* Conjugation

c) *E. coli* Transduction
d) Phage Titration
e) Transposition
f) α- Complementation

2. EUKARYOTIC GENETICS

g) To Study the model organism, *Drosophila Melanogaster*
h) Concept of Crossing: - Monohybrid and Dihybrid crosses using *Drosophila Melanogaster*
i) Drosophila Genetics:
To Observe & Study the Mutants of *Drosophila Melanogaster*
Concept of Mutation - Lethal Mutations
j) Karyotyping

3. BIODIVERSITY

k) Setting up biodiversity niches in the lab & Hospital :fish-tank & Winogradsky column
l) Biodiversity in soil, air & Winogradsky's Column – Plating , Colony Characterization & Gram Staining
m) Field Trips - SEWRI MUD FLATS – ½ DAY, COLABA WOODS - ½ DAY, THANE BUTTERFLY PARK - ½ DAY, KARNALA BIRD SANCTUARY - ½ DAY, MAHIM NATURE PARK - ½ DAY

4. MOLECULAR BIOLOGY

n) General Laboratory Procedures
Pouring Nutrient Agar Plates
Preparation of Solutions
Bacterial Culturing Techniques
o) Designing of Primers for PCR procedure
p) Extraction and Isolation of genomic DNA
Using Kit method
By conventional Ethanol Precipitation method
q) Detection of Nucleic acids (AGE)
r) Polymerase Chain Reaction (PCR) & Detection of the PCR product and its purification
s) Blunt-end cloning (after Ligation)
t) Preparation of competent cells & Transformation of E. coli cells with plasmid
u) Plasmid Purification, RE Digestion & Detection of the RE-digested product
v) Overexpression & Detection by PAGE
w) Using restriction mapping to teach basic skills in the molecular biology lab, L. Walsh et al., *Biochem. Mol. Biol. Educ.* **35**, 199-205 (2007).
x) Western blot analysis to illustrate relative control levels of the *lac* and *ara* promoters in *E. coli*, B. Nielsen et al., *Biochem. Mol. Biol. Educ.* **35**, 133- 137 (2007).

SEMESTER –VI

Subject Code	Subject	Contact hrs/per week Theory + Tutorials	Credits
B 601	Immunology	[3 +1]	4
B 602	Animal Physiology	[3 +1]	4
B 603	Plant Physiology	[3 +1]	4
B 604	Microbiology	[3 +1]	4
CB 601	Biophysical Chemistry	[3 +1]	4
H601	Ethics of Science and IPR	[2 + 0]	2
		Contact hrs/per week Lab	**Credits**
BL 601	Biology Laboratory	8	4
			26

CB601: Biophysical Chemistry

1. The Chemistry of Life: An introduction

(A) Physical properties of water: Structure, water as solvent, The hydrophobic effect, osmosis and diffusion

(B) Introduction to Biomolecules: Nucleic Acid, Protein - Polymer Description of Macromolecular Structure, Intermolecular and Intramolecular forces, Non Covalent Interaction

2. General principles of Biophysical chemistry I

(A) Hydrodynamic properties: Diffusion and sedimentation, determination of molecular weight from sedimentation and diffusion; Introduction of Ultra Centrifugation, Dynamic Light Scattering and Electrophoresis

(B) Spectroscopic properties of proteins and nucleic acid: UV/Vis, Intrinsic fluorescence, Circular dichroism

3. General principles of Biophysical chemistry II

The concept and application of Chemical and Physical equilibria in Biological system, The equilibrium constant and Standard Gibbs Free energies of reactants and products, Temperature dependence of the equilibrium constant, Double Strand formation in nucleic acid, Ligand-protein binding, Protein denaturation and stability, Introduction of DSC and ITC

4. Molecular self-assembly and Molecular medicine:

Protein folding kinetics and Biophysical methods, Misfolding and aggregation ; Physical basis of conformation diseases, Therapeutic approaches to protein misfolding diseases**.**

5. Introduction to structure biology:

Introduction to basic principles of protein X-ray crystallography, protein NMR, Small Angle X-ray scattering (SAXS), and Electron microscopy (EM).

Books: -Tinoco, Sauer, Wang, and Puglisi. (2003) *Physical Chemistry: Principles and Applications in the Biological Sciences.* Prentice Hall, Inc.

- Physical Chemistry for the Life Sciences: Peter Atkins and Julio de Paula

-General review papers

1: Dobson CM. Principles of protein folding, misfolding and aggregation. Semin Cell Dev Biol. 2004 Feb;15(1):3-16.

B601: Immunology (60 hrs.)

Requisites: Introductory Biology, Basic Molecular Biology, Advanced Cell Biology

1) Overview of the Immune system: Types of immunity, innate, acquired, passive and active, self vs non-self discrimination, Adaptive immune response, Autoimmunity

2) Cells and organs of the immune system: T cell receptors, T cell receptor genes & gene rearrangements, T cell maturation, activation & differentiation, B cell generation, activation & development

3) Antigens and Antibodies: Immunoglobulins- structure and function, Immunoglobulin genes- Organization and rearrangement, Antibody diversity, Antigen antibody reactions, MHC (antigens and genes), Antigen processing & presentation

4) Immune response: Self Non-self discrimination (mechanism), Clonal selection theory & idiotypic network hypothesis, Cytokines, The complement system, Cell mediated effector response, Leukocyte migration and inflammation, Hypersensitive reactions, Immune regulation, Immune response to infectious organisms, Vaccines, Immunodeficiency diseases (AIDS)

5) Immunology & applications: Transplantation immunology, Tumour immunology, Immunotechnology, Animal models

6) Plant immunity

Recommended Books:-

1. "Kuby Immunology" by Goldsby, Kindt, and Osborne
2. Essential Immunology – Roitt
3. Immunology by Janice Kuby
4. Essential Immunology Ivan Roitt, 8th Edition, Blackwell Publication
5. Cellular and Molecular Immunology by Kathyrn Austyn
6. Biology of Immunological Diseases by David
7. Immunocytochemistry, A practical guide for Biomedical Research, by Richard Burry W. 2010, XV, 209 p.

B602: Animal Physiology (60 hrs.)

