PT. RAVISHANKAR SHUKLA UNIVERSITY

Centre for Basic Sciences

Syllabus of

Integrated M. Sc. : Biology Stream

[Choice and Credit Based System]

Semester Examination

SESSION 2015-2020

Integrated M. Sc. : Biology Stream

[Choice and Credit Based System]

Scheme of Examination: Session 2015-20

(P: Physics, M: Mathematics, C: Chemistry, B: Biology, G: General, H: Humanities CB: Chemistry Biology, PCB: Physics Chemistry Biology, MB: Maths for Biology)

FIRST YEAR [July 2015 to June 2016]

SEMESTER-I

Subject	**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
MB101	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

SEMESTER-II

Subject	**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
MB101	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]	2
		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
			25

SECOND YEAR [July 2016 to June 2017]

SEMESTER-III

Subject	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

SEMESTER-IV

Subject	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

THIRD YEAR [July 2017 to June 2018]

SEMESTER-V

Subject	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	10	5
			25

SEMESTER-VI

Subject	**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 + 0]	3
H601	Ethics of Science and IPR	[2 + 0]	2
		Contact hrs/per week Lab	**Credits**
BL 601	Biology Laboratory	8	4
			25

FOURTH YEAR [July 2018 to June 2019]

SEMESTER-VII

Subject	**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

SEMESTER-VIII

Subject	**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

FIFTH YEAR [July 2019 to June 2020]

SEMESTER-IX

Subject	Subject	Contact hrs/per week Lab	Credits
BPr 901	Project	-	20
			20

SEMESTER-X

Subject	Subject	Contact hrs/per week Lab	Credits
E 1001	Electives I	[3 + 2]	5
E 1002	Electives II	[3 + 2]	5
E 1003	Electives III	[3 + 2]	5
E 1004	Elective IV	[3 + 2]	5
			20

Total Credits: 240

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

FIRST YEAR

Semester – I [July- December 2015]

B 101: Biology I (Introductory to Biology)

Unit-I
Life: History and origin of life, Concepts of biological evolution, natural selection, speciation. Classification of living things: Classification and domains of life, Prokaryotes and Eukaryotes, Taxonomy of plants, animals and microorganisms.

Unit-II
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.

Unit-III
Cell Biology: Discovery of cell, cell theory, classification of cell types, cell membrane, cell-cellinteractions, energy and metabolism, respiration, photosynthesis, sexual reproduction.

Unit-IV
Cell Division and System Development: cell cycle, mitosis, meiosis, mechanism of development (stem cells), formation of tissues.

Unit-V
Physiology- Body Systems: Digestive system, circulatory system, Lymphatic system, nervous system, respiratory system, sensory system, homeostasis.

Books Recommended:

S.No.	Author	Book
1	Neil A Campbell and JB Reece (2007)	Biology with Mastering Biology (8th Edition)
2	NA Campbell, JB Reece, MR Taylor and EJ Simon (2008)	Biology: Concepts & Connections with biology (6th Edition)
3	Charles Darwin (2008)	On the Origin of Species
4	B Alberts, D Bray, K Hopkin and AD Johnson (2009)	Essential Cell Biology
5	Rene Fester Kratz (2009)	Molecular and Cell Biology For Dummies
6	MJ Behe (2006)	Darwin's Black Box: The Biochemical Challenge to Evolution
7	SD Garber (2002)	Biology: A Self-Teaching Guide, (2nd Edition)

C 101: Chemistry –I [Structure & Bonding]

Unit-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.

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

Unit-II
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.

Unit-III
Metallic and organometallic bonds – general properties. Coordinate bond- coordination complexes.
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.

Unit-IV
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.
Reaction mechanism: Types of mechanisms, Arhenius theory, collision theory, types of reactions, redox reactions, displacement and addition reactions, thermodynamic and kinetic requirements.

Unit-V
Hammond postulate, Curtin-Hammett principle, transition states and intermediates, carbocations, carbanions, free radicals, methods of determining mechanisms, isotopic effects.
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.

Books Recommended:

S.No.	Author	Book
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, 1992
4	R. T. Morrison, R. N. Boyd, P. Sykes	Organic Chemistry, Prentice Hall of India
5	G.W. Castellan	Physical Chemistry, 3rd Ed. Addison - 1993

P 101 Physics- I (Classical Physics)

Unit-I
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.

Unit-II
Rotational kinematics and dynamics, Rigid body motion. Impulse and collisions, Central forces, Kinetic theory of gases, Equipartition of energy.

Unit-III
Free oscillations in one, two, and many degrees of freedom. Linearity and superposition principle. Normal modes; Transverse and longitudinal modes

Unit-IV
General notion of a continuous string; Resonance; Coupled pendula and oscillators, Normal coordinates.

Unit-V
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).

Books Recommended:

S.No.	Author	Book
1	R. P. Feynman, R. B. Leighton, M. Sands	The Feynman lectures in Physics" Volume-1
2	D. Kleppner and R. Kolenkow	An introduction to mechanics
3	C. Kittel, W. D. Knight and M. A. Ruderman	Mechanics [Berkeley Physics CourseVol. 1]
4	F. S. Crawford	Waves [Berkeley Physics Course Volume 3]

MB 101: Mathematics – 1

Unit-I
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.

Unit-II
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.

Unit-III
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.

Unit-IV
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.

Unit-V

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.

Books Recommended:

S.No.	Author	Book
1	Gilbert Strang (MIT Courseware)	Calculus
2	M. Weir, J. Hass and F. R. Giordano (Pearson Education)	Calculus

H 101: Communication Skills

Unit-I

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

Unit-II

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.

Unit-III

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,

Unit-IV

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.

Unit-V

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)

G101: Computer Basics

Unit-I

Introducing LINUX: getting started;

Unit-II

FORTRAN programming

Unit-III

LaTeX introduction (sufficient to make small documents); gnuplot - graph plotting and data fitting; xfig - simple drafting tool; MATHEMATICA - algebraic computations.

Unit-IV

Projects on:

Some of the projects done by the students are listed below; Predator-prey problem; Harmonic oscillator with friction Coupled pendulum

Unit-V

Projects on:

Testing random number generator; Brownian motion as a random walk problem; Sorting function and its application to making ranked lists, SUDOKU solver

BL 101 Biology laboratory

1) Introduction to Biology laboratory
2) Taxonomy
3) Methods of Classification
    Dichotomous key; Hierarchical Classification; Phylogenetic Classification
4) Natural Selection
5) Natural Selection using Daphnia
6) Concept of pH & Buffers:
    Hydrogen ion concentration in solution; 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.

CL 101: Chemistry Laboratory

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

Books Recommended:

S.No.	Author/Book
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

PL 101: 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.

Books Recommended:

S.No.	Author	Book
1	Worsnop and Flint	Advanced Practical Physics for Students

GL 101 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-thenelse, Case, Go-to. Loops- Do loops, cycle, exit, nested loops. Arrays- 1 dimensional and multidimensional.
Formatting - input and output. Input and output from file.
Functions and Subroutines.; Creating HTML pages; Plotting utilities like GNU Plot.

Semester – II [January - June 2016]

B 201: Biology –II [Introduction to Macro Molecules]

Unit-I
Cell – Overview: Cellular organization, Biomembranes, Nucleus, Cytoplasmic organelles, Bacteriophages. Nucleic Acids, Genomes and Proteomics: Building blocks- nucleotides, DNA structure, RNA structure and function, chromatin structure, genome code, genes, repetitive DNA sequences.

Unit-II
Gene Transcription: Overview of gene expression, overview of transcription, gene's regulatory elements, transcription mechanisms in prokaryotes and eukaryotes (a comparison).

Unit-III
Protein Structure and Function: Building blocks- amino acids, peptides, secondary structure, three dimensional structure, membrane proteins, miscellaneous proteins, enzymes.

Unit-IV
Cell Signaling: Overview, signaling via hydrophobic molecules, signaling via ion channels, Signaling via G-protein coupled receptors, signaling via cell surface enzymes, intracellular signaling.

Unit-V
Biotechnology: DNA cloning, Uses of recombinant DNA technology, Polymerase chain reaction (PCR), Production of recombinant proteins and SDS-PAGE.

Books Recommended:

S.No.	Author	Book
1	B Alberts, A Johnson, J Lewis, and M Raff	Molecular Biology of the Cell
2	J D. Watson, T A. Baker, S P. Bell, & A Gann	Molecular Biology of the Gene (6th Edition)
3	John Wilson and Tim Hunt (2007)	Molecular Biology of the Cell: The Problems
4	Benjamin Lewin (2007)	Genes IX (Lewin, Genes XI)

C 201: Chemistry- II [Chemical Thermodynamics]

Unit-I

Classification of system, intensive and extensive properties, equilibrium and Heat, work and energy, irreversible and reversible expansion work of an ideal First law of thermodynamics, heat content or enthalpy of a system; Thermochemistry – Enthalpy of a reaction, exothermic and endothermic

Unit -II

Second law of thermodynamics, Carnot cycle, entropy, entropy change and 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.

