

PONDICHERRY UNIVERSITY



Biochemistry & Molecular Biology

CURRICULUM / SYLLABUS

2015-2016 ONWARDS

Puducherry - 605014, India

PONDICHERY UNIVERSITY
SCHOOL OF LIFE SCIENCES
DEPARTMENT OF BIOCHEMISTRY AND MOLECULAR BIOLOGY

Admission Process

Selection of students to M. Sc. Programs is based on National Level Entrance Examination conducted by Pondicherry University at 40 different centers in the country. The test consists of objective type questions in Biochemistry, Molecular Biology, Zoology, Botany, Chemistry, Biophysics, Microbiology, Genetics, Physiology and allied areas. Students desirous to join Ph.D. Program also have to take the National level Entrance exam and based on their merit in the rank list, are entitled to receive the University Research Fellowship. Project Fellows desirous of registering for the Ph.D. program need to appear for the Entrance Examination. In addition, UGC/CSIR- NET qualified students are admitted directly to the Ph.D. program.

Curriculum goals/Objectives: The curriculum of this Department incorporates classical to recent concepts within different areas of each subject offered, and updates syllabus with periodic revision exercises, ensured by the Board of Studies and ratified through the School Board. The curriculum is made with a view to impart fundamental and advanced knowledge in the field of Biochemistry and Molecular Biology to students admitted from diverse academic backgrounds. The theory and practical sessions augment their ability to understand the implications of the scientific and technical approaches involved in this domain of knowledge, enabling to mold them into prospective skillful scientific workforce for the future. Project/dissertation being soft core course is offered to limited number of students based on their performance till 3rd Semester to obtain exposure for research career.

EVALUATION

The student assessment followed in this department is as per the regulations notified by the Office of the Controller of Exams, Pondicherry University.

All subjects in the PG program carry an internal assessment component (40%) and an End Semester External component (60%). Each teacher is expected to organize continuous assessment modes for each course assigned to him/her. The internal assessment is categorized into 30 marks for internal tests/term papers and 10 marks for Seminars/Assignment/ Presentation/Write ups/Viva, etc. There is double evaluation of answer scripts for the end semester exams. Where the difference in evaluation is more than 15% of marks, the answer paper shall be revalued by an Examination Committee. Students are expected to secure at least 40% marks in the end semester external component and 50% marks (sum of the internal and the end semester external marks) for passing the course. Students who have failed due to insufficient attendance (less than 70%) and / or secured less than 40% in internal assessment marks should repeat the course as when it is offered. Performance of students in each paper is expressed in terms of marks as well as in letter grades. A student is not permitted to repeat any course only for the purpose of improving the grade. The grades are arrived at by dividing the difference between the highest mark secured and the minimum pass mark by 6 (as there are six passing grades). The formula is as given below:

$K = (X-50)/6$ where, K= class interval, X= the highest mark in the subject.

GRADING

TABLE I

Range of Marks in %	Letter Grade	Points for Calculation of GPA/CGPA
X to (X-K)+1	A+	10
(X-K) to (X-2K)+1	A	9
(X-2K) to (X-3K)+1	A-	8
(X-3K) to (X-4K)+1	B+	7
(X-4K) to (X-5K)+1	B	6
(X-5K) to 50	C	5
Below 50	F	0
Failure due to lack of attendance	FA	0

K should not be rounded off to less than two decimal places. The numbers given in range of Marks column, (X-K), (X-2K), (X-3K), etc., can be rounded off to the nearest whole number.

In courses where the number of students who have secured 50 marks and above is less than 10 then grading may be given based on Table II.

TABLE II

Range of Marks in %	Letter Grade	Points for Calculation of GPA/CGPA
81-100	A+	10
71-80	A	9
66-70	A-	8
61-65	B+	7
56-60	B	6
50-55	C	5
Below 50	F	0

The GPA and CGPA will be calculated as weighted average of points secured by the student in all papers registered. The weights are number of credits for each paper. For example, a student getting an A grade in 4 credit course, A- grade in 2 credit course, A+ grade in a 3 credit course and F grade in a 3 credit course will have a GPA as $(9 \times 4 + 8 \times 2 + 10 \times 3 + 0 \times 3) / (4 + 2 + 3 + 3) = (36 + 16 + 30 + 0) / 12 = 82 / 12 = 6.83$ out of 10.0; GPA = 6.83. The CGPA shall also be calculated in similar lines including all the subjects taken by a student in all semesters. Students with CGPA of 9.0 and above, without fail in any of the courses taken shall be awarded distinction. A CGPA of 6.0 and above shall be placed in first class. Students who secure less than 50% marks in any paper get F grade and are treated as failed in the particular paper.