Prerequisites: Introductory Biology, Basic Molecular Biology, Advanced Cell Biology

1) Cell Structure & Metabolism: Homeostasis, Mechanisms of Cellular Control, Membrane Transport, Membrane Potentials (a review)

2) Body Control: Hypothalamic/Pituitary Axis, Mystic Rhythms

3) Neurons and the Nervous system: Synapses, Sense Perception, Special Senses, CNS Design: Autonomic Nervous System, Action Potential, - Basic structures of neurons and glia, Neurotransmission: Ion channels, Membrane potentials, Resting potential – Depolarization, repolarization and hyperpolarization. Electrotonic and Action potential, Mechanism of neurotransmission. Membrane channels –voltage gated, ligand gated, mechanically gated. Basics of a synapse (electrical and chemical). Introduction to central nervous system design: Structural and functional outline of the brain and the spinal cord, Hypothalamus: Osmoregulation, temperature control, and role in neuroendocrine system: Hypothalamo-hypophyseal portal system, Autonomic Nervous System (sympathetic and parasympathetic pathways). Reflex action.

4) Muscular system: Skeletal Muscle, Muscle Characteristics, Muscle Control, Muscle Exercise, Smooth Muscle

5) Cardiovascular Systems: Cardiac Muscle, Heartbeat, Cardiac Control

6) Digestion: Absorption

7) Blood: Hemostasis, Temperature Control, Vessels, Tissue Exchange, EKGs and Blood Pressure.

8) Respiratory Systems: Respiration, Respiratory Control

9) Energy Balance and Metabolism: Fuel Metabolism (both plants and Animals)

10) Processes: Excretion Control Salt & Water Balance, An example of a process going wrong – Diabetes.
11) Comparative Physiology
Recommended reading:-
a. Kaplan Lecture Notes: Physiology
b. Physiology: Board Review Series, by Linda S. Costanzo
c. Review of Medical Physiology (Lange Basic Science) by William Ganong
d. Guyton and Hall Physiology Review by Hall
e. Appleton and Lange Review of Physiology 278 pages with 700 exam-type comprehensive Q&A review book.
f. Clinical Physiology Made Ridiculously simple 160 pages hilarious style easy to read.
g. Linardakis Illustrated review of Physiology.
h. Textbook of Medical Physiology by Arthur C. Guyton.

B603: Plant Physiology

1. Plant Cells - Model Organisms, The Plant Kingdom, Flower Structure and the Angiosperm Life Cycle, Plant Tissue Systems: Dermal, Ground, and Vascular

- The Structures of Chloroplast Glycosylglycerides
- A Model for the Structure of Nuclear Pores
- The Proteins Involved in Nuclear Import and Export
- Protein Signals Used to Sort Proteins to their Destinations
- SNAREs, Rabs, and Coat Proteins Mediate Vesicle Formation, Fission, and Fusion
- ER Exit Sites (ERES) and Golgi Bodies Are Interconnected
- Specialized Vacuoles in Plant Cells
- Actin-Binding Proteins Regulate Microfilament Growth
- Kinesins Are Associated with Other Microtubules and Chromatin

3. Water and Plant Cells

- Calculating Capillary Rise, Calculating Half-Times of Diffusion
- Alternative Conventions for Components of Water Potential
- Temperature and Water Potential, Can Negative Turgor Pressures Exist in Living Cells?
- Measuring Water Potential, The Matric Potential, Wilting and Plasmolysis
- Understanding Hydraulic Conductivity

4. Water Balance of Plants

- Irrigation, Physical Properties of Soils, Leaf Transpiration and Water Vapor Gradients
- Calculating Velocities of Water Movement in the Xylem and in Living Cells

5. Mineral Nutrition

- Symptoms of Deficiency in Essential Minerals - Wade Berry, UCLA
- Observing Roots below Ground

6. Solute Transport

- Relating the Membrane Potential to the Distribution of Several Ions across the Membrane: The Goldman Equation, Patch Clamp Studies in Plant Cells, Chemiosmosis in Action
- Kinetic Analysis of Multiple Transporter Systems, ABC Transporters in Plants
- Transport Studies with Isolated Vacuoles and Membrane Vesicles

7. Photosynthesis: The Light Reactions

- Principles of Spectrophotometry, Quantum Yield
- The Distribution of Chlorophylls and Other Photosynthetic Pigments
- Antagonistic Effects of Light on Cytochrome Oxidation
- Structures of Two Bacterial Reaction Centers
- Midpoint Potentials and Redox Reactions
- Oxygen Evolution, Photosystem I, ATP Synthase
- Mode of Action of Some Herbicides, Chlorophyll Biosynthesis

8. Photosynthesis: The Carbon Reactions

- Inorganic Carbon-Concentrating Mechanisms: CO_2 and HCO_3^- Pumps
- How the Calvin–Benson Cycle Was Elucidated
- Rubisco: A Model Enzyme for Studying Structure and Function
- Energy Demands for Photosynthesis in Land Plants
- Rubisco Activase, Thioredoxins, Operation of the C_2 Oxidative Photosynthetic Carbon Cycle
- Carbon Dioxide: Some Important Physicochemical Properties
- Three Variations of C_4 Metabolism
- Single-Cell C_4 Photosynthesis, Photorespiration in CAM plants
- Glossary of Carbohydrate Biochemistry, Starch Architecture
- Fructans, Chloroplast Phosphate Translocators

9. Photosynthesis: Physiological and Ecological Considerations

- Working with Light, Heat Dissipation from Leaves: The Bowen Ratio
- The Geographic Distributions of C_3 and C_4 Plants
- Calculating Important Parameters in Leaf Gas Exchange
- Prehistoric Changes in Atmospheric CO_2
- Projected Future Increases in Atmospheric CO_2
- Using Carbon Isotopes to Detect Adulteration in Foods
- Reconstruction of the Expansion of C_4 Taxa

10. Translocation in the Phloem

- Sieve Elements as the Transport Cells between Sources and Sinks
- An Additional Mechanism for Blocking Wounded Sieve Elements in the Legume Family
- Sampling Phloem Sap, Nitrogen Transport in the Phloem
- Monitoring Traffic on the Sugar Freeway: Sugar Transport Rates in the Phloem
- Alternative Views of Pressure Gradient in Sieve Elements: Large or Small Gradients?
- Experiments on Phloem Loading, Experiments on Phloem Unloading
- Allocation in Source Leaves: The Balance between Starch and Sucrose Synthesis
- Partitioning: The Role of Sucrose-Metabolizing Enzymes in Sinks
- Possible Mechanisms Linking Sink Demand and Photosynthetic Rate in Starch Storers
- Proteins and RNAs: Signal Molecules in the Phloem