Unit -III

Electrode potential and free energy, electrochemical series. Nernst heat Theorem and third law of thermodynamics, experimental Elements of statistical thermodynamics

Unit -IV

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 Phase equilibrium in simple systems: Equilibrium condition, stability of the 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.

Unit -V

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.

Books Recommended:

S.No.	Author	Book
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,
4	K. Denbigh	The principles of Chemical Equilibrium
5	B. G. Kyle	Chemical & Process Thermodynamics

P 201: Physics – II: [Electricity, Magnetism and Optics]

Unit-I
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.

Unit-II
Magnetostatics: Biot – Savart law, Ampere's law; Electromagnetic induction; Mutual inductance and self inductance; Magnetic fields in matter.

Unit-III
Displacement current; Maxwell's equations; Alternating current circuits; Electric and magnetic properties of matter; Plane electromagnetic waves in vacuum; Polarisation;

Unit-IV
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).

Unit-V
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.

Books Recommended:

S.No.	Author	Book
1	Edward M. Purcell	Electricity and Magnetism Berkeley Vol. 2
2	Frank S. Crawford	Waves, Berkeley Vol. 3
3	Jenkins and White	Fundamentals of Optics
4	Feynman	Feynman Lectures Vol. 2

MB 201: Mathematics – II [Linear Algebra, Calculus of Several variables]

Unit I
Functions of several variables, partial derivatives, geometric interpretation, properties of partial derivatives, chain rule, applications. 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.

Unit II
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. Line integrals. Double and triple integrals, their properties and applications to areas, volumes, etc.

Unit III
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).

Unit IV
Curvilinear coordinate systems, spherical and cylindrical coordinates, area and volume elements, illustrations. Gradient, divergence and curl in curvilinear coordinate systems.

Unit V

Introduction to linear algebra. Vector spaces, linear dependence and independence, notion of basis, and dimension, subspaces. Examples. More on matrices: special kinds of matrices, their properties. Eignevalues and eigenvectors, secular determinant, characteristic polynomial. Eigenvalues and eigenvectors of a real symmetric matrix. Illustrative examples. Applications of linear algebra.

Books Recommended:

S.No.	Author	Book
1	Gilbert Strang (MIT Courseware)	Calculus
2	Thomas	Calculus
3	Howard Anton and Chris Rorres	Elementary Linear Algebra
4	Gilbert Strang (MIT Courseware)	Introduction to Linear Algebra
5	George B. Arfken and Hans J. Weber	Mathematical Methods for Scientists and Engineers

G201- Electronics & Instrumentation

Unit-1

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; 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.

Unit-2

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.

Unit-3

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.

Unit-4

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.

Unit-5

Basic concepts of instrumentation, generalized instrumentation systems block diagram representation; Sensing elements: electrodes and transducers. Electrode-electrolyte interface, stability of electrode potentials, circuit models, external and internal electrodes, pH, pO2 and pCO2 electrodes. Transducer, definition, types, displacement, velocity, acceleration, pressure, temperature vibration, ultrasound etc., calibration, sensitivity and resolution.

Books Recommended:

S.No.	Author	Book
1	R. L. Boylestad, L. Nashelsky, K. L. Kishore, Pearson	Electronic Devices and Circuit Theory
2	Malvino and Bates	Electronic Principles
3	Donald A. Neamen, Tata McGraw Hill	Electronic Circuit Analysis and Design
4	David A. Bell	Electronic Devices and Circuits
5	Leach, Malvino and Saha	Digital Principles and Applications
6	R.P. Jain	Modern Digital Electronics, Tata McGraw-Hill (2003)
7	M. Morris Mano, Michael D. Ciletti	Digital Design, Pearson Education Asia, (2007)
8	Thomas L. Floyd	Digital Fundamentals, Pearson Education Asia (1994)
9	DVS Murthy	Measurement & Instrumentation
10	A.K. Sawhney	Electrical Measurements & Electronic Measurements

G202- Glimpses of Contemporary Science

Unit-I

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.

Unit-II

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.

Unit-III

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.

Unit-IV

Astrophysics, Astrochemistry and Astrobiology

Unit-V

Quantum mechanics, atoms : Entanglement Light-atom interaction, Bringing atoms to rest, Laser tweezers, How bright is laser, Quantum computing.

Books Recommended:

S.No.	Author	Book
1	Darcy Wentworth Thompson	Growth and Forms
2	Rob Phillips	Physical biology of the cell
3	Harward Berg	Random walks in biology
4	L. Cooper	Physics: Structure and Meaning
5	R. P. Feynman, R. B. Leighton, and M. Sands	The Feynman Lectures on Physics vol. 3
6	S. Chandrasekhar	Introduction to the study of stellar structure

BL 201: Biology Practical

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

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.

Books Recommended:

S.No.	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

PL 201- Physics Laboratory

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.

Books Recommended:

Author	Book
Worsnop and Flint	Advanced Practical Physics for Students

GL 201 Electronics laboratory

1. To study the Half wave & Full wave rectifier and study the effect of C filter.
2. To design a Single Stage CE amplifier for a specific gain and bandwidth.
3. Study of Operational amplifier in inverting and non-inverting mode.
4. To verify and design AND, OR, NOT and XOR gates using NAND gates.
5. Measurement of pressure, strain and torque using strain gauge.

Second Year

Semester – III [July - December 2016]

CB 301- Essential Mathematics for Chemistry & Biology

Unit-I
Applications of Taylor series, Euler series

Unit-II
Review of first order ordinary differential equations, second order ODE's with constant coefficients, solutions by series expansion methods, introduction to partial differential equations,

Unit-III
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.

Unit-IV
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.

Unit-V
Complex numbers, Analytic functions, Cauchy Riemann equations, Cauchy's integral formula, Residue theorem and simple applications.

Books Recommended:

S.No.	Author	Book
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
3	J. Marsden, A. Tromba and A. Weinstein	Basic Multivariable Calculus, Springer
4	Inder K. Rana	Calculus@iitb, Concepts and Examples, Version 1.2

CB 302: Biochemistry-I

Unit-I

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.

Unit-II

Chemical structure of Major: Carbohydrates, Lipids, Nucleic acids, Proteins: amino acid ; 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

Unit-III

Enzymes and enzyme activity: enzyme kinetics , enzyme inhibition, proteolysis; ubiquitin – proteasome, kinase -- dehydrogenase

Unit-IV

Membranes : fluid mosaic model; diffusion, osmosis. Phospholipids, glycolipid, glycocalyx, antigen, isoprene ion channel; proton pump, electron transport , ion gradient, antiporter, symporter, quinine, riboflavin Lipids, Vitamins, Hormones

Unit-V

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

Books Recommended:

S.No.	Author	Book
1	D. L. Nelson & M. M. Cox	Lehninger Principles of Biochemistry,
2	Stryer L (1995	Biochemistry, 4 th edition,
3	Starzak, Michael E.	Energy and Entropy equilibrium to stationary states
4	J. McMurry (1999)	Fundamentals of General Organic & Biological Chemistry

B 301: Cell Biology -I

Unit-I

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.

Unit-II

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.

Unit-III

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

Unit-IV

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.

Unit-V

Organization, Replication, and Maintenance of the genome: Complexity of eukaryotic genomes, Chromosomes and chromatin, DNA replication, DNA damage and repair, DNA rearrangements

Books Recommended:

S.No.	Author	Book
1	D. L. Nelson & M. M. Cox	Lehninger Principles of Biochemistry,
2	Stryer L (1995	Biochemistry,
3	Starzak, Michael E.	Energy and Entropy equilibrium to stationary states
4	J. McMurry (1999)	Fundamentals of General Organic and Biological Chemistry (Study Guide)

CB 303: Organic Chemistry –I

Unit-I

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.

Unit -II

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.

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.

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

Alkenes - Elimination reactions ; Saytzeff & Hoffman elimination; Reactions – halogenation reactionsfree radical and polar mechanisms. Markownikoff's rule, the peroxide effect, allylic halogenations using NBS; Ozonides/Ozonolysis. epoxidation; hydroboration-oxidation; oxymercuration-demercuration; Oxidation using $KMnO_4$ & OsO_4.; polymerization.

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

Unit -III

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

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

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

Unit -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 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

Unit -V

Carboxylic acids - Methods of formation of mono and di carboxylic acids; acidity and factors affecting acidity; reactions of carboxylic acids :
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.
Nitrogen and sulphur compounds - Nitro alkanes

Books Recommended:

S.No.	Author	Book
1	I. L. Finar	Organic Chemistry, Vol. 1 & 2, ELBS.
2	R. T. Morrison and R. N. Boyd	Organic Chemistry, Prentice Hall of India
3	L. G. Wade,	Organic Chemistry, Pearson Education
4	G. Solomons and C. Fryhle,	Organic Chemistry, John Wiley & Sons
5	W.G. Solomons	Fundamentals of Organic Chemistry,
6	J. March	Advanced Organic Chemistry, 3rd Edn.
7	F.J. Carey and R.J. Sundburg	Advanced Organic Chemistry, Part A & Part B
8	D. D. Ebbing	General Chemistry, Houghton Miffin Co
9	M. J. Sienko and R. A. Plane	Chemical Principles and Applications,

H 301: World Literature

Unit-I

What is Literature? - a discussion; Introduction to literary terms, genres, and forms of various periods, countries, languages, etc. Comprehensive idea about Sanskrit literature in relation to scientific writing: Vedic and Classical literature

Unit-II

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.