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SYLLABI FOR M. Sc. BIOCHEMISTRY AND MOLECULAR BIOLOGY
(Applicable from Academic Year 2015-16 Onwards)

CODE	NAME OF THE COURSE	CREDIT	PAGE NO.
FIRST SEMESTER			
BMB 418	CELL BIOLOGY	3	1
BMB 420	BIOMOLECULES & BIOENERGETICS	3	2
BMB 421	ANALYTICAL BIOCHEMISTRY & BIOPHYSICS	3	3
BMB 422	HUMAN PHYSIOLOGY	3	4
BMB 423	ENZYMOLGY	3	5
BMB 471	BIOMOLECULES LAB	1	6
BMB 472	ENZYMOLGY LAB	1	6
BMB 473	CELL BIOLOGY LAB	1	7
BMB 474	HUMAN PHYSIOLOGY LAB	1	7
BMB 475	ANALYTICAL BIOCHEMISTRY & BIOPHYSICS LAB	1	8
SECOND SEMESTER			
BMB 424	METABOLISM & REGULATION	3	9
BMB 425	MOLECULAR ENDOCRINOLOGY	3	10
BMB 428	MOLECULAR BIOLOGY	3	11
BMB 429	PLANT BIOCHEMISTRY & BIOTECHNOLOGY	3	12
BMB 476	MOLECULAR BIOLOGY LAB	1	13
BMB 477	METABOLISM & REGULATION LAB	1	13
BMB 478	PLANT BIOCHEMISTRY & BIOTECHNOLOGY LAB	1	14

CODE	NAME OF THE COURSE	CREDIT	PAGE NO.
THIRD SEMESTER			
BMB 525	IMMUNOLOGY	3	15
BMB 526	GENETIC ENGINEERING	3	16
BMB 527	MOLECULAR GENETICS	3	17
BMB 554	GENETIC ENGINEERING LAB	1	18
BMB 556	IMMUNOLOGY LAB	1	18
FOURTH SEMESTER			
BMB 530	MOLECULAR BASIS OF CELLULAR DISORDERS	3	19
BMB 531	PROTEOMICS	3	20
<u>SOFT CORE COURSES</u>			
BMB 419	BIostatISTICS & SCIENTIFIC WRITING	3	21
BMB 426	GENERAL MICROBIOLOGY	3	22
BMB 427	CLINICAL BIOCHEMISTRY	3	23
BMB 479	GENERAL MICROBIOLOGY LAB	1	24
BMB 528	GENOMICS	3	25
BMB 529	STEM CELL & REGENERATIVE BIOLOGY	3	26
BMB 532	CANCER BIOLOGY	3	27
BMB 533	NEUROBIOLOGY	3	28
BMB 534	DEVELOPMENTAL BIOLOGY	3	29
BMB 575	PROJECT/DISSERTATION	4	--

Syllabus for Pre-Ph.D. Part I

RESEARCH METHODOLOGY	31
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UNIT- I

Dynamics of the eukaryotic cell- Molecules of life- Cellular evolution- assembly of macromolecules and Origin of life- integrated structural organization of prokaryotic and eukaryotic cells- Concept of a composite cell and Molecular composition of cells. 9 h

Biomembranes- Structural organization- Models of a plasma membrane, Membrane permeability- Transport across cell membranes- Transmembrane signals- Artificial membranes- liposome.

UNIT- II

Micro bodies-Peroxisomes, Glyoxysomes and Lysosomes and their functions. 6 h

The Cytoskeleton-microtubules and microfilaments.

The extracellular matrix-collagen, elastin, fibrillin, fibronectin, laminin and proteoglycans.

UNIT- III

Molecular organization and function of mitochondria- components of respiratory chain- Chemiosmotic theory- Kinetics of electron transport, ATP formation- uncouplers of oxidative – phosphorylation- mitochondrial DNA and Semiautonomy. 6 h

UNIT- IV

Endomembrane system- Endoplasmic reticulum- protein segregation- microsomes- functions of endoplasmic reticulum- Golgi complex and cell secretion- Protein glycosylation. 8 h

Ribosomes- Structural organization.

Nucleus- Internal organization- Nuclear pore complex- Nucleosomes, Chromatin.

UNIT- V

Cell cycle - Different stages of mitosis – significance of meiosis - Cohesins and condensins in chromosome segregation, Microtubules in spindle assembly, Structure of kinetoshore, centrosomes and its functions, Components in cell cycle control - Cyclin, CDKs, Check points in cell cycle, phase dependent cyclic CDK complexes. 7 h

Text Book:

1. Essential Cell Biology, 3rd edition, by Alberts *et al.*, Garland. Publishing Co., 2009.
2. Raven, P.H *et al.*, Biology, 7th edition Tata McGrawHill publications, New Delhi, 2006.