11. Respiration and Lipid Metabolism

- Isolation of Mitochondria
- The Q-Cycle Explains How Complex III Pumps Protons across the Inner Mitochondrial Membrane, Multiple Energy Conservation Bypasses in Oxidative Phosphorylation of Plant Mitochondria, F_oF_1-ATP Synthases: The World′s Smallest Rotary Motors
- Transport Into and Out of Plant Mitochondria, The Genetic System in Plant Mitochondria Has Several Special Features, Does Respiration Reduce Crop Yields?
- The Lipid Composition of Membranes Affects the Cell Biology and Physiology of Plants
- Utilization of Oil Reserves in Cotyledons

12. Assimilation of Mineral Nutrients

- Development of a Root Nodule, Measurement of Nitrogen Fixation
- The Synthesis of Methionine, Oxygenases

13. Secondary Metabolites and Plant Defense

- Cutin, Waxes, and Suberin, Structure of Various Triterpenes
- The Shikimic Acid Pathway, Detailed Chemical Structure of a Portion of a Lignin Molecules

15. Cell Walls: Structure, Biogenesis, and Expansion

- Plant Cell Walls Play a Major Role in Carbon Flow through Ecosystems
- Terminology for Polysaccharide Chemistry
- Molecular Model for the Synthesis of Cellulose and Other Wall Polysaccharides That Consist of a Disaccharide Repeat, Matrix Components of the Cell Wall
- The Mechanical Properties of Cell Walls: Studies With *Nitella*

- Wall Degradation and Plant Defense, Structure of Biologically Active Oligosaccharins
- Glucanases and Other Hydrolytic Enzymes May Modify the Matrix

16. Growth and Development

- Embryonic Dormancy, Rice Embryogenesis
- Polarity of *Fucus* Zygotes, *Azolla* Root Development
- Class III HD-Zip Transcription Factors Promote Adaxial Development through a microRNA-Sensitive Mechanism
- During Senescence Photoactive Chlorophyllide Is Converted into a Colorless Chlorophyll Catabolite

17. Phytochrome and Light Control of Plant Development

- *Mougeotia*: A Chloroplast with a Twist, Phytochrome and High-Irradiance Responses
- The Origins of Phytochrome as a Bacterial Two-Component Receptor
- Profiling Gene Expression in Plants, Two-Hybrid Screens and Co-immunoprecipitation
- Phytochrome Effects on Ion Fluxes, Microarray Analysis of Shade Avoidance

18. Blue-Light Responses: Morphogenesis and Stomatal Movements

- Blue-Light Sensing and Light Gradients, Guard Cell Osmoregulation and a Blue Light-Activated Metabolic Switch
- The Coleoptile Chloroplast, Phytochrome-Mediated Responses in Stomata

20. Gibberellins: Regulators of Plant Height and Seed Germination

- Structures of Some Important Gibberellins and Their Precursors, Derivatives, and Inhibitors of Gibberellin Biosynthesis
- Commercial Uses of Gibberellins, Gibberellin Biosynthesis
- Gas Chromatography—Mass Spectrometry of Gibberellins
- Environmental Control of Gibberellin Biosynthesis, Auxin Can Regulate Gibberellin Biosynthesis
- Negative Regulators of GA Response, Effects of GAs on Flowering
- DELLA Proteins as Integrators of Multiple Signals

21. Cytokinins: Regulators of Cell Division

- Cultured Cells Can Acquire the Ability to Synthesize Cytokinins
- Structures of Some Naturally Occurring Cytokinins
- Various Methods Are Used to Detect and Identify Cytokinins
- The Biologically Active Form of Cytokinin Is the Free Base
- Cytokinins Are Also Present in Some tRNAs in Animal and Plant Cells
- The Structures of Opines, The Ti Plasmid and Plant Genetic Engineering
- Phylogenetic Tree of *IPT* genes
- A Root-Derived Hormone, Strigolactone, Is Involved in the Suppression of Branching in Shoots
- Cytokinin Can Promote Light-Mediated Development
- Cytokinins Promote Cell Expansion and Greening in Cotyledons
- Cytokinins Interact with Elements of the Circadian Clock

22. Ethylene: The Gaseous Hormone

- Ethylene in the Environment Arises Biotically and Abiotically
- Ethylene Readily Undergoes Oxidation
- Ethylene Can Be Measured by Gas Chromatography
- Cloning of the Gene That Encodes ACC Synthase
- Cloning of the Gene That Encodes ACC Oxidase
- Ethylene Binding to ETR1 and Seedling Response to Ethylene
- Conservation of Ethylene Signaling Components in Other Plant Species
- ACC Synthase Gene Expression and Biotechnology
- The *hookless* Mutation Alters the Pattern of Auxin Gene Expression
- Ethylene Inhibits the Formation of Nitrogen-Fixing Root Nodules in Legumes
- Ethylene Biosynthesis Can Be Blocked with Anti-Sense DNA

- Abscission and the Dawn of Agriculture
- Specific Inhibitors of Ethylene Biosynthesis Are Used Commercially to Preserve Cut Flowers

23. Abscisic Acid: A Seed Maturation and Stress-Response Hormone

- The Structure Of Lunularic Acid from Liverworts
- ABA May Be an Ancient Stress Signal
- Structural Requirements for Biological Activity of Abscisic Acid, The Bioassay of ABA
- Evidence for Both Extracellular and Intracellular ABA Receptors
- The Existence of G Protein-Coupled ABA Receptors Is Still Unresolved
- The Yeast Two-Hybrid System
- Yellow Cameleon: A Noninvasive Tool for Measuring Intracellular Calcium
- Phosphatidic Acid May Stimulate Sphingosine-1-Phosphate Production
- The ABA Signal Transduction Pathway Includes Several Protein Kinases
- The *ERA*1 and *ABH* Genes Code for Negative Regulators of the The ABA Response
- Promoter Elements That Regulate ABA Induction of Gene Expression
- Regulatory Proteins Implicated in ABA-Stimulated Gene Transcription
- ABA Gene Expression Can Also Be Regulated by mRNA Processing and Stability
- ABA May Play a Role in Plant Pathogen Responses
- Proteins Required for Desiccation Tolerance, The Types of Coat-Imposed Seed Dormancy
- Types of Seed Dormancy and the Roles of Environmental Factors
- The Longevity of Seeds, Genetic Mapping Of Dormancy: Quantitative Trait Locus (QTL) Scoring of Vegetative Dormancy Combined with a Candidate Gene Approach
- ABA-Induced Senescence and Ethylene