Unit-III

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.

Unit-IV

Poetry: Brief introduction; Study of poetic genres, forms, topics, figures of speech, poetic language etc. by analysing various poems from around the world

Unit-V

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

Unit-I

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.

Unit-II

Genesis of systematic ideas: Science in ancient Greece; against mythological explanations to natural phenomena; Early atomism, mathematical atomism, against atomism. 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".

Unit-III

Method of analysis and synthesis; Beginning of mathematical sciences; multicultural origins of science. Renaissance and scientific revolution:

Unit-IV

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.

Unit-V

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.

Books Recommended:

S.No.	Author	Book
1	Colin Ronan	Cambridge Illustrated History of Science
2	Rom Harre	Great Scientific Experiments: 20 Experiments that Changed our View of the World
3	T. A. Saraswati Amma	Geometry in Ancient and Medieval India
4	Kim Plofker	Mathematics in India (Princeton Univ. Press)
5	Samir Okasha	Philosophy of Science – A Very Short Introduction
6	Henry Collins and Trevor Pinch	The Golem – What Everyone should Know about Science by (Cambridge Uni. Press, 1996)
7	Alan Chalmers	What is this thing called Science?

BL 301: 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, 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 SDSPAGE, 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
    Meiosis using lily anthers

GL 301- Applied Electronics Lab

Experiments based on:

1- Norton's theorem and Maximum power transfer theorem; basic concepts of semiconductor diode and transistor;
2-Principle of DC power supply; half and full wave bridge rectifier, capacitor filter – ripple factor,
3-Zener regulator; concept of Switch Mode Power Supply (SMPS), power supply ICs,
4- Bipolar Junction Transistor (BJT) – biasing circuits:
5- Anlog to Digital Converter (ADC); filters: low pass, high pass; band pass; Butterworth filter
6- controlled inverter, adder / subtracter, parity checker; Flip-Flops (FF):
7- RS-FF, D-FF, JK-FF; counters and shift registers: binary counter, ripple counter.

Semester – IV [January - June 2017]

B401: Cell Biology - II

Unit-I

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

Unit-II

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.

Unit-III

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

Unit-IV

Types of cell death: Apoptosis, Necrosis, Anoikis, Oncosis

Unit-V

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.

Books Recommended:

S.No.	Author	Book
1	Alberts *et al*.	Molecular biology of the Cell
2	Alberts, Bray *et al*	Essential Cell Biology Garland, Publication New York 1997
3	James E. Darnell, Harvey F. Lodish, and David Baltimore	Molecular Cell Biology
4	Geoffrey M Cooper	The Cell, 2nd edition, A Molecular Approach
5	http://publications.nigms.nih.gov/insidethecell/index.html.	Inside the Cell, an internet-based study of cells (National Institute of General Medical Sciences)

B 402: Biochemistry-II

Unit-I

Metabolism and metabolic pathways: Glycolysis, TCA cycle, Oxidative Phosphorylation, Photophosphorylation

Unit-II

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

Unit-III

Pigments : chlorophyll , carotenoids, xanthophyll , cytochrome, phycobilin, Bacteriorhodopsin, hemoglobin, myoglobin, absorption spectrum, action spectrum, fluorescence

Unit-IV

Photosynthesis : light reaction -- dark reaction. Fermentation : Acetyl-CoA -- lactic acid
Cellular respiration : Adenosine triphosphate (ATP) - NADH - pyruvate - oxalate – citrate Chemosynthesis

Unit-V

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

Books Recommended:

S.No.	Author	Book
1	D. L. Nelson , M. Cox	Lehninger Principles of Biochemistry,
2	Stryer L	Biochemistry.
3	Starzak Michael E.	Energy and Entropy equilibrium to stationary states
4	J McMurry	Fundamentals of General Organic and Biological Chemistry (Study Guide)

CB 401: Introductory Spectroscopy [UV-Vis, Florescence, IR, Raman, NMR]

Unit-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. Spectroscopic Processes: Absorption, emission, and scattering of light. Beer-Lambert Law - Quantitative absorption measurements, Jablonski diagram Fourier transformation: A mathematical tool to our advantage, basic principle and its relevance in spectroscopy.

Unit -II

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: pi-star and pi to pi-star transitions. band position and band intensities. 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.

Unit -III

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.
Raman Spectroscopy: Raman Effect and molecular polarizability. Technique and instrumentation. Pure rotational Raman spectra, vibrational Rama spectra. Structure determination from Raman and IR.

Unit -IV
Nuclear Magnetic Resonance (NMR): Introduction to Nuclear Magnetic Resonance (NMR) spectroscopy. 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.. 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. Interpretation of NMR spectra using

Unit -V
Examples of organic compounds. Short introduction about application of NMR for proteins.
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.

Books Recommended:

S.No.	Author	Book
1	K Wilson and John Walker	Practical Biochemistry: Principles & Techniques
2	GR Chatwal and SK Anand	Instrumental methods of Chemical Analysis
3	S. K. Sawhney	Introductory Practical Biochemistry
4	RF Boyer	Biochemistry Laboratory: Modern Theory & Techniques
5	S Carson, H Miller and D Scott	Molecular Biology Techniques: A Classroom Laboratory Manual
6	T C Ford and J M Graham	An Introduction to Centrifugation
7	TS Work and E Work	Density Gradient Centrifugation, Vol. 6
8	David Rickwood	Centrifugation Techniques
9	A Braithwaite and FG Smith	Chromatographic Methods
10	LR Snyder, JJ Kirkland & JW Dolan	Introduction to Modern Liquid Chromatography
11	S J Pennycook and PD Nellist	Scanning Transmission Electron Microscopy
12	DJ Rawlins	Light microscopy
13	M Hoppert	Microscopic Techniques in Biotechnology
14	M Hoppert and A Holzenburg	Electron microscopy in microbiology
15	T Peng, D L Horrocks and E L Alpen	Liquid Scintillation Counting: Recent Applications and Development, Volume I
16	R Baserga and D Malamud	Autoradiography: techniques and application
17	T Chard	An Introduction to Radioimmunoassay and Related Techniques , Volume 6
18	MD Bruch	NMR Spectroscopy Techniques
19	B A Wallace and R. William	Modern Techniques for Circular Dichroism and Synchrotron Radiation ..., Volume 1

PCB 401: Physical & Chemical Kinetics

Unit -I

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.
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.

Unit -II

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.
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.

Unit -III

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.
Chain reactions: general treatment, activation energy, chain length, chain transfer reactions, inhibition.

Unit -4

Bond dissociation energies, branching chain reactions.
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.
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 reactionpath, potential energy surface for electronically excited molecule. Molecular beam scattering, Stateresolved spectroscopic technique, molecular dynamics of H2 + H reaction, state-to-state kinetics of F +H2 reaction.

Unit -V

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.

Books Recommended:

S.No.	Author	Book
1	K.A. Connors	Chemical Kinetics: A Study of Reaction Rates in Solution,
2	J.I. Steinfeld, J.S. Francisco & W.L. Hase	Chemical Kinetics and Dynamics,
3	K. J. Laidler	Chemical Kinetics,
4	R. D. Levine and R. B. Bernstein	Molecular Reaction Dynamics & Chemical Reactivity
5	J.W. Moore and R.G. Pearson	Pearson, Kinetics and Mechanisms,
6	Sanjay K. Upadhay	Chemical kinetics and Reaction Dynamics,

G 401: Statistical Techniques and Applications

Unit-I
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.

Unit-II
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

Unit-III
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.

Unit-IV
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.

Unit-V
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.

Books Recommended:

S.No.	Author	Book
1	R.J. Barlow	Statistics: A Guide to the Use of Statistical Methods in the Physical Sciences
2	John Mandel, Dover	The Statistical Analysis of Experimental Data
3	Philip Bevington and Keith Robinson	Data Reduction and Error Analysis for the Physical Sciences, 3rd Edition

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).

GL 401: 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.

Third Year

Semester – V [July - December 2017]

B501: Genetics

Unit-I
Introduction and overview of genetics: Information transfer DNA-RNA-Protein/genotype & phenotype, Eukaryotic & Prokaryotic genes, Pseudogenes. Gene regulation: λ phage, Bacterial gene regulation, Eukaryotic gene regulation, Epigenesis, Reverse genetics, genomes and genomics.

Unit-II
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.

Unit-III
Human genome and genetics: Elements of human genetics & genetic disorders, Examples from *Drosophila*, yeast, maize and mouse, Immunogenetics.

Unit-IV
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.

Unit-V
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.

Books Recommended:

S.No.	Author	Book
1	E. J. Gardner, D.P Snustad and M. J. Simmons	Principles of Genetics
2	Leland Hartwell, Leroy Hood, Michael Goldberg, Ann Reynolds, Lee Silver, Ruth Veres.	Genetics: From genes to genomes
3	Anthony J. F. Griffiths. 2010	Introduction to genetic analysis
4	Harvey Motulsky, 2010	Intuitive Biostatistics: A Nonmathematical Guide to Statistical Thinking
5	Marcello Pagano, 2000	Principles of Biostatistics
6	Genetics for Dummies, 2005	T. R. Robinson

B 502: Molecular Biology

Unit-I

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.