Suggested Reading:

1. Campbell NA and Reece JB. Biology, 8th edition, Pearson Benjamin Cummings, San Francisco. 2008.

UNIT- I

The chemical unity of life: chemical bonding and interactions– synthesis and cleavage of covalent bonds. Reactive species– electrophiles, nucleophiles and radicals. Types of organic reaction and mechanism (SN¹, SN², E1, E2). Properties of water– ionization of water, K_w– weak acids and weak bases – pH, pKa– buffers– Henderson Hasselbalch equation. 5 h

UNIT- II

Carbohydrates: Monosaccharides– Stereochemistry, optical activity, specific reactions– Disaccharides– Oligosaccharides– Sugar derivatives. Homo- and hetero-polysaccharides structures and functions. Glycoproteins– Proteoglycans– Glycosaminoglycans– structures and biological functions. Bacterial cell wall polysaccharides– blood group substances and Sialic acid. Sugar code– Lectins types and functions. 7 h

UNIT- III

Proteins and Amino acids: Amino acids classification and chemistry. Proteins– primary structure– sequence determination– Ramachandran plot– peptide synthesis (automated solid phase), secondary– tertiary– quaternary– super secondary structures. Globular and fibrous proteins structures and functions (triple helix collagen, keratin, haemoglobin and myoglobin). Protein folding and dynamics– Molten globule state– Molecular chaperones– HSPs. Denaturation (pH, temperature, chaotropic agents) – refolding. 7 h

UNIT- IV

Lipids and Nucleic acids: Lipids classification– structure and chemical properties– saturated and unsaturated fatty acids. Structure and functions of phospholipids– glycolipids– sphingolipids– lipid soluble vitamins. Types and functions of plasma lipids. Arachidonic acid– Structure and biological functions of prostaglandins, thromboxanes and leukotrienes. Nucleic acids types (A, B and Z forms – Chemistry and structural organization)–supercoiling– triple helix of DNA. DNA denaturation and renaturation– hyper and hypochromicity - T_m. Secondary and tertiary structure of RNA– hnRNA– siRNA– miRNA. 9 h

UNIT- V

Bioenergetics: Principles, Laws of thermodynamics and their applications in biological system– internal energy, entropy, enthalpy, standard free energy changes, redox potential, standard reduction potentials, membrane potential, emf. Electron transport chain– role in electron capture and energetics. ATP and high energy phosphate compounds– Thermodynamics of coupled reaction. Carbon, oxygen, nitrogen cycles catabolism– food chain and energy flow. Bioluminescence. Energy terms and balance in macromolecular conformations and intermediary metabolism (outline of TCA cycle and glycolysis). 8 h

Text Book:

1. Nelson.D.L, Cox. M. M. Lehninger's .Principle of Biochemistry. 6th ed. Freeman, 2009
2. Voet and Voet. Biochemistry.4th edition, John Wiley, 2010.

Suggested Reading:

1. Berg.J.M, Tymoczko.J.L, Stryer, L. Biochemistry. 6th- ed. Freeman, 2006.
2. D.A. Harris. Bioenergetics at a glance. John Willey and Sons Ltd, 1995.

BMB 421 ANALYTICAL BIOCHEMISTRY & BIOPHYSICS 3 CREDITS

UNIT- I

Electrochemical techniques & Photometry- basic principles- The pH electrode- Ion-selective- gas- sensing and oxygen electrodes- Elementary details of biosensors. 5 h

Principles and techniques of colorimetry & spectrophotometry-Beer-Lamberts Law -instrumentation - qualitative and quantitative methods of analysis-protein estimation methods- hypo and hyper chromicity- coupled assays - Fluorimetry - Atomic absorption Spectrometry- Circular Dichroism (CD) - Optical Rotary Dispersion (ORD). 5 h

UNIT- II

Microscopy- basic principles and applications –Light – Compound – Phase contrast – Dark Field - Fluorescence Microscopy Scanning Electron Microscopy (SEM)-Transmission Electron Microscopy(TEM) - Scanning Tunneling Microscopy- (STM) - Confocal Microscopy. 5 h

UNIT- III

Centrifugation- basic principles - instrumentation - centrifugation units - types of centrifuges-rotors-accessories- colloids-centrifugation methods - sedimentation velocity-sedimentation equilibrium-cell fractionation methods. 5 h

UNIT- IV

Chromatography & Electrophoresis - types of chromatography - column, thin layer, paper, adsorption, partition, gas liquid ion exchange, affinity, HPLC- principles of each type- instrumentation and accessories- detection methods & systems-qualitative and quantitative aspects-applications; types of Electrophoresis - paper and gel- agarose and PAGE - pulsed field-capillary - isoelectric focusing- blotting techniques - western- southern & northern- application methods in life sciences and biotechnology. 10 h

UNIT- V

Radioactivity- types of radioisotopes- half life- units of radioactivity- uses of radioisotopes in life sciences & biotechnology- detection and measurement techniques - liquid scintillation counting- solid state counting- Geiger counter - Radiation hazard& laboratory handling methods.. 6 h

Text Book: 1. Freifelder D. M. Physical Biochemistry- Application to Biochemistry and Molecular Biology, 2nd ed., W.H. Freeman, 1982.