25. The Control of Flowering

- Contrasting the Characteristics of Juvenile and Adult Phases of English Ivy (*Hedera helix*) and Maize (*Zea mays*), Regulation of Juvenility by the *TEOPOD* (*TP*) Genes in Maize
- Flowering of Juvenile Meristems Grafted to Adult Plants
- Characteristics of the Phase-Shifting Response in Circadian Rhythms
- Support for the Role of Blue-Light Regulation of Circadian Rhythms
- Genes That Control Flowering Time, Regulation of Flowering in Canterbury Bells by Both Photoperiod and Vernalization, The Self-Propagating Nature of the Floral Stimulus
- Examples of Floral Induction by Gibberellins in Plants with Different Environmental Requirements for Flowering, The Effects of Two Different Gibberellins on Flowering (Spike Length) and Elongation (Stem Length), The Contrasting Effects of Phytochromes A and B on Flowering
- A Gene That Regulates the Floral Stimulus in Maize

26. Responses and Adaptations to Abiotic Stress

- Stomatal Conductance and Yields of Irrigated Crops, Membrane Lipids and Low Temperatures
- Ice Formation in Higher-Plant Cells, Water-Deficit-Regulated ABA Signaling and Stomatal Closure, Genetic and Physiological Adaptations Required for Zinc Hyperaccumulation
- Cellular and Whole Plant Responses to Salinity Stress
- Signaling during Cold Acclimation Regulates Genes That Are Expressed in Response to Low Temperature and Enhances Freezing Tolerance

Recommended reading:-

Plant Physiology by Hans Mohr, Peter Schopfer, Springer 1995, 629 pages

Taiz & Zeiger (2006) Plant Physiology. 4th Edition. Sinauer

Hopkins WG (1998 or 2004 ed). **Introduction to Plant Physiology**. 2nd or 3rd Ed. Wiley. Used previously for course. This is a good introductory text, but it is not a substitute for Taiz.

Stern KR (1997) **Introductory Plant Biology**. 7th Ed. Wm C Brown Publishers

Fosket (1994) **Plant Growth and Development**: A molecular approach. Acad. Press. More details on how plants grow and develop.

Buchanan R., Gruissem W. and Jones R. (eds) 2000. **Biochemistry and Molecular Biology of Plants**. An excellent new text by leading plant biologists in the world. The book provides a contemporary view of molecular biology, cell biology and plant physiology. Valuable reference for teaching and research.
Chrispeels MJ and DE Sadava (2002) **Plants, Genes and Crop Biotechnology**. 2nd Ed. Jones and Bartlett. Understanding plant biology and the potential of agricultural biotechnology. Highly recommended.

B604: Microbiology

1) General Microbiology - Introduction to Microscopy, Prokaryotic Structure & Function, Microbial Nutrition, Microbial Growth, Control of Microbes, From Taxonomy through the *Archaea*: Gram Negative Bacteria, Gram Positive Bacteria, metabolism, microbial genetics, and the role of microorganisms in disease, immunity, and other selected applied areas.
2) Fundamentals of General Microbiology - Isolation of a broad range of nonpathogenic bacteria from natural sources, using selective and enrichment techniques, with microscopic, biochemical, and molecular identification. Related exercises include genetics, physiology, quantitation, and growth energetics. Survey of the microbial world, metabolism, biosynthesis, regulation, growth, structure, and function.
3) Microbes and Society Focuses on activities of bacteria, viruses, and other microorganisms, and their influence on humans. Microbe-related topics include disease, bioterrorism, food, biotechnology, and ecology. Examine the nature of scientific inquiry, along with major biological concepts.
4) Bacterial Genetics - Molecular genetics: description of fundamental genetic processes such as mutation, repair, genetic exchange, recombination, and gene expression. Use of genetic strategies to analyze complex biological processes. Focuses on prokaryotic organisms.
5) Prokaryotic Diversity - Structure, biochemical properties, and genetics of the major groups of prokaryotes.
6) Microbial Ecology - Consideration of the various roles that microorganisms, particularly bacteria and cyanobacteria, play in environmental processes. The interrelationships among microorganisms and the effects of the physical, chemical, and biological properties of their environment are discussed and assessed. Microbial ecology; food, industrial and medical microbiology Symbiosis Aquatic Ecology, Terrestrial Ecology, Industrial Microbiology, Food Microbiology
7) Medical Bacteriology - Medically important bacterial pathogens in terms of the clinical, therapeutic, and epidemiological aspects of diseases caused by them, molecular mechanisms of pathogenesis and their identification in the clinical laboratory, procedures for isolation and identification of pathogenic bacteria, testing their susceptibility to antibiotics. Bacterial Pathogenesis: Introduction, Genetic tools used for bacterial pathogenesis study; Bacterial cell-cell communications and biofilm formation, Bacterial genomics, lateral transfer, phage, Vertebrate microbial communities in health and disease, Strategies for bacterial adhesion and invasion
8) Medical Mycology and Parasitology - Consideration of medically important fungi and parasites, with emphasis on their biology in relation to disease and its laboratory diagnosis.
9) Aquatic Microbiology - Basic principles of aquatic microbiology and aquatic microbial ecology: role and identity of aquatic microorganisms; introduction to modern methodologies for research. Laboratory work with local freshwater and marine samples for those enrolled in the five-credit section.
10) Evolution of Prokaryotic Diversity - Evolution, diversity, and genomics of prokaryotic microorganisms, Enrichment, isolation, and molecular phylogenetic characterization of selected prokaryotic organisms.
11) Methanogenesis genetics and biochemistry of selected bacteria.
12) Molecular Mechanisms of Bacterial Pathogenesis Mechanisms of bacterial pathogenesis explored at the molecular, genetic, and cellular levels through selected models as presented in the current scientific literature. Molecular and Medical Microbiology recent advances in molecular biology of microbial pathogenesis or the current research of the participants is presented and discussed critically.
13) Signal transduction in bacteria