Unit-II

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.

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.

Unit-III

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.

Unit-IV

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.

Unit-V

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.

Books Recommended:

S.No.	Author	Book
1	Stryer L	Biochemistry, 4 th edition,
2	Watson J. D., Hopkins, N. H., Roberts, J. W., Steitz, J. A. and Weiner, A. M.	Molecular biology of the gene, 4th edition, The Benjamin/Cummings publishing companies,
3	Benjamin Lewin	Genes VII, oxford University Press, Oxford
4	Weaver R. F.	Molecular biology,
5	Brown T A	Essential molecular biology, vol. I, A practical approach, IRL press, Oxford.28
6	Cox Lynne S	Molecular Themes in DNA Replication
7	Cantor, C. R., and Schimmel, P. R.	Biophysical Chemistry.

B 503: Biodiversity of plants/animals/microbes

Unit-I

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 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

Unit-II

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
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

Unit-III
Taxonomy of plants: Plant identification, nomenclature, collecting and documentation, plant phylogeny and systematics.
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.

Unit-IV
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

Unit-V
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 & Alteration b. Exotic Species c. Chemical Pollutants d. Loss of Genetic Diversity in Crops

Books Recommended:

S.No.	**Author**	**Book**
1	Cecie Starr, Ralph Taggart, Christine Evers, and Lisa Starr	Biology: The Unity and Diversity of Life
2	Hawksworth, D. L. & Bull Alan T.	Plant Conservation and Biodiversity. Series: Topics in Biodiversity and Conservation, Vol. 6 (Eds.) Reprinted from Biodiversity and Conservation, 16:6, 2007, VIII, 424 p.
3	M P Singh	Plant Biodiversity & Taxonomy
4	E.O.Wilson, *Editor.* Frances M. Peter	Biodiversity
5	Peter H. Raven, Ray F. Evert, and Susan E. Eichhorn	Biology of Plants

CB 501- Analytical Chemistry

Unit-I
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.

Unit -II
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).

Unit -III
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 (LAICP), Secondary Ionisation (SI), Resonance Ionisation (RI), Matrix Assisted Laser Desorption and Ionisation (MALDI), Hyphenated Technique – IC-MS, HPLC-MS, GC-MS.

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

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

Books Recommended:

S.No.	Author	Book
1	RA Meyers	Encyclopaedia of Analytical Chemistry: Applications, Theory and Instrumentation
2	DA Skoog, DM West, FJ Holler and SR Crouch	Fundamentals of Analytical Chemistry, 8th Edition
3	DA Skoog, FJ Holler and TA Niemann	Principles of Instrumental Analysis, 5th Edition, Saunders College Publishing (1998)
4	GH Jeffery, J Bassett, Mendham and RC Denney	A text book of Quantitative Analysis, 5th Edition Revised
5	AK De and SM Khopkar	Chalmers, Solvent Extraction of Metals, Van Nostrand, Reinhold
6	F Helfferich	Ion Exchangers, McGraw Hill
7	LR Snyder and JJ Kirkland	Introduction to Modern Liquid Chromatography, 2nd Edition, Wiley
8	Editors JA Marinsky, Y Marcus, Marcel Dekker	Ion Exchange and Solvent Extraction: A Series of Advances
9	ED Katz Chichester	High Performance Liquid Chromatography : Principles and Methods in Biotechnology;
10	A Metcalfe	Atomic Absorption and Emission Spectroscopy,
11	K Jose and AC Broekaert	Analytical Atomic Spectrometry with flames and Plasmas, Wiley-VCH
12	lJ Sneddon	Advances in Atomic Spectroscopy, Jai Press
13	M John Roboz	Introduction to Mass Spectrometry: Instrumentation and Techniques, Interscience
14	Steve J Hill	Inductively Coupled Plasma Spectrometry and its Application, Sheffield Academic Press
15	WW Wendlandt	Thermal Methods of Analysis, 2nd Edition, Wiley
16	T Daniels, Kogan Page	Thermal Analysis
17	AJ Bard and LR Faulkner	Electrochemical Methods, 2nd Edition, Wiley
18	SP Kruger	Principles of Activation Analysis, Wiley Interscience
19	LC Feldman and JW Meyer	Fundamentals of Surface and Thin Film Analysis, North Holland
20	JC Miller and JN Miller	Statistics for Analytical Chemistry, 2nd Edition, Wiley

G 501: Earth Science and Energy & Environmental Sciences

Unit –I

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, seismic 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.

Unit-II

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.

Unit-III

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.

Unit-IV

Water harvesting, storage and treatment.
Natural calamities, hazards, and effects of human activity: Chemical and other technological hazards.
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).

Unit-V

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.

Books Recommended:

S.No.	Author	Book
1	Merill RT, McElhinny MW and McFadden PL	The magnetic field of the Earth: International Geophysical Series
2	Edward J, Tarbuck EJ and Lutgens FK	Earth Science
3	HR Sheehan *et al.,*	Introduction to Applied Geophysics: Exploring the Shallow Subsurface Burger
4	Condie KC	Mantle Plumes and Their Record in Earth History; Cambridge University Press, Cambridge, UK

5	WM Telford, Robert E Sheriff and LP Geldart	Applied Geophysics (Paperback)
6	JB Marion	Energy in Perspective, University of Maryland, Academic Press
7	Robert A Ristinen and Jack J Kraushaar	Energy and Environment, , 2nd Edn., John Wiley and Sons, Inc.
8	Boyle Godfrey	Renewable Energy, Oxford University Press
9	D.K.Asthana and Meera Asthana	Environment, Problems and Solutions, S. Chand and Company
10	Balaram Pani IK	Text Book on Environmental Chemistry, International Publishing House

BL 501: 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 Techniqueso) 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 [January - June 2018]

B601: Immunology

Unit-I
Overview of the Immune system: Types of immunity, innate, acquired, passive and active, self vs nonself discrimination, Adaptive immune response, Autoimmunity

Unit-II
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

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

Unit-IV
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)

Unit-V
Immunology & applications: Transplantation immunology, Tumour immunology, Immunotechnology, Animal models. Plant immunity

Books Recommended:

S.No.	Author	Book
1	Goldsby, Kindt, and Osborne	Immunology
2	Janice Kuby	Immunology
3	Ivan Roitt	Essential Immunology, 8th Edition
4	Cellular and Molecular Immunology	Kathyrn Austyn
5	David	Biology of Immunological Diseases
6	Richard Burry	Immunocytochemistry: A practical guide for Biomedical Research

B 602: Animal Physiology

Unit-I
Cell Structure & Metabolism: Homeostasis, Mechanisms of Cellular Control, Membrane Transport, Membrane Potentials (a review). Body Control: Hypothalamic/Pituitary Axis, Mystic Rhythms

Unit-II
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.

Unit-III

Muscular system: Skeletal Muscle, Muscle Characteristics, Muscle Control, Muscle Exercise, Smooth Muscle. Cardiovascular Systems: Cardiac Muscle, Heartbeat , Cardiac Control, Blood: Hemostasis, Temperature Control, Vessels, Tissue Exchange, EKGs and Blood Pressure. Digestion: Absorption

Unit-IV

Respiratory Systems: Respiration, Respiratory Control. Energy Balance and Metabolism: Fuel Metabolism (both plants and Animals)

Unit-V

Processes: Excretion Control Salt & Water Balance, An example of a process going wrong.
Diabetes. Comparative Physiology

Books Recommended:

S.No.	Author	Book
1	Linda S. Costanzo	Physiology: Board Review Series
2	William Ganong	Review of Medical Physiology (Lange Basic Science)
3	Guyton and Hall	Physiology Review
4	Appleton and Lange	Review of Physiology
5	Linardakis	Illustrated review of Physiology
6	C Guyton	Textbook of Medical Physiology

B 603: Plant Physiology

Unit-I

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

Unit-II
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
Photosynthesis: The Carbon Reactions
Inorganic Carbon-Concentrating Mechanisms: CO2 and HCO3 – 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 C2 Oxidative Photosynthetic Carbon Cycle
Carbon Dioxide: Some Important Physicochemical Properties
Three Variations of C4 Metabolism
Single-Cell C4 Photosynthesis, Photorespiration in CAM plants
Glossary of Carbohydrate Biochemistry, Starch Architecture
Fructans, Chloroplast Phosphate Translocators

Photosynthesis: Physiological and Ecological Considerations
Working with Light, Heat Dissipation from Leaves: The Bowen Ratio
The Geographic Distributions of C3 and C4 Plants
Calculating Important Parameters in Leaf Gas Exchange
Prehistoric Changes in Atmospheric CO2
Projected Future Increases in Atmospheric CO2
Using Carbon Isotopes to Detect Adulteration in Foods
Reconstruction of the Expansion of C4 Taxa