2. Principles and Techniques of Biochemistry and Molecular Biology, ed, Keith Wilson & John Walker, March 2010, Cambridge Univ Press.

Suggested Reading:

1. West & Todd. Biochemistry. 4th ed. Oxford and IBH.
2. Horst Friebolin. Basic One and Two-dimensional spectroscopy. VCH Publ, 1991
3. Murphy D. B. Fundamental of Light Microscopy & Electron Imaging. 1st ed. Wiley-Liss, 2001.

BMB 422**HUMAN PHYSIOLOGY****UNIT I**

Introduction- Internal environment and homeostasis- coordinated body functions. 9 h
Digestion- digestive processes at various regions of digestive system, regulation of -
gastric secretion and motility- intestinal secretion and motility-role of gastrointestinal
hormones.

UNIT II

Cardiophysiology- functional anatomy of heart- genesis and spread of cardiac 7 h
impulses- cardiac cycle- heart sound- cardiac output- cardiovascular regulatory
mechanisms- basic E.C.G.

UNIT III

Respiratory physiology- functional anatomy of air-passages and lung- respiratory 6 h
muscles- mechanism of respiration- lung volumes and capacities- gas exchange in
the lungs- regulation of respiration.

UNIT IV

Renal physiology- structure of nephron- glomerular filtration- tubular reabsorption 6 h
and secretion- formations of urine- regulation of water and mineral excretion-
counter current multiplier and exchanger- renal role in acid base balance.

UNIT V

Nerve physiology-Structure of neuron and synapse- excitability- action potential- 8 h
conduction of never impulse-synaptic transmission- neurotransmitter systems.
Muscle physiology- skeletal and smooth muscle- electrical properties and ionic
properties- types of muscle contraction- Neuromuscular transmission.

Text Book:

1. Pal, G.K. Textbook of Medical Physiology, Ahuja Publishing House, Delhi, 2007
2. Hall. J.E. Guyton and Hall Textbook of Medical Physiology. 12th ed. Saunders, Elsevier Inc., 2011.

Suggested Reading:

1. Barrett KE, Brooks HL, Boitano S and Barman SM, Ganong's Review of Medical Physiology, 23rd Ed., McGraw-Hill Medical, 2009.

UNIT- I

Introduction to Enzymes- Historical perspective- Nomenclature and Classification of Enzymes – Properties of Enzymes, Enzyme Activity and Units, Specific Activity, Catalytic Power and Specificity, Lock and Key Theory, Induced Fit Model, Transition State and Strain Theory of Enzyme Action. 3 h

Enzyme kinetics- Factors affecting enzyme activity- Michaelis-Menten equation- Catalytic Efficiency - Analyses of kinetic data- Lineweaver-Burk plot- Eadie Hofstee, Hanes Woolf, and Cornish Bowden Plots - Haldane relationship - Hill's Plot - Scatchard Plot. 5 h

UNIT- II

Bi-substrate Reactions- Sequential – Ping-Pong reactions- rate equations, examples – Differentiating Bi-substrate Mechanisms. 3 h

Enzyme Inhibition- Irreversible- Reversible- Competitive- Uncompetitive –Mixed and Non-Competitive inhibition- graphical analysis – Determination of K_i . 3 h

UNIT- III

Enzymatic Catalysis- Acid-Base Catalysis- Covalent Catalysis- Metal ion Catalysis- Electrostatic Catalysis- Catalysis through Proximity and Orientation effects- Catalysis by Transition State Binding, Coenzymes – NAD(P)^+ , FMN & FAD, CoA.SH, TPP, PLP, Biotin, THF, Methylcobalamin, Ascorbate, Menaquinone - Structure & Function. 4 h

Catalysis in Model Enzymes – Ribonuclease A – Chymotrypsin - Carbonic anhydrase – Carboxypeptidase A - Lysozyme. 4 h

UNIT- IV

Regulation of enzyme activity- Regulation by availability, Importance of Compartmentalization, Isoenzymes – Isoenzymes of Clinical Importance, Regulation by reversible covalent modification- proteolytic activation- Sequential, Concerted and Cumulative Feedback Control - Allosteric Control. 4 h

Allosteric enzymes- Monod, Wyman and Changeux Model - Koshland, Nemethy & Filmer Model of Allosteric Enzymes, Subunit interaction and regulation of enzyme activity in Aspartate transcarbamoylase. 3 h

UNIT- V

Applications of Enzymology – Enzyme purification – methods and strategies, test for catalytic activity – active site titrations – Immobilized enzymes- methods and applications in industry- medicine- enzyme electrodes – biosensors, Enzyme inhibitors as drugs. 7 h

Text Book:

1. Biochemistry by Donald Voet, Judith G. Voet. John Wiley and Sons. 2011.
2. Lehninger's Principle of Biochemistry by D. L. Nelson and M.M. Cox. 4th ed. Freeman, 2004
3. Enzymes: Biochemistry, Biotechnology, Clinical Chemistry by Trevor Palmer, Philip L.R. Bonner, 2nd Edition, Horwood Publishing Ltd, 2007.