14) Protozoan infections: Introduction to protozoa, A survey of the major protozoan infections of humans including a brief description of the parasite life cycles and a brief discussion of the clinical diseases seen during these infections.
15) Biology and pathogenesis of Plasmodium. life cycle Plasmodium parasites and pathology of human malaria, biochemical and cell biological similarities and differences with other apicomplexa (Babesia, Cryptosporidium, Toxoplasma, etc.), and implications for therapeutic development. Biology and pathogenesis of Toxoplasma, Leishmania, Trypanosoma.
Recommended Reading
1) Brock's Biology Of Microorganisms (Hardcover) by Thomas D. Brock
2) Medical Microbiology: with STUDENT CONSULT Access (Paperback) by Patrick R. Murray
3) The Great Influenza: The Story of the Deadliest Pandemic in History (Paperback) by John M. Barry
4) Benson's Microbiological Applications: Laboratory Manual in General Microbiology (Spiral-bound) by Alfred E. Brown
5) Textbook of Microbiology, Ananthanarayan and Paniker Orient Blackswan, 2005 - Medical microbiology - 665 pages

BL601: Biology Laboratory (Animal Physiology + Plant Physiology +Immunology + Microbiology)

1. ANIMAL PHYSIOLOGY

a) Animal cell culture and microscopy
b) Gross anatomy of the animal brain & Staining of mouse brain sections
c) Wound Healing Assay

2. IMMUNOLOGY

d) Isolations of monocytes/macrophages- properties; Isolation of Lymphocytes- T and B cell identification & Lymphocyte Activity.
e) Separation of WBC & RBC; counting by Haemocytometer
f) Serum Electrophoresis
g) ELISAs - direct & indirect
h) Ag detection & Ab detection
i) Widal – Tube & Slide
j) VDRL
k) Blood typing & Pregnancy hCG Ag
l) Double diffusion
m) Immunoelectrophoresis
n) Radial Immunodiffusion

3. PLANT PHYSIOLOGY

p) *Arabidopsis thaliana* - model organism and its development
q) *Funaria hygrometrica* - differentiation from chloronema to caulonema to bud formation
r) Callus formation from carrot cells

FOURTH YEAR
SEMESTER –VII

Subject Code	Subject	Contact hrs/per week Theory + Tutorials	Credits
B 701	Neurobiology	[3 +1]	4
B 702	Immunology – II	[3 +1]	4
B 703	Developmental Biology	[3 +1]	4
B 704	Imaging technology in biological research	[3 +1]	4
BPr 701	Reading Project	-	4
		Contact hrs/per week Lab	**Credits**
BL 701	Advanced Biology Laboratory	[5 + 5]	5
			25

B701: Neurobiology (60 hrs.)

Prerequisites: Advanced Cell Biology, Physiology

1) The glial system: Generation of Astrocytes, Oligodendrocytes, and Schwan cells. Function of glia in normal brain and in neuroprotection.

2) Chemical composition of the brain: metabolism (utilization and uptake of glucose and amino acids). Blood-Brain barrier.

3) Neurotransmitters: Synthesis, storage, release, uptake, degradation and action of neurotransmitters, Acetyl choline, GABA, Serotonin, Dopamine, Glutamate, Nitrous oxide, etc. Receptors: different subtypes (cholinergic, dopaminergic, adrenergic, and glutamatergic), mechanism of action, Agonists and Antagonists – their mode of action and effects. Exocytosis of neurotransmitter – Role of synapsins, synaptogamins, SNAP, SNARE and other proteins in docking, exocyotosis and recycling of vesicles.

4) Sleep and Learning and memory: Mechanism of short-term memory and Long-term memory (long-term potentiation). Role of sleep in memory consolidation. Electroencephalogram. Role of second messenger pathways in learning and memory process. Role of synaptic plasticity.

5) Sensory organs:

Vision: Biochemistry of vision: Rod and cone cells, mechanism and regulation of vision, color vision, visual field, visual acuity. Visual pathway and topographic mapping.

Audition: functional anatomy of the middle and inner ear. Amplification of sound. Functional anatomy and mechanism of detection of specific sound frequency in the inner ear. Mechanism of action of the mechanosensory receptors in the inner ear.

Chemical senses:

Olfaction: The olfactory pathway, mechanism and the combinatorial code of detecting a smell.

Taste: Mechanism of taste perception.

Touch/pain: The touch/pain/temperature pathway (ascending and descending). Higher order integration in the brain.

6) Pathologies of the nervous system: Molecular basis of Parkinson's disease, Alzheimer's disease, Schizophrenia, Myasthenia gravis and Multiple sclerosis, stress and antidepressants.

Recommended reading:

a. Neurochemistry by Ferdinand Hucho, VCH Publication, 1986.

b. Basic Neurochemistry by M. P. Spiegel.

c. Cell Biology of the Axon, Series: Results and Problems in Cell Differentiation, Vol. 48. Koenig, Edward (Ed.) 2009, 350 p.
d. Principles of neural Sciences. Eric Kendel, J. H. Schwartz, T. Jessel. 5th
e. Textbook of medical Medical physiology. A Guyton and J Hall

B702: Immunology-II (Immunity and Disease)

1. Host-Pathogen relationship
2. Diseases caused by Viruses and the immune response to them- HIV and AIDS-immune responses
3. Bacterial diseases – and the immune response to bacteria
4. Vaccines- mechanisms, types of vaccines
5. Parasites – protozoan parasites, parasitic worms and the immune response to them- eg malaria, leishmaniasis, worm infestations
6. Immediate Hypersensitivity and allergy, anaphylaxis
7. Hypersensitivity and chronic inflammatory diseases- tuberculosis and leprosy
8. Autoimmune diseases- generalized- SLE, Rheumatoid arthritis; localized- multiple sclerosis
9. Diseases due to immune cross reactivity- Rh incompatibility, transfusion, transplantation
10. Inherited immune diseases
11. Cancer immunology

Recommended reading:
Immunobiology, 5th edition, The Immune System in Health and Disease, by Charles A Janeway, Jr, Paul Travers, Mark Walport, and Mark J Shlomchik
Medical Microbiology. 4th edition., Baron S, editor. Galveston (TX): University of Texas Medical Branch at Galveston; 1996.

B703: Developmental Biology

1. Basic concepts of molecular regulation of development: Transcription factors in differential gene expression; morphogens and axis formation; autocrine and paracrine regulation. How cell proliferation, apoptosis, and fate specification determine developmental processes.
2. Fertilization: Structure of oocytes and spermatocytes. The process of fertilization.
3. Comparative study of early embryonic development: (*Caenorhabditis elegans*, amphibians, birds, and mammals)

a) Cleavage formation
b) Gastrulation
c) Axis formation: Signaling cascades and molecular understanding of anteroposterior, mediolateral, and dorsoventral axes development.