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

Unit-III
Respiration and Lipid Metabolism
The Q-Cycle Explains How Complex III Pumps Protons across the Inner Mitochondrial Membrane, Multiple Energy Conservation Bypasses in Oxidative Phosphorylation of Plant Mitochondria, FoF1-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

Assimilation of Mineral Nutrients
Development of a Root Nodule, Measurement of Nitrogen Fixation
The Synthesis of Methionine, Oxygenases

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

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

Unit-IV
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 micro RNASensitive Mechanism
During Senescence Photoactive Chlorophyllide Is Converted into a Colorless Chlorophyll Catabolite
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
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
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
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
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
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
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

Unit-V
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
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

Books Recommended:

S.No.	Author	Book
1	Hans Mohr, Peter Schopfer	Plant Physiology; Springer, 629 pages
2	Taiz and Zeiger	Plant Physiology; 4th Edition. Sinauer
3	Hopkins WG	Introduction to Plant Physiology. 2nd or 3rd Edition
4	Stern KR	Introductory Plant Biology. 7th Ed. Wm C Brown Publishers
5	Fosket	Plant Growth and Development: A molecular approach. Acad. Press. More details on how plants grow and develop.
6	Buchanan R, Gruissem W and	Biochemistry and Molecular Biology of

	Jones R	Plants
7	Chrispeels MJ and DE Sadava	Plants, Genes and Crop Biotechnology. 2nd Ed. Jones and
8	Bartlett	Understanding plant biology and the potential of agricultural biotechnology

B 604: Microbiology

Unit-I

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.

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.

Unit-II

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.

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. Signal transduction in bacteria

Unit-III

Evolution of Prokaryotic Diversity - Evolution, diversity, and genomics of prokaryotic microorganisms, Enrichment, isolation, and molecular phylogenetic characterization of selected prokaryotic organisms. Prokaryotic Diversity - Structure, biochemical properties, and genetics of the major groups of prokaryotes.

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

Unit-IV

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

Medical Mycology and Parasitology - Consideration of medically important fungi and parasites, with emphasis on their biology in relation to disease and its laboratory diagnosis.

Unit-V

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.

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.

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.

Books Recommended:

S.No.	Author	Book
1	Thomas D Brock	Brock's Biology of Microorganisms
2	Patrick R Murray	Medical Microbiology: with STUDENT CONSULT Access
3	John M Barry	The Great Influenza: The Story of the Deadliest Pandemic in History
4	Alfred E Brown	Benson's Microbiological Applications: Laboratory Manual in General Microbiology (Spiral-bound)
5	Ananthanarayan and Paniker Orient Blackswan	Textbook of Microbiology: Medical microbiology

CB601: Biophysical Chemistry

Unit-I

Physical properties of water: Structure, water as solvent, The hydrophobic effect, osmosis and Diffusion. Introduction to Biomolecules: Nucleic Acid, Protein - Polymer Description of Macromolecular Structure, Intermolecular and Intramolecular forces, Non Covalent Interaction

Unit -II

Hydrodynamic properties: Diffusion and sedimentation, determination of molecular weight from sedimentation and diffusion; Introduction of Ultra Centrifugation, Dynamic Light Scattering and Electrophoresis.
Spectroscopic properties of proteins and nucleic acid: UV/Vis, Intrinsic fluorescence, Circular Dichroism

Unit -III

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

Unit -IV

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

Unit -V

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

Books Recommended:

S.No.	Author	Book
1	Tinoco, Sauer, Wang & Puglisi	Physical Chemistry: Principles and Applications in the Biological Sciences
2	Peter Atkins and Julio de Paula	Physical Chemistry for the Life Sciences

H 601 Ethics of Science and IPR

Unit-I

Introduction – causes of unethical acts, ignorance of laws, codes, policies and Procedures, recognition, friendship, personal gains; Bioethics: Definition – moral, values, ethics; Role and importance of ethics in biology; Professional ethics – professional conduct

Ethical decision making, ethical dilemmas; Teaching ethical values to scientists, good laboratory practices, good manufacturing practices, laboratory

Basic Approaches to Ethics; Posthumanism and Anti-Posthumanism;

Bioethics: legal and regulatory issues;

Unit-II

Bioethics in healthcare, agriculture, modern biology, biotechnology, animal welfare & right / animals in research, wildlife conservation and management, commercialism in scientific research

Bioethics and cross-cultural bioethics – Autonomy, Rights, Beneficience, Do No Harm, Justice, Confidentiality, Animal Rights, Environmental ethics, Decision-Making Perceptions of Ethical Biotechnology 'Moral' is not the same as Ethical, Mixed Perception of Benefit & Risk, Reasoning behind Acceptance or Rejection of Genetic Manipulation, Concerns about Consuming products of GMOs.

Past and Present 'Bioethical Conflicts' in Biotechnology- Interference with Nature , Fear of Unknown, Regulatory Concerns, Human Misuse Future 'Bioethical Conflicts' in Biotechnology - Changing perception of Nature, Human Genetic Engineering

Unit-III

Ethical issues related to Synthetic bilogy:

Engineering DNA-based biological circuits, including but not limited to standardized biological parts;

Defining a minimal genome/minimal life (top-down); Constructing protocells, i.e. living cells, from scratch (bottom-up), Creating orthogonal biological systems based on a biochemistry, e.g. non-ATGC DNA bases or non-DNA non-RNA nucleic acids, so called XNA

Unit-IV

Introduction to IPR; Types of Intellectual property – Patents, Trademarks

Copyrights and related rights; Traditional vs. Novelty; Importance of intellectual property rights in the modern global economic environment, Importance of intellectual property rights in India; IPR and its relevance in biology and environmental sciences;

Case studies and agreements - Evolution of GATT and WTO and IPR provisions under TRIPS;

Madrid agreement; Hague agreement; WIPO treaties; Budapest treaty; Indian Patent Act (1970)

Unit-V

Patents: Definition, patentable and non patentable inventions; types of patent application – Ordinary, Conventional, PCT, Divisional, and Patent of addition; Concept of Prior Art; Precautions while patenting disclosure / nondisclosure; Time frame and cost; Patent databases, Searching International databases; Patent licensing and agreement; Patent infringement – meaning, scope, litigation, case studies. Patenting rules – European Scenario, US Scenario, Australia Scenario, Indian Scenario, Non Patentable IP and Patentable IP in Indian Patent Act

Rights of patents – Infringement of patent rights Remedies for infringement of patent rights; Patentability and emerging issues

Books Recommended:

S.No.	Author	Book
1	Lesk	Introduction to Bio Informatics, OUP
2	Cynthia Gibas and Per Jambeck,	Developing Bioinformatics Computer Skills
3	Atwood, Pearson Education	Introduction to Bioinformatics
4	Tisdall, SPD	Beginning Perl for Bio-informatics
5	Smith, D.W., 1994	Biocomputing: Informatics and Genome Project
6	Baxevanis, A.D., Quellette, B.F.F.,	Bioinformatics: A practical Guide to the Analysis of Genes and Proteins

BL 601: Biology Laboratory
(Animal Physiology + Plant Physiology +Immunology + Microbiology+ Bioinformatics)

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) ELISA - 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

4. Bioinformatics:

DNA sequence analysis using BLAST; sequence pattern, motifs and profiles.
Prediction of secondary structure of proteins
Prediction of tertiary structure of (fold recognition, homology search)
Molecular modeling and dynamics: using small oligonucleofides and small protein with known crystal structure (available from data bank)
Drug designing – using available data Applications of bio informatics – open ended / small project.

FOURTH YEAR

Semester – VII [July – December 2018]

B 701: Neurobiology

Unit-I

The glial system: Generation of Astrocytes, Oligodendrocytes, and Schwan cells. Function of glia in normal brain and in neuroprotection.
Chemical composition of the brain: metabolism (utilization and uptake of glucose and amino acids).
Blood-Brain barrier.

Unit-II

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.

Unit-III

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

Unit-IV

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.

Unit-V

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

Books Recommended:

S.No.	Author	Book
1	Ferdinand Hucho	Neurochemistry
2	MP Spiegel	Basic Neurochemistry
3	Koenig and Edward	Cell Biology of the Axon, Series: Results & Problems in Cell Differentiation, Vol. 48
4	Eric Kendel, JH Schwartz, T Jessel	Principles of neural Sciences
5	A Guyton and J Hall	Textbook of medical Medical physiology

B 702: Immunology-II (Immunity and Disease)

Unit-I

Host-Pathogen relationship
Diseases caused by Viruses and the immune response to them- HIV and AIDS-immune responses

Unit-II

Bacterial diseases – and the immune response to bacteria
Vaccines- mechanisms, types of vaccines

Unit-III

Parasites – protozoan parasites, parasitic worms and the immune response to them- eg malaria, leishmaniasis, worm infestations

Unit-IV

Immediate Hypersensitivity and allergy, anaphylaxis
Hypersensitivity and chronic inflammatory diseases- tuberculosis and leprosy
Cancer immunology

Unit-V

Autoimmune diseases- generalized- SLE, Rheumatoid arthritis; localized- multiple sclerosis
Diseases due to immune cross reactivity- Rh incompatibility, transfusion, transplantation
Inherited immune diseases

Books Recommended:

S.No.	Author	Book
1	Charles A Janeway, JP Travers, Mark Walport and Mark J Shlomchik	Immunobiology, 5th edition; The Immune System in Health and Disease
2	Baron S, Galveston	Medical Microbiology; 4th Edition; University of Texas Medical Branch at Galveston
3	RA Goldsby *et al.*	Kuby's Immunology
4	E Benjamini, R Coico and G Sunshine	Immunology- A short Course
5	Roitt, Brostoff and Male	Immunology
6	William Paul	Fundamentals of Immunology
7	Tizard	Immunology
8	Abbas *et al*.	Immunology

B 703: Developmental Biology

Unit-I

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.
Fertilization: Structure of oocytes and spermatocytes. The process of fertilization.