Suggested Reading:

1. Fundamentals of Enzymology: Cell & Molecular Biology of Catalytic Proteins by Nicholas Price and Lewis Stevens, Third Edition, Oxford University Press. 1999.
2. Dixon & Webb. Enzymes. 3rd Edition Longmans, 1979.

BMB 471 BIOMOLECULES LAB**1 CREDIT**

1. Laboratory safety methods
2. Determination of Absorption Maximum
3. Verification of Beer-Lambert's Law
4. Preparation of Standard curve and estimation of protein by Biuret method.
5. Estimation of protein by Lowry's method
6. Isolation and estimation of DNA by Diphenylamine (DPA) method
7. Isolation and estimation of RNA by Orcinol method
8. Isolation and estimation of Casein in milk
9. Estimation of inorganic pyrophosphatase
10. Estimation of free proline by Bate's method
11. Estimation of cholesterol by Zak's method
12. Determination of the isoelectric point of amino acid.

REFERENCE

1. Introduction to practical Biochemistry. David T. Plummer
2. Nigam. 2007. Lab Manual Of Biochemistry. By. Tata McGraw-Hill Education, USA.

BMB 472**ENZYMولوجY LAB****1 CREDIT**

1. Estimation of enzyme activity.
2. Effect of pH on enzyme activity.
3. Effect of Temperature on enzyme activity.
4. Effect of substrate concentration on enzyme activity.
5. Determination of K_m & V_{max} of an enzyme.
6. Coupled enzyme assay.
7. Partial purification of enzyme and determination of specific activity.
8. Determination of catalytic efficiency.
9. Enzyme inhibition studies.

REFERENCE

1. Hans Bisswanger. Practical enzymology. 2nd ed. John Wiley & Sons, 2011.

BMB 473**CELL BIOLOGY LAB****1 CREDIT**

1. Observation of prokaryotic and eukaryotic cells with the help of light microscope.
2. Permanent slide preparation and preparation of slide for Dicot leaf section.
3. Assessment of plasma membrane function: 1) Selective permeability 2) Osmosis
4. Cell counting and viability (Yeast/Bacteria).
5. Mitosis and the cell cycle in Onion root-tip cell.
6. Isolation of mitochondria and assay for function.
7. Isolation of peroxisomes and assay for function.
8. Isolation of Goat RBC Plasma membrane and estimation of Na⁺/K⁺ ATPase.
9. Determination of osmotic fragility of cell (Goat RBC).

REFERENCE

Becker WM Kleinsmit, LJ, Hardin J, and Bertoni GP, 2009. The World of the Cell, seventh edition. Pearson/Benjamin-Cummings, Boston, MA.

BMB 474**HUMAN PHYSIOLOGY LAB****1 CREDIT**

1. Microscopy
2. RBC count & WBC count
3. Differential leucocyte count by Leishman' s staining
4. Estimation of Haemoglobin by Sahli's acid haematin method
5. Determination of Packed cell volume (PCV)
6. Determination of Erythrocyte sedimentation rate (ESR)
7. Determination of Coagulation time & Bleeding time
8. Determination of blood group
9. Determination of Blood Pressure by Sphygmomanometry

REFERENCE

G.K.Pal & P. Pal. 2006. Textbook of Practical Physiology. 2nd Edn. Orient Blackswan.

ANALYTICAL BIOCHEMISTRY & BIOPHYSICS LAB

BMB 475

1 CREDIT

1. Buffer preparation
2. pH titration
3. Protein purification by ammonium sulfate precipitation.
4. Molecular modeling using modeling kit.
5. Absorption spectra- UV-Visible.
6. Paper Chromatography of amino acids, carbohydrates, nucleic acid.
7. Ion exchange chromatography.
8. SDS Gel electrophoresis.