4. Organogenesis in vertebrates: Germ layer formation. Regulation of formation of the somites, heart, kidney, blood vessels, and limb. Changes in circulation pattern between fetus and newborn.
5. Metamorphosis and regeneration process: Hormonal control of metamorphosis in amphibians and insects; wing imaginal disc formation in *drosophila*. Regeneration in planeria and that of vertebrate limb.
6. Stem cells: Concepts of totipotent, pluripotent, and multipotent cells. Factors regulating "stemness" of a cell. Embryonic vs. adult stem cells. Sources of stem cells in vertebrates and their applications.
7. Developmental disorders and aging: Regulatory role of genetic and environmental factors. Role of carcinogens and teratogens.
8. Development processes in plants: How are the mechanisms different from that of animal development? Gametogenesis, pollination, and fertilization processes in angiosperms. Hormonal regulation of seed dormancy and the process of germination. Root and shoot development mechanisms. Reproductive phase: photoperiod sensitivity and molecular regulation of flowering process.
9. Epigenetic and environmental control of development: Sexual dimorphism, sex determination, X inactivation. Environ-elicited phenotypic changes. Defense mechanism-related changes.

B 704: Imaging technology in biological research (60 hrs.)

Pre-requisites: Basic Cell Biology, Physiology, Optics

1) The power of ten (understanding how small cells and the sub-cellular contents are)
2) An introduction to light and optics, exploring with lenses (what are lenses, looking through them, understanding the concept of magnification, mirrors, angles of reflection, refraction, prisms and colors)
3) Fundamentals of illumination (ray diagrams, types of light sources, LEDs, power levels, coherence of light, elliptical reflectors)
4) Exploring microscopes (short history, magnifying glass, simple and compound microscopes, electron microscopes)
5) Fluorescence microscopy (Understanding fluorescence, Fluorescence protein technology, GFP, YFP)
6) Live cell imaging (confocal microscopes)
7) Comparing Confocal and Widefield Fluorescence Microscopy

Recommended reading:-

a. Hands: A Pattern Theoretic Study of Biological Shapes (Research Notes in Neural Computing) (v. 2) - Paperback (Dec. 21, 1990) by Ulf Grenander, Y. Chow, and Daniel M. Keenan.
b. Optical Polarization in Biomedical Applications (Biological and Medical Physics, Biomedical Engineering) - Hardcover (Oct. 5, 2006) by Valery V. Tuchin, Lihong Wang, and Dmitry A. Zimnyakov.
c. Biological Models in Radiopharmaceutical Development (Developments in Nuclear Medicine) - Hardcover (Dec. 31, 1995) by R.M. Lambrecht.
d. Asperger Syndrome and Your Child: A Parent's Guide - Paperback (Sept. 23, 2003) by Michael D. Powers and Janet Poland.
e. Bacterial Virulence: Basic Principles, Models and Global Approaches (Infection Biology (VCH)) - Hardcover (Apr. 19, 2010) by Philippe Sansonetti.
f. A Practical Guide to the Study of Calcium in Living Cells, Volume 40 (Methods in Cell Biology) - Hardcover (Mar. 24, 1994) by Richard Nuccitelli, Leslie Wilson, and Paul T. Matsudaira
g. Bio-Applications of Nanoparticles (Advances in Experimental Medicine and Biology) - Hardcover (Nov. 29, 2007) by Warren C.W. Chan

SEMESTER –VIII

Subject Code	Subject	Contact hrs/per week Theory + Tutorials	Credits
B 801	Virolog	[3 + 1]	4
B 802	Biotechnology - I	[3 + 1]	4
B 803	Bioinformatics	[3 + 1]	4
B 804	Biotechnology - II	[3 + 1]	4
		Contact hrs/per week Lab	**Credits**
BL 801	Advanced Biology Laboratory	[5 + 5]	5
BPr 800	Project	-	4
			25

B801: Virology

1. Introduction to Virology: definition, properties and origin of viruses
2. Virus architecture and nomenclature
3. Virus replication cycle
4. Basic virological methods
5. Basics of virus entry, spread and transmission
6. Host resistance to viral infection: immune responses
7. Vaccines and antiviral chemotherapy: the prevention and treatment of viral diseases
8. Epidemiology
9. Exploiting viruses as gene therapy and vaccine vectors
10. Viruses and cancer: oncoviruses and oncolytic viruses
11. Polioviruses and other single-stranded positive-strand RNA viruses
13. Rabies and other single-stranded nonsegmented negative-strand
RNA viruses
14. Influenza viruse and ther single-stranded segmented negative-strand RNA viruses.
15. 15. Evolution of viruses: new and reemerging viruses
16. Herpesviruses (nuclear large double-stranded DNA viruses)
17. Poxviruses (cytoplasmic large double-stranded DNA viruses)
18. HIV and other retroviruses
19. Hepatitis B virus (reverse-transcribing DNA virus) and other viruses causing hepatitis
20. Prion diseases
21. Plant viruses
22. Bacteriophages

Reference Books

Human Virology (4th edition, paperback) Leslie Collier, John Oxford and Paul Kellam. Oxford University press 2011
Principles of Virology (3rd edition): By S. J. Flint, L. W. Enquist, V. R. Racaniello, and A. M. Skalka, ASM 2009
Principles of Molecular Virology, 4th edition by A.J. Cann, Academic Press, 2005
Understanding Viruses by Teri Shors. Jones and Bartlett Publishers 2008

Introduction to Modern Virology 6th ed by N.J. Dimmock, A. Easton, K. Leppard.. Wiley-Blackwell 2007
Field's Virology. 6th edition David M. Knipe, PhD; Peter M. Howley, MD; Diane E. Griffin, MD, PhD; Robert A. Lamb, PhD, ScD; Malcolm A. Martin, MD; Bernard Roizman, ScD; Stephen E. Straus, MD Raven Press 2007
Principles and Practice of Clinical Virology (6th edition) A.J. Zuckerman (au) and editors J.E. Banatvala, P. Griffiths, B. Schoub, P. Mortimer. Wiley 2009
Clinical and Diagnostic Virology by G. Kudesia and T.Wreghitt (Cambridge Clinical Guides) 2009
How Pathogenic Viruses Work by L. Sompayrac. Published by Jones and Bartlett 2002.

B802: Biotechnology-I (60 hrs.)