Unit-II

Comparative study of early embryonic development: (*Caenorhabditis elegans*, amphibians, birds, and mammals), Cleavage formation, Gastrulation
Axis formation: Signaling cascades and molecular understanding of anteroposterior, mediolateral, and dorsoventral axes development.

Unit-III

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.
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.

Unit-IV

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.
Developmental disorders and aging: Regulatory role of genetic and environmental factors. Role of carcinogens and teratogens.

Unit-V

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.
Epigenetic and environmental control of development: Sexual dimorphism, sex determination, X inactivation. Environ-elicited phenotypic changes. Defense mechanism-related changes.

Books Recommended:

S. No.	Author	Book
1	Alberts *et al*.	Molecular Biology of the Cell
2	SF Gilbert	Developmental Biology
3	Lewin Benjamin	Gene VIII

4	PO Moody	Introduction to Evolution, 1970,
5	Dobzhansky et al.	Evolution, W. H. Freeman. New York
6	SW Fox and K Dose	Molecular Evolution and the Origin of Life,
7	FJ Ayala and JW Valentine	Evolving: The theory and processes of Organic evolution
8	EO Dodson	Evolution: Process and Product
9	MW Strickberger	Evolution, 1979, James and Barlett International

B 704: Imaging Technology in Biological Research

Unit-I

The power of ten (understanding how small cells and the sub-cellular contents are)
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)

Unit-II

Fundamentals of illumination (ray diagrams, types of light sources, LEDs, power levels, coherence of light, elliptical reflectors)
Exploring microscopes (short history, magnifying glass, simple and compound microscopes, electron Microscopes, stereomicroscope)

Unit-III

Fluorescence microscopy (Understanding fluorescence, Fluorescence protein technology, GFP, YFP)
two-photon fluorescence microscopy, matrix-assisted laser desorption/ionization mass spectrometry (MALDI-MS) imaging

Unit-IV

Live cell imaging (confocal microscopes), Differential interference contrast (DIC) images
Comparing Confocal and Widefield Fluorescence Micro scopy
Atomic force microscopy and optical tweezers force spectroscopy

Unit-V

NMR Imaging

Spatially nonresolved NMR spectroscopy; low-field NMR instruments; ^{1}H-nuclear magnetic resonance (NMR) microimaging ; ^{1}H-magic angle spinning NMR spectroscopy; MAS-^{13}C NMR spectroscopy
Spectral-resolution enhancement using magic angle spinning

Books Recommended:

S.No.	Author	Book
1	Ulf Grenander, Y Chow and Daniel M Keenan	Hands: A Pattern Theoretic Study of Biological Shapes (Research Notes in Neural Computing) (Volume-2)
2	Valery V Tuchin, Lihong Wang and Dmitry A Zimnyakov	Optical Polarization in Biomedical Applications (Biological and Medical Physics, Biomedical Engineering)
3	RM Lambrecht	Biological Models in Radiopharmaceutical Development (Developments in Nuclear Medicine)
4	Michael D Powers and Janet Poland	Asperger Syndrome and Your Child: A Parent's Guide
5	Philippe Sansonetti	Bacterial Virulence: Basic Principles, Models and Global Approaches (Infection Biology (VCH)
6	Richard Nuccitelli, Leslie Wilson and Paul T Matsudaira	A Practical Guide to the Study of Calcium in Living Cells, Volume 40 (Methods in Cell Biology)
7	Warren CW Chan	Bio-Applications of Nanoparticles (Advances in Experimental Medicine and Biology)
8	Bertram Manz, Kerstin Mu¨ ller,	Water Uptake and Distribution in Germinating

	Birgit Kucera, Frank Volke, and Gerhard Leubner-Metzger	Tobacco Seeds Investigated in Vivo by Nuclear Magnetic Resonance Imaging. Plant Physiology, July 2005, Vol. 138, pp. 1538–1551

Semester – VIII [January – June 2019]

B 801: Virology

Unit-I
Introduction to Virology: definition, properties and origin of viruses
Virus architecture and nomenclature
Virus replication cycle
Basic virological methods
Basics of virus entry, spread and transmission

Unit-II
Host resistance to viral infection: immune responses
Vaccines and antiviral chemotherapy: the prevention and treatment of viral diseases
Epidemiology
Exploiting viruses as gene therapy and vaccine vectors

Unit-III
Viruses and cancer: oncoviruses and oncolytic viruses
Polioviruses and other single-stranded positive-strand RNA viruses
Rabies and other single-stranded nonsegmented negative-strand
Influenza viruse and ther single-stranded segmented negative-strand RNA viruses.

Unit-IV
Evolution of viruses: new and reemerging viruses
Herpesviruses (nuclear large double-stranded DNA viruses)
Poxviruses (cytoplasmic large double-stranded DNA viruses)
HIV and other retroviruses

Unit-V
Hepatitis B virus (reverse-transcribing DNA virus) and other viruses causing hepatitis
Prion diseases
Plant viruses
Bacteriophages

Books Recommended:

S.No.	Author	Book
1	L Collier, J Oxford and Paul Kellam	Human Virology (4th edition),
2	SJ Flint, LW Enquist, VR Racaniello and AM Skalka	Principles of Virology (3rd edition) 2009
3	AJ Cann	Principles of Molecular Virology,
4	Teri Shors, Jones and Bartlett	Understanding Viruses
5	NJ Dimmock, A Easton, K Leppard	Introduction to Modern Virology 6th edition,
6	David M Knipe, Peter M Howley, MD Diane E Griffin, Robert A Lamb, Malcolm A Martin, Bernard Roizman, Stephen E Straus	Field’s Virology. 6th edition

7	AJ Zuckerman, JE Banatvala, P Griffiths, B Schoub and P Mortimer	Principles and Practice of Clinical Virology (6th edition)
8	G Kudesia and T Wreghitt: Cambridge Clinical Guide	Clinical and Diagnostic Virology
9	L. Sompayrac	How Pathogenic Viruses Work;

B 802: Biotechnology-I

Unit-I

Basic principles of genetic engineering:
Methods of creating recombinant DNA molecule, splicing, properties of restriction endonucleases and their mode of action. 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

Unit-II

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]

Unit-III

Transgenic plants [Agrobacterium mediated transformation, Ti plamid, Transgenic tobacco expressing luciferase gene, Bt Cotton, Herbicide-resistant plants, Plant viruses as vectors (eg CaMV virus)]. Application of genetic engineering in medicine and agriculture, vaccine production.

Unit-IV

Chemical synthesis of gene and engineering artificial life . Selection/screening: Analysis of genomic DNA by Southern hybridization, Northern and Western blotting techniques, Restriction mapping: Restriction fragment length polymorphism (RFLP). DNA sequencing and analyses techniques: plus and minus, dideoxynucleotide, Maxam and Gilbert, deep sequencing and next gen sequencing, microarray technology and hybridisations.

Unit-V

DNA manipulation techniques:
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. 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.

B 804: Biotechnology-II

Unit-I

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. Ethics of GM crops and animal cloning . Model organisms - S. cereviceae, Dictostylium, Caenorhabditis elegans, Arabidopsis, Zebra Fish, Mouse, Drosophila

Unit-II

Industrial Biotechnology-I

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

Unit-III

Industrial Biotechnology-II

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

Unit-IV

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

Unit-V

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.