REFERENCE:

T S Work and E Work, 2009. Laboratory techniques in biochemistry and molecular biology. by Amsterdam, North-Holland Pub. Co.,

UNIT-I

General Introduction- Metabolism – Anabolism - Catabolism, Xenobiotic metabolism. **Metabolism of carbohydrates:** Glycolytic pathway, Gluconeogenesis pathway, Reciprocal regulation of gluconeogenesis and glycolysis. Pentose phosphate pathway, Citric acid cycle and its regulation, Glycogen synthesis and degradation, Regulation of glycogen metabolism. Cori's cycle. 8 h

UNIT-II

Metabolism of Lipids: Oxidation of fatty acids - Beta oxidation, alpha oxidation and omega oxidation, Oxidation of fatty acids with odd number of carbon atoms. Ketogenesis. Biosynthesis of saturated fatty acids and unsaturated fatty acids. Regulation of fatty acid biosynthesis. Biosynthesis of triacylglycerol and phospholipids. Cholesterol biosynthesis, transport and excretion, Regulation of cholesterol biosynthesis. 8 h

UNIT-III

Metabolism of Amino acids: Overview of biosynthesis of non-essential amino acids from amphibolic intermediates- Alpha- ketoglutarate, oxaloacetate, 3-phosphoglycerate. Glucose - alanine cycle, Urea cycle reactions. 8 h

UNIT-IV

Metabolism of Porphyrins: Biosynthesis and catabolism of Porphyrins - Heme-Bile pigments. **Metabolism of Purines and Pyrimidines:** Biosynthesis and catabolism of purines and pyrimidines. Regulation of purine and pyrimidine biosynthesis. 7 h

UNIT-V

Dietary Minerals: Sources and daily allowance. Biological roles of magnesium, sodium, potassium and phosphate trace elements. **Metabolism of iron:** Absorption, storage, transport and excretion. Iron deficiency and overload. **Genetic errors of metabolism:** Representative examples– Galactosemia, Phenylketonuria, Alkaptonuria, Albinism. 5 h

Text Book:

1. Nelson.D.L, Cox. M. M. Lehninger's. Principle of Biochemistry. 6th ed. Freeman, 2012.
2. Murray. R.K, Granner.D.K, Mayes. P. A, Rodwell. V. W. Harper's Biochemistry. 27th ed. McGraw Hill, 2006.

Suggested Reading:

1. Berg.J.M, Tymoczko.J.L, Stryer, L. Biochemistry. 6th ed. Freeman, 2006.
2. Zubay. Biochemistry. 4th ed. William C. Brown Publication, 1998.
3. Fundamentals of Biochemistry. Life at the molecular level (Fourth Edition) by Donald Voet, Judith G. Voet and Charlotte W. Pratt. Willey 2010.

UNIT -I

Definition and scope of Endocrinology- Historical and anatomical aspects of mammalian endocrine system. Definition of a hormone- chemical nature of mammalian hormones- types of hormone receptors- secondary messenger system- general mechanism of peptide and non- peptide hormones action. Feed-back regulation of Endocrine System. 7 h

UNIT -II

The Endocrines of Hypothalamus- Hypo-Physiotropic hormones- Neurovascular hypothesis. Pituitary gland hormones- chemistry and biochemical functions. Pineal gland hormones- chemistry- biochemical functions- mechanism of action. Thyroid gland hormones- chemistry- biochemical functions- mechanism of action. Parathyroid glands- biochemical functions. 7 h

UNIT -III

Adrenal gland: Hormones of adrenal gland- chemistry- mechanism of action- biochemical functions. Pancreas- Insulin/glucagon: chemistry- biochemical functions- mechanism of action. Somatostatin. Hormones involving in calcium metabolism- chemistry- mechanism of action. Neuro-hormones- the brain-renin-angiotensin, Urotensin- neuropeptides. 6 h

UNIT -IV

Hormones of female and male reproductive system: Ovarian steroid hormones- chemistry- biosynthesis and transport; Synthesis, chemistry and metabolism of androgens- dynamics of steroid hormone production and metabolism- mechanisms of action of sex steroid hormones. Testicular and ovarian determining genes – Mullerian-inhibiting substance genes- molecular basis of male and female contraception. 8 h

UNIT -V

Endocrinopathies: Hypo-physeal, Thyroid, parathyroid, adrenal and pancreas. Disorders of pituitary hormone axis- thyrotoxicosis- hypothyroidism- Hashimoto's thyroiditis- metabolic bone diseases- Cushing syndrome- Addison's diseases- Diabetes mellitus- androgen deficiency syndromes- Testicular neoplasm- Klinefelter's syndrome and Turner's syndrome. Clinical evaluation of endocrine functions-overview. 8 h

Text Book:

1. Henry M. Kronenberg, Shlomo Melmed, Kenneth S. Polonsky, P. Reed Larsen. William Textbook of Endocrinology, 11th ed. Saunders Elsevier 2008
2. Bolander, F. F. Molecular Endocrinology, III ed. Academic Press, 2004.

Suggested Reading:

1. Lehninger's Principle of Biochemistry.: Nelson Cox. 3rd ed. MacMillian Worth Publ. 2000.
2. Endocrinology: Mac E. Hadely. 5th ed. Pearson Education, 2000.