Requisites: Advanced Cellular and Molecular Biology, Physiology

1) Basic principles of genetic engineering:

a. Methods of creating recombinant DNA molecule, splicing, properties of restriction endonucleases and their mode of action

b. Cloning vectors (lambda phage plasmid, M-13 phage, cosmid, shuttle vectors, yeast and viral vectors, expression vectors), construction of DNA library, Subtraction cDNA cloning, genomic vs cDNA library - Expression libraries and vectors for protein synthesis, protein purification, protein solubilization, protein export, RNA probes, BACs, PACs and cosmid vectors, Yeast vectors and YACs

c. Chemical synthesis of gene and engineering artificial life

2) Selection/screening: Analysis of genomic DNA by Southern hybridization, Northern and Western blotting techniques, Restriction mapping: Restriction fragment length polymorphism (RFLP).

3) DNA sequencing and analyses techniques: plus and minus, dideoxynucleotide, Maxam and Gilbert, deep sequencing and next gen sequencing, microarray technology and hybridisations.

4) DNA manipulation techniques:

a. Preparation of radiolabelled and synthetic probes, Amplification of DNA by polymerase chain reaction (PCR), Site directed mutagenesis, Gene transfer methods for animals and plants; Agrobacterium mediated gene transfer, electroporation and particle gun,

b. Transgenic animals [Selectable markers for animal cells eg HAT, methotrexate Reporter genes for promoter analysis (Lac Z, GFP) vectors (Baculoviruses) microinjection, retroviruses, Embryonic stem cells), Transgenic mouse / Super mouse – (MT promoter fused to human growth hormone) (isolation of cloned proteins from goat milk)

Viruses as gene-transfer Methods for production of transgenic mice (Pronuclear Transgenic Goats Whole animal cloning eg Dolly, Knock-out, knock-down, knock-in technology, Site-specific recombination using Cre-recombinase LOX system, Gene therapy eg SCID]

c. Transgenic plants [Agrobacterium mediated transformation, Ti plamid, Transgenic tobacco expressing luciferase gene, Bt Cotton, Herbicide-resistant plants, Plant viruses as vectors (eg CaMV virus)]

d. Application of genetic engineering in medicine and agriculture, vaccine production.

5) Cell and tissue culture in plants and animals: Primary culture; Cell line; Cell clones; Callus cultures; Somaclonal variation; Micropropagation; Somatic embryogenesis; Haploidy;

Protoplast fusion and somatic hydridization; Cybrides; Gene transfer methods in plants and in animals; Transgenic biology; Allopheny; Artificial seeds; Hybridoma technology.

B804: Biotechnology-II (60 hrs.)

1) Principles of plant breeding: Important conventional methods of breeding self and cross pollinated and vegetatively propagated crops; Non-conventional methods; Polyploidy: Genetic variability; Plant diseases and defensive mechanisms.

2) Ethics of GM crops and animal cloning

3) Model organisms - S.cereviceae, Dictostylium, Caenorhabditis elegans, Arabidopsis, Zebra Fish, Mouse, Drosophila

4) Industrial Biotechnology

a. Bioprocess Technology [basics of bioreactor kinetics and mathematical equations regarding bioreactors, scale-up and aeration of bioreactors in detail, Kinetics of microbial growth, substrate utilization and product formation: Batch, Fed- Batch and continuous processes, Scale up concepts with respect to fermenter design and product formation, Gas exchange and mass transfer: O2 transfer, critical oxygen concentration, determining the oxygen uptake rate, Solid state fermentation. Common examples: Biopolymers: Xanthan , melanin , adhesive proteins , rubber, poly hydroxyl alkaloids

b. Downstream Processing - Flocculation and floatation, Filtration, Centrifugation, Cell disruption, Liquid extraction, Precipitation, Adsorption, Dialysis, Reverse osmosis, Chromatography, Crystallization and drying, Biodegradation of xenobiotic compounds:

c. Remediation and Biotechnology - Priority pollutants and their health effects, Microbial basis of biodegradation, Bioremediation (phyto and metal), Environmental and industrial pollution control, Biopesticides, Microbial plastics, Solid waste management

5) Medical Biotechnology -

a. Small Biological Molecules: - ascorbic acid, indigo, amino acids, lycopene, succinic acid production, Antibiotics, Tissue Engineering - Growth Factors and morphogens: signals for tissue engineering and whole organ development, extracellular Matrix: structure, function and applications to tissue engineering, Cell adhesion and migration, Inflammatory and Immune responses to tissue engineered devices

b. Biomaterials - Polymeric scaffolds, Calcium Phosphate Ceramics for bone tissue engineering, Bio mimetic materials, Nanocomposite scaffolds

6) Nanotechnology

a. Introduction to nanotechnology and nano-biotechnology, Nanomaterials and their uses.

b. Nanoparticles derived from biological molecules, Synthesis of nanoparticles: strategies, biological methods, general properties and characterization methods

c. Applications of nanotechnology: Nanosensors, Carbon nanotubes and their applications in biology

d. Environmental and safety issues with nanoparticles.

References:

1. Benjamin Lewin , Gene VII, Oxford Publishers
2. T A Brown , Genome, Second edition, Bios Scientific publishers
3. Old and Primrose, Principles of Gene Manipulation. Blackwell Science publishers
4. Simmons, Gardner , Principles of genetics , John Wiley and sons, Inc publishers 2
5. Donald Voet and Judith Voet. Biochemistry third edition, 2004, John Wiley and sons, Inc
6. T D.Watson and others, Molecular biology of the gene , 6th
7. G M Cooper, The Cell, a molecular approach, Library of Congress cataloging in publication data.
8. Griffiths, A. and Miller J , An introduction to genetic analysis , Freeman
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10.Sambrook J, Russell., Molecular cloning, Vol I, II , III, CSHL Press
11. T A Brown, Gene cloning and DNA analysis, Bios Scientific publishers
12. Bernard Glick , Jack Pasternak and Cheryl Patten, Molecular Biotechnology- principles and applications of Recombinant DNA, 4th
13. Kaushik Deb and Satish Totey. (2009) Stem Cells Basics and Applications. Tata McGraw Hill.
14. Gary Stein and Maria B et al. (2011) Human Stem Cell Technology and Biology. Wiley Blackwell.
15. R. Ian Freshney, Glyn N. Stacey, Jonathan M. Auerbach. (2007) Culture of Human Stem Cells. John Wiley & Sons
16. Bernard R. Glick, Jack J. Pasternak, Cheryl L.Patten. (2010) Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press.
17. Robert Lanza, Robert Langer, Joseph P. Vacanti. (2011) Principles of Tissue Engineering. Academic Press. edition , 2004 , Pearson education ltd.ed, ASM Press, 2010
18.Inderbir Singh & GP Pal. (2007) Human Embryology. MacMillan Publishers.
19. Thomas W. Sadler. (2009) Langman's Medical Embryology. Lippincott Williams & Wilkins. 20.Scott F Gilbert.(2000) Developmental Biology, 6th edition. Sinauer Associates.