Books Recommended:

S.No.	Author	Book
1	Benjamin Lewin	Gene VII, Oxford Publishers
2	T A Brown	Genome, Second edition,
3	Old and Primrose	Principles of Gene Manipulation;
4	Simmons and Gardner	Principles of genetics;
5	Donald Voet and Judith Voet	Biochemistry 3rd Edition,
6	T D.Watson and others	Molecular Biology of the Gene , 6th Edition
7	GM 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
9	Lodish H and Berk	A Molecular cell biology;
10	Sambrook J, Russell	Molecular cloning:- Vol I, II , III; CSHL Press
11	TA Brown	Gene cloning and DNA analysis;
12	B Glick, J Pasternak & C Patten	Molecular Biotechnology- principles and applications of Recombinant DNA, 4th
13	K. Deb and Satish Totey	Stem Cells Basics and Applications;
14	Gary Stein and Maria B et al.	Human Stem Cell Technology and Biology;

15	R. Ian Freshney, Glyn N. Stacey, Jonathan M. Auerbach	Culture of Human Stem Cells. John Wiley & Sons
16	Bernard R Glick, Jack J Pasternak, Cheryl L Patten	Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press
17	Robert Lanza, Robert Langer, Joseph P Vacanti	Principles of Tissue Engineering
18	Inderbir Singh and GP Pal	Human Embryology; MacMillan Publishers
19	Thomas W Sadler	Langman's Medical Embryology;
20	F Gilbert	Developmental Biology; 6th Edition;
21	Gordana Vunjak-Novakovic, R Ian Freshney	Culture of Cells for Tissue Engineering;
22	SB Primrose and Twyman	Principles of gene manipulation
23	RW Old and SB Primrose	Principles of gene manipulation
24	Watson	Recombinant DNA
25	TA Brown	Gene cloning and DNA analysis
26	SC Rastogi *et al.,*	Bioinformatics-Methods and Applications
27	A Caldwell et al.,	Integrated Genomics; Wiley Publishers
29	D Clark, N Pazdernik	Bioprocess Technology- Biotechnology- Applying the genetics to revolution
30	Wulf Crueger and Anneliese Crueger	Biotechnology: A Textbook of Industrial Microbiology; Panima Publishers, New Delhi
31	Michael L Shuler, Fikret Kargi	Bioprocess Engineering: Basic concepts
32	Stanbury PF, Whitaker A, Hall SJ	Principles of Fermentation Technology; Butterworth-Heinemann
33	Glazer AN and Nikaido H	Microbial Biotechnology: Fundamentals of Applied Microbiology
34	Sulabha Kulkarni	Nanotechnology principles and practices;
35	David S Goodsell	Bionanotechnology: Lessons from Nature;
36	James A Schwarz, Cristian I Contescu and Karol Putyera	Dekker Encyclopaedia of Nanoscience and nanotechnology;

B 803: Bioinformatics

Unit-I

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)

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.

Unit-II

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.

Unit-III

Biological databases**:** Introduction to variety of data sources. Population, sample, Classification and modeling of Data. Quality of data, Private and public data sources.

Example Databases:
(a) Nucleic acid databases (NCBI, DDBJ, and EMBL). (b) Protein databases (Primary, Composite, and Secondary) (c) Specialized Genome databases: (SGD, TIGR, and ACeDB) (d) Structure databases (CATH, SCOP, & PDBsum)

Unit-IV

Alignment: Basics and techniques, Local alignment and Global alignment Pairwise sequence alignment: NEEDLEMAN and Wunsch algorithm, Smith and Waterman algorithm, The Dot Plot, Dynamic Programming Algorithm. Multiple Sequence Alignment (MSA): Definition, Objective, Consensus, Methods for MSA: Heuristic approach, Dynamic programming approach and their combinations. Complexity analysis. Phylogenetic Analysis: Molecular-Phylogenetics, Phylogenetic-trees, Terminology of tree-reconstruction, rooted and un-rooted trees, gene vs species trees and their properties. Algorithms /methods of phylogenetic analysis: UPGMA, Neighbor-Joining Method.

Unit-V

Protein structure analysis and prediction: Identification/assignment of secondary structural elements from the knowledge of 3-D structure of macromolecule using DSSP and STRIDE methods , Prediction of secondary structure: PHD and PSI-PRED method Tertiary (3-D) Structure prediction: Fundamentals of the methods for 3D structure prediction (sequence similarity/identity of target proteins of known structure, fundamental principles of protein folding etc.) Homology Modeling, fold recognition, threading approaches, and ab-initio structure prediction methods. Genomics: Basic concepts on identification of disease genes, role of bioinformatics-OMIM database, reference genome sequence, integrated genomic maps, gene expression profiling; identification of SNPs, SNP
database (DbSNP). Role of SNP in Pharmacogenomics, SNP arrays
Drug discovery and Development : - Introduction to Drug Design and Development, Drug targets, Lead Identification and Modification, Computer-Aided Drug Design, Drug Delivery, Pre-clinical and Clinical Testing Applications of Bioinformatics: Pharmaceutical industries, immunology, agriculture, forestry; Legal, ethical and commercial ramifications of bioinformatics; Bio-sensing

Books Recommended:

S.No.	Author	Book
1	E Wayne W Daniel	Biostatistics: A foundation for Analysis in the Health Sciences
2	Prem S Mann	Introductory Statistics. 5th Edition;
3	Olive Jean Dunn	Basic Statistics: A primer for Biomedical Sciences
4	Auram Gold Stein	Biostatistics: An introductory text
5	Taro Yamane	Statistics: An Introductory Analysis;
6	C Stan Tsai	Computational Biochemistry;

FIFTH YEAR

Semester – IX [July – December 2019]

BPr 901 Research Project*

Note: Project Work*

The project has to be carried out in recognized national laboratories or UGC-recognized universities. No student will be allowed to carry out project work in private laboratories/ college/ institutions, excluding the colleges recognized as research centers by the RDC of Pt. Ravishankar Shukla University, Raipur.

Semester – X [January – June 2020]

E 1001	**Elective I**
E 1002	**Elective II**
E 1003	**Elective III**
E 1004	**Elective IV**

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

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Center for Basic Sciences
(CBS)
SCHEME OF EXAMINATION
&
COURSE STRUCTURE
Of
SEMESTER IX and X
M.Sc. Integrated (Biology Stream)
UNDER
FACULTY OF LIFE SCIENCE
EFFECTIVE FROM JANUARY 2020

Center of Basic Science
Pt. Ravishankar Shukla University
Raipur (C.G.) 492010
PH: - 0771-2262864
WEBSITE: -www.prsu.ac.in

Approved by Board of Studies in Bio Science
Pt. Ravishankar Shukla University, Raipur (C.G.)

CENTER FOR BASIC SCIENCES
Pt. Ravishankar Shukla University, Raipur

5-Year Integrated M.Sc. Biology
Under
Faculty of Life Science

SEMESTER-IX (Biology Stream)

Project (BPr901) Evaluation Scheme

20 Credits

		Marks
1.	Project Report/Dissertation (Certified by the Supervisor of the Institute)	150
2.	Seminar based on Project	150
3.	Viva-Voce based on Project report and Seminar	100
	Total Marks	400

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CENTER FOR BASIC SCIENCES
Pt. Ravishankar Shukla University, Raipur

5-Year Integrated M.Sc. Biology
Under
Faculty of Life Science

SEMESTER-X (Biology Stream)

Subject		Subject Contact hrs/per week Theory+Tutorial	Credits
BE 1001	Electives I	[4 + 1]	5
BE 1002	Electives II	[4 + 1]	5
BE 1003	Electives III	[4 + 1]	5
BE 1004	Elective IV	[4 + 1]	5
		Total	20

Min. 20
(Total 240 credits)

*Any four papers out of the available seven papers (as mentioned in the next pages) shall be in operation on availability of the instructors with more than 50% of students opting for them.

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Electives for X Semester-Biology Stream

1. Proteomics and Genomics

Unit-I

Introduction and scope of proteomics; Protein separation techniques: ion exchange, size-exclusion and affinity chromatography techniques; Polyacrylamide gel electrophoresis; Isoelectric focusing (IEF); Two dimensional PAGE for proteome analysis; Image analysis of 2D gels.

Unit-II

Introduction to mass spectrometry; Strategies for protein identification; Protein sequencing; Protein modifications and proteomics; Applications of proteome analysis to drug.

Unit-III

Protein-protein interaction (Two hybrid interaction screening); Protein engineering; Protein chips and functional proteomics; Clinical and biomedical application of proteomics; Proteome database; Proteomics industry.

Unit-IV

Introduction and Classification of genomics; Methods of preparing genomic DNA; Genome sequencing methods (next-generation sequencing); Databases of genomes; Genetic mapping; Mapping of human genome; Human genome project; HapMap Project, The 1000 genome project, and The ENCODE Project.

Unit-V

Gene variation and Single Nucleotide Polymorphisms (SNPs); Expressed sequenced tags (ESTs); Gene disease association; DNA fingerprinting; Microarray based techniques for RNA analysis; metagenomics.

Suggested readings:

1. Cantor and Smith, Genomics, John Wiley & Sons, 1999.
2. Introduction to Genomics - Arthur M Lesk, Oxford University Press, 2007.
3. R.M.Twyman, Principles of Proteomics, BIOS Scientific Publishers, 2004.
4. P.Michael Conn, Handbook of Proteomic Method. Humana Press, Totowa, New Jersay, USA, 2003.
5. L.Stryer, Biochemistry, W. H. Freeman and Co., New York, 2007.

2. Nanobiotechnology

Unit-I

The nanoscale dimension and paradigm, Various definitions and Concept of Nano-biotechnology, Historical background, Development. Fundamental sciences and broad areas of Nanobiotechnology.

Unit-II

Nanomaterial in biotechnology - nanoparticles, quantum dots, nanotubes and nanowires etc. Cell – Nanostructure interactions. Protein-based Nanostructures, Cell as Nanobio-machine,

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DNA-Protein Nanostructures-Overview and introduction, DNA-Protein conjugates in microarray technology.

Unit-III

Biosensors; molecular recognition elements, transducing elements. Applications of molecular recognition elements in nanosensing of different analytes, Application of various transducing elements as part of nanobiosensors.