UNIT I

History and scope of molecular biology- Discovery of DNA- evidence for DNA as the genetic material. The genomes of bacteria, viruses, plasmids, mitochondria and chloroplast- Gene transfer in microorganisms- conjugation- transformation, transduction - protoplasmic fusion. 9 h

UNIT II

Organisation of eukaryotic genome- components of eukaryotic chromatin- chromatin and chromosome structure- DNA-supercoiling -linking number- satellite DNA-possible functions- Cot curve- C- value paradox. 5 h

UNIT III

DNA replication- Prokaryotic and eukaryotic DNA replication, mechanism of replication. Enzymes and necessary proteins in DNA replication. Telomeres, telomerase and end replication. Role of telomerase in aging and cancer. 9 h
DNA Repair- Mismatch, Base-excision, Nucleotide-excision and direct repair
DNA recombination- Homologous, site-specific and DNA transposition

UNIT IV

Transcription- Prokaryotic and eukaryotic Transcription- RNA polymerases- general and specific transcription factors- regulatory elements- mechanism of transcription regulation- Transcription termination. Post transcriptional modification- 5' cap formation-3' end processing and polyadenylation- splicing- editing- nuclear export of mRNA- mRNA stability. 8 h

UNIT V

Translation- Genetic code- Prokaryotic and eukaryotic translation- translational machinery- Mechanism of initiation- elongation and termination- Regulation of translation. 5 h

Text Book:

1. Watson. J. D, Baker. T. A, Bell. S. P, Gann. A, Levine. M, Losick. R. Molecular Biology of Gene. 6th The Benjamin / Cummings Pub. Co. Inc, 2008
2. Lehninger's Principles of Biochemistry, sixth Edition, 2009 Publisher: W. H. Freeman; 6th edition | ISBN: 071677108X

Suggested Reading:

1. Darnell, Lodish and Baltimore. Molecular Cell Biology, Scientific American Publishing Inc, 2000
2. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Molecular biology of the Cell. 4th ed. Garland publishing Inc, 2002
3. Benjamin Lewin. Gene VII. Oxford University Press, Nelson Cox.

BMB 429 PLANT BIOCHEMISTRY AND BIOTECHNOLOGY**UNIT- I**

Introduction to Plant cells

Photosynthesis: Chloroplast- structure and function; Photosynthetic pigments and light harvesting complexes, Photo inhibition of photosynthesis, Photosynthetic carbon reduction (PCR) cycle, C4 syndrome and Crassulacean acid metabolism. Oxidative respiration, Alternate electron pathways and Respiration rate. 8 h

UNIT- II

Nitrogen metabolism: Physical and biological nitrogen fixation, Ammonification, Nitrification, Denitrification, Biochemistry and Genetics of nitrogen fixation and Ammonium assimilation. 10 h

Plant Hormones: Biosynthesis, Physiological effects and mechanism of action of Auxins, Gibberellic acids, Cytokinins, Abscisic acid, Ethylene, Brassinosteroids and Polyamines.

UNIT- III

Plant Stress physiology: Plant stress, Plant responses to abiotic and biotic stresses, Water deficit and drought resistance, Flooding, Temperature stress, Salt stress, Ion toxicity, Pollution stress and potential biotic stress (insects and diseases). 6 h

UNIT- IV

Introduction to tissue culture-Media composition and preparation. 6 h
Culture types callus culture cell suspension culture, protoplast culture and etc., Somatic embryogenesis, organogenesis, Embryo culture and embryo rescue. Micropropagation.
Protoplast isolation, Protoplast culture and fusion, selection of hybrid cells, cybrids, somaclonal variation. Germplasm storage and cryo- preservation.

UNIT- V

Application of transgenesis in crop improvement – Insect resistance, disease resistance, virus resistance herbicide resistance, and resistance to abiotic stress. 6 h
Transgenesis for male sterility and terminator seed. Transgenic plant-Bt cotton, Bt brinjal, Plant genome-Rice

Text Book:

1. Mukherji, S and Gosh A. K. Plant Physiology. 2nd ed. New Central Book Agency, Kolkata, 2005.
2. Slater A, NW Scott, MR Fowler. Plant bio technology, 2nd ed. Oxford University Press, 2008.

Suggested Reading:

1. Hopkins, W. G and Huner, N. P. A. Introduction to Plant Physiology. 3rd ed. John Wiley & Sons Inc. New York, 2004.

BMB 476**MOLECULAR BIOLOGY LAB****1 CREDIT**

1. Isolation & purification of genomic DNA from bacteria
2. Isolation & purification of plasmid DNA
3. Spectrophotometric analysis of purity of isolated DNA
4. Agarose gel electrophoresis of genomic DNA
5. Agarose gel electrophoresis of plasmid DNA
6. Restriction digestion of chromosomal DNA
7. Restriction digestion of plasmid DNA
8. Isolation of DNA fragment from agarose gel

REFERENCE

J Sambrook & D. W. Russell (2001). Molecular cloning: a laboratory manual Vol 1, 2 & 3, CSHL Press.