21. Gordana Vunjak-Novakovic, R. Ian Freshney. (2006) Culture of Cells for Tissue Engineering. John Wiley & Sons.
22. Principles of gene manipulation by S.B. Primrose and Twyman, 7
23. Principles of gene manipulation by R.W. Old and S.B. Primrose, 6
24. Recombinant DNA by Watson, 3
25. Gene cloning and DNA analysis by T.A. Brown, 2
26. Bioinformatics-Methods and Applications by S.C. Rastogi et al 2
27.Integrated Genomics by A. Caldwell et al, Wiley Publishers, 2006
28. Molecular Biotechnology- Principles and application of recombinant DNA, 4 ASM Press, 2010.
29. Biotechnology- Applying the genetics to revolution, D. Clark, N. Pazdernik, Bioprocess Technology.
30. Wulf Crueger and Anneliese Crueger (1990) Biotechnology: A Textbook of Industrial Microbiology. Panima Publishers. New Delhi
31. Michael L. Shuler, Fikret Kargı (1992) Bioprocess Engineering: basic concepts. Prentice Hall Publishers.New York.
32. Stanbury P.F., Whitaker A, Hall S.J. (1999) Principles of Fermentation Technology. edition, Butterworth-Heinemann
33.. Glazer A.N. & Nikaido H. (1995) Microbial Biotechnology: Fundamentals of Applied Microbiology. W.H. Freeman & Company, New York.
Nanotechnology:
1. Sulabha Kulkarni (2010) Nanotechnology principles and practices, Capital Publishing Company
2. David S. Goodsell (2004) Bionanotechnology: Lessons from Nature, John Wiley & Sons Publisher
3. James A. Schwarz, Cristian I. Contescu and Karol Putyera (2004) Dekker Encyclopaedia of Nanoscience and nanotechnology, Marcel Dekker, Inc., USA rd ed. ASM Press, 2001. nd ed. 2009 nd

B803: Bioinformatics (60 hrs.)

Requisites: Basic Statistics and Computation, Basic Cellular and Molecular Biology

1) Basic terms, measures of central tendency and dispersion: Population, Sample, variable, parameter, primary and secondary data, screening and representation of data. Frequency distribution, tabulation, bar diagram, histograms, pie diagram, cumulative frequency curves. Mean median, mode, quartiles and percentiles, measures of dispersion: range, variance, standard deviation, coefficient of variation, symmetry: measures of skewness and kurtosis

2) Probability and distributions: Sample space, events, equally likely events. Definition of probability (frequency approach), independent events. Addition and multiplication rules, conditional probability, Examples Bernoulli, Binomial, Poisson and Normal distributions. Mean and variance of these distributions (without proof). Sketching of p.m.f. and p.d.f, Use of these distributions to describe in biological models. Model sampling and Simulation study.

3) Bivariate data: Scatter plot, correlation coefficient (r), properties (without proof), Interpretation of r, linear regression. Fitting of lines of regression, regression coefficient, coefficient of determination.

4) Methods of Sampling: Use of random numbers to generate simple random samples with replacement and without replacement. Sampling distribution and standard deviation of sample mean. Stratified sampling and its advantages.

5) Hypothesis testing: Hypothesis, critical region, and error probabilities. Tests for proportion, equality of proportions, equality of means of normal populations when variance known and when variances are unknown. Chi-square test for independence. P-value of the statistic. Confidence limits, Introduction to one way and two-way analysis of variance.

6) Computer related introductory topics: History of development of computers, Basic components of computers, Hardware; CPU, input, output, storage devices. Software; operating systems, Programming languages (Machine, Assembly and Higher level)

7) Application software: Introduction to MSEXCEL-Use of worksheet to enter data, edit data, copy data, move data. Use of in-built statistical functions for computations of Mean, S.D., Correlation, regression coefficients etc. Use of bar diagram, histogram, scatter plots, etc. graphical tools in EXCEL for

presentation of data. Introduction to MSWORD word process or editing, copying, moving, formatting, Table insertion, drawing flow charts etc.

8) Bioinformatics core topics: Introduction to Internet and use of the same for communication, searching of database, literature, references etc. Introduction to Bioinformatics, Databank search- Data mining, Data management and interpretation, BLAST, Multiple sequence alignment, Protein Modeling, Protein structure Analysis, Docking, Ligplot interactions, Genes, Primer designing, Phylogenetic Analysis, Genomics and Proteomics.

Recommended reading:-

a. Biostatistics: A foundation for Analysis in the Health Sciences 7/E Wayne W. Daniel, Wiley Series in Probability and Statistics.
b. Introductory Statistics. Fifth Edition. (2004) Prem S. Mann. John Wiley and Sons (ASIA) Pvt. Ltd.
c. Basic Statistics-A primer for Biomedical Sciences- (Olive Jean Dunn).
d. Biostatistics-An introductory text - (Auram Gold Stein).
e. Statistics : An Introductory Analysis (Taro Yamane) Harper and Row Publisher 1964,67,73
f. Computational Biochemistry, By: C. Stan Tsai, A John Wiley & Sons, Inc., publication.

FIFTH YEAR
SEMESTER –IX

Subject Code	Subject	Contact hrs/per week Lab	Credits
BPr 901	Project	-	24
			24

SEMESTER –X

Subject Code	Subject	Contact hrs/per week Lab	Credits
E 1001	Electives I	[3 + 1]	4
E 1002	Electives II	[3 + 1]	4
E 1003	Electives III	[3 + 1]	4
E 1004	Elective IV	[3 + 1]	4
			16

Total Credits: 243

Electives:

1. Toxicology and clinical research
2. Molecular modeling and drug design
3. Ethology
4. Parasitology
5. Reproductive biology
6. Occupational diseases (infectious incl)
7. Plant pathology
8. Plant communication
9. Animal migration
10. Commercial products from plants and animals
11. Biology of food industry
12. Transgenics
13. Ethical issues in biology and medicine
14. Physical biology
15. Astrobiology
16. Biology of traditional medicines
17. Translational biology
18. Science writing and communication
19. Forensic science
20. Epigenetics
21. On-line courses