Unit-IV

Miniaturized devices in nanobiotechnology - types and applications, lab on a chip concept. Biological nanoparticles production - plants and microbial, methods, Properties, Characterization and applications.

Unit-V

Nanobiotechnological applications in health and disease - infectious and chronic. Nanobiotechnological applications in Environment and food - detection and mitigation.

Suggested readings:

1. Nanobiotechnology: Concepts,Applications and Perspectives (2004), Christof M.Niemeyer (Editor), Chad A. Mirkin (Editor), Wiley VCH.
2. Nanobiotechnology - II more concepts and applications. (2007) - Chad A Mirkin and Christof M. Niemeyer (Eds), Wiley VCH.
3. Nanotechnology in Biology and Medicine: Methods, Devices, and Applications.

3. Plants for Human Welfare

Unit-I

A general overview of economically important plants and their role in human welfare as food, oil, drugs, nutraceuticals, fuel. Food crops: Cereals; Spices and condiments; Alcoholic and non-alcoholic beverages.

Unit-II

Medicinal: Traditional plants as source of drugs against several diseases such as cancer, diabetes, malaria, dengue, psoriasis,etc. Plant secondary metabolites; classification, knowledge of extraction, isolation, characterization and elicitation of bioactive metabolites.

Unit-III

Nutraceuticals and functional foods; Important plants such as Aloe vera, Piper, Withania, Ginseng, Amaranthus etc. yielding antioxidants and nutraceutical compounds. Edible and non-edible oils: Oil yielding plants, transgenic approaches and constraints for improvement in different oils. Essential oils.

Unit-IV

Plant-based biofuels e.g., Difference between first and 2nd generation biofuels, Jatropha, Pongamia, Zea mays, Madhuca, etc. Extraction and economic viability; application as alternate source of diesels, Bioelectricity.

Unit-V

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Plants as a source of timber: e.g., Tectona grandis, Salix sp., Dalbergia sisso, Fibre yielding plants: Cotton (Gossypium sp.), Jute (Corchorus sp.) with special reference to their improvement through breeding and genetic transformation e.g., Bt cotton.

Suggested readings:

1. Glossary of Indian medicinal plants, R.N.Chopra, S.L.Nayar and I.C.Chopra, 1956. C.S.I.R, New Delhi.
2. The indigenous drugs of India, Kanny, Lall, Dey and Raj Bahadur, 1984. International Book Distributors.
3. Herbal plants and Drugs Agnes Arber, 1999. Mangal Deep Publications.
4. Acharya, Deepak; Anshu, Shrivastava (2008). Indigenous Herbal Medicines: Tribal Formulations and Traditional Herbal Practices. Jaipur, India: Aavishkar Publishers
5. Raven, Peter H.; Evert, Ray F.; Eichhorn, Susan E. (2005). Biology of Plants (7th ed.). New York: W. H. Freeman and Company

4. Plant Genetic Engineering

Unit-I

Plant transformation vectors and methods: T-DNA and viral vectors; Selectable marker and reporter genes, Plant transformation by Agrobacterium sp., Molecular mechanism of T-DNA transfer; in planta transformation; Direct gene transfer methods in plants.

Unit-II

Genetic engineering for increasing crop productivity by manipulation of Photosynthesis, Nitrogen fixation, Nutrient uptake efficiency. Genetic engineering for biotic stress tolerance (Insects, fungi, bacteria, viruses, weeds). Genetic engineering for abiotic stress (drought, flooding, salt, metal and temperature)

Unit-III

Genetic engineering for quality improvement of Protein, lipids, carbohydrates, vitamins & mineral nutrients, Plants as bioreactor, Marker-assisted selection of qualitative and quantitative traits. Concept of gene synteny, Concept of map-based cloning and their use in transgenics.

Unit-IV

Chloroplast transformation; Transgene analysis, silencing and targeting; Marker-free and novel selection strategies; Multigene engineering; Gene knock-down by ribozymes, antisense RNA and RNA interference.

Unit-V

Plant Metabolic Engineering. The concept of secondary metabolites, Historical and current views, Importance of secondary metabolites in medicine and agriculture, Introduction to various pathways, Flavanoid pathway, Terpenoid pathway, Polyketoid pathway, Plant vaccine.

Suggested readings:

1. Plant Tissue Culture: Theory and Practice Bhojwani S. S. & Razdan M. K. Elsevier
2. Plant Biotechnology: The Genetic Manipulation of Plants Slater A. Scott N. & Fowler M. Oxford University Press Inc.

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3. Plants, Genes and Crop Biotechnology Chrispeels M. J. & Sadava D. E. Jones and Barlett Publishers
4 Principles of Gene Manipulation and Genomics Primrose S. B. & Twyman R. M. Blackwell Publishing.
5. Plant Cell, Tissue and Organ Culture: Fundamental Methods. (Eds). Gamborg O. L & Phillips G. C. Springer-Verlag.

5. Evolutionary Biology

Unit- I

Origin of life: Historical theories and background information. Experimental approaches. Chemogeny, Biogeny, RNA and DNA world, evolution of proteins, origin of photosynthesis, evolution of eukaryotes. Lamarckism, Darwinism, pre-Darwinian and post-Darwinian period, Neo-Darwinism. Theories of organic evolution. Evidences of Evolution.

Unit- II

Sources of variations: Heritable variations and their role in evolution. Natural selection: types of natural selection (Directional, stabilizing and disruptive) and examples (Industrial melanism, Australian rabbits, resistant to pestiscides, heavy metal resistance in plants), Sexual selection, group and kin selection,

Unit- III

Polpulation genetics and evolution: Hardy-Weinberg Law (statement and derivation of equation, application of law to human Population); Evolutionary forces upsetting H-W equilibrium. Genetic Drift (mechanism, founder's effect, bottleneck phenomenon); Role of Migration and Mutation in changing allele frequencies.

Unit-IV

Evolution above species level: Adaptation, adaptive radiation, microevolution, macroevolution, megaevolution, punctured equilibria and related phenomenon. Isolation: Introduction and types of isolation. Speciation: species concept, modes of speciation: allopatric, sympatric

Unit-V

Origin and evolution of man, Unique hominin characteristics contrasted with primate characteristics, primate phylogeny from Dryopithecus leading to Homo sapiens, Phylogenetic trees, Multiple sequence alignment, construction of phylogenetic trees.

Suggested readings:
1. S. Freeman and J. C. Herron, *Evolutionary Analysis*, 4th Edn., Benjamin-Cummings (2007).
2. D. J. Futuyma, *Evolution*, 2nd Edn., Sinauer Associates Inc. (2009)

6. Plant-Microbe Interaction

Unit-I

History of Plant pathology and recent developments: Significance of plant diseases, and pathology, types of plant-microbe associations (pathogenic– bacteria, virus, fungi, and symbiotic).

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Unit-II

Beneficial Plant - Microbe interactions (molecular aspects): a. Nitrogen fixing bacteria and blue green algae b. Mycorrhizal association c. Phytohormones and Biocontrol antibiotics

Unit-III

Parasitism and disease development: Pathogenecity, host range of pathogens, disease cycle and epidemics.

Unit-IV

Molecular biology of pathogenicity: Mechanisms of variability in pathogens, pathogenicity genes and mechanisms in pathogenic bacteria, biotrophic and necrotrophic fungi, Virus and Viroid genes involved in pathogenicity, Agrobacterium and plant interaction-a model system.

Unit-V

Molecular genetics of plant disease susceptibility and resistance: Types of plant resistance to pathogens (R gene resistance, quantitative and monogenic), basal and induced defense mechanisms, pre-formed inhibitors of pathogens, gene for gene interaction in plant defense, Systemic Acquired Resistance (SAR) and Induced Systemic Resistance (ISR), Recognition mechanism and signal transduction during plant - pathogen interaction.

Suggested readings:

1. Plant Pathology Agrios G. N. Academic Press
2. Molecular Plant pathology Dickinson M. BIOS Scientific Press
3. Plant Pathogenesis and Resistance: Biochemistry and Physiology of Plant-Microbe Interactions Jeng-Sheng H. T Kluwer Academic Pubs.T Gen 904(ii)- MEDICA

7.Animal Tissue Culture

Unit-I

Introduction and significance of Animal cell culture, historical background of cell culture. Types of cell culture: Primary and secondary cell culture.

Laboratory requirements for animal cell culture: Sterile handling area. Sterilization of different materials used in animal cell culture, Aseptic concepts. Instrumentation and equipments for animal cell culture.

Unit-II

Culture requirements and reagents: Culture media, properties of media, Types of cell culture media, Ingredients of media, Physiochemical properties, Antibiotics, growth supplements, Foetal bovine serum; Serum free media, Trypsin solution, Selection of medium and serum, Conditioned media, Other cell culture reagents, Preparation and sterilization of cell culture media, different types of serum and other reagents.

Unit-III

Types of cell culture: Different types of cell cultures, Trypsinization, Cell separation,Continuous cell lines, Suspension culture, Organ culture.

Cell lines: Introduction, development of cell lines, Characterization and maintenance of cell lines, stem cells, Cryopreservation, Common cell culture contaminants.

Unit-IV

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