BMB 477**METABOLISM AND REGULATION LAB****1 CREDIT**

1. Preparation of lactalbumin from milk
2. Estimation of reducing sugar by DNSA (dinitrosalicylic acid) method
3. Estimation of glucose by Benedict's method
4. Estimation of urea by Diacetyl monoxime method
5. Estimation of uric acid
6. Estimation of creatinine in urine
7. Estimation of cholesterol by ZAK's method
8. Estimation of calcium by Clarke and Collip method
9. Estimation of pyruvate by DPNH (2,4-dinitrophenylhydrazine) method

Reference:

Harold Varley, 1988, Practical Clinical Biochemistry, 6th edition, edited by H.Gowenlock with the assistance of Janet R. McMurray and Donald M. McLauchlan, Heinemann Medical in London

1. Plant tissue culture (Only demonstration-Report)
2. Isolation of chloroplast and estimation of total chlorophyll, chlorophyll a and chlorophyll b pigments from leaves.
3. Determination of Gibberllic acid in growing shoot.
4. Assay of starch hydrolysis in germinating seeds.
5. Test the different phytohormone in seed germination.
6. Determination of protein quantity under different stress conditions.
7. Estimation of starch content in plants grown in different stress conditions by Anthrone reagent.
8. Spectrophotometric estimation of Indole acetic acid in different plant tissues.

REFERENCE:

Sadasivam, S, and Manickam, A., (2001), Biochemical Methods, 3rd edition, New Age International Publishers, New Delhi

UNIT I

Introduction and Historic perspectives of Immunology: Types of Immunity – Innate, acquired; Basic defenses-physical and physiological, role of acute phase proteins, complements and interferons, PAMPs and PRRs-Toll like receptors; Acquired Immunity-natural, artificial, active and passive immunity; hematopoietic stem cells, myeloid and lymphoid lineage; Role of Granulocytes, macrophages –Phagocytosis and Inflammatory response. Humoral and Cell mediated immunity- types of B and T lymphocytes and their role in innate and adaptive immunity; primary and secondary immune response; Pathways of activation of complement cascade and their significance.

6 h

UNIT II

Organs and cells of Immune system- Primary and Secondary Lymphoid organs- development and maturation of T cells and B cells in primary lymphoid organs. Types and significance of MHC molecules; Role of professional antigen presenting cells-macrophages, dendritic cells; mechanism of antigen processing and presentation; B cell and T cell activation in secondary lymphoid organs.

6 h

UNIT III

Humoral Immunity- Antigens – nature of antigens, immunogenicity, antigenicity, epitopes; Immunoglobulins- Structure, types and biological functions; Molecular basis of antibody diversity- - arrangement of light chain and heavy chain genes, multiple germline gene segments, somatic gene rearrangement, somatic hypermutation and junctional diversity; T cell B-cell interaction and Class Switching; Antigen-Antibody reactions - mechanism of Ag-Ab interaction; principle and applications of tests based on Ag-Ab reactions-precipitation, agglutination, complement fixation, immunoelectrophoresis, RIA, ELISA, Western Blotting, and immunofluorescence techniques; Hybridoma technique - development of monoclonal antibodies and their applications

8 h

UNIT IV

Cell mediated Immunity -MHC restriction - T-cell receptors ;T-cell activation & differentiation into effector T cells; Tolerance mechanisms-central and peripheral tolerance- positive and negative selection, Clonal deletion and Clonal anergy; Lymphocyte recirculation; Functions of T cell subsets-TH1, TH2, CTLs - mechanism of killing by CTL and NK cells in antiviral and antitumor immunity; Role of Treg, lymphokines and cytokines in immune regulation; Vaccines- conventional vaccines- attenuated, killed and subunit vaccines; modern vaccines-recombinant vaccines, DNA vaccines and edible vaccines

8 h

UNIT V

Immunopathology -hypersensitivity reactions- types, causes and mechanism of immediate and delayed type reactions; Immunodeficiency diseases – types and causes; Autoimmunity - types and causes autoimmune diseases; Transplantation immunity- mechanism of graft rejection and prevention of graft rejection; Types and applications of immunosuppressive agents-physical, chemical and biological immunosuppressants.

8 h

Text Books:

1. Janeway' s Immunobiology 8th ed. Garland Science, Taylor & Francis Group, 2011
2. Kuby Immunology. 6th ed., W. H. Freeman & Company, 2007.

Suggested Reading:

Roitt's Essential Immunology. 11th ed. P. Delves, et al., ed., Blackwell Publishing, 2006,

UNIT I

History of genetic engineering. Enzymes used in genetic engineering: Restriction endonucleases, DNA polymerase, Reverse transcriptase, Polynucleotide kinase, DNA ligase, DNase, RNase, Terminal deoxynucleotidyl transferase, Alkaline phosphatase. Characteristics of *E. coli* as host for cloning, Basic design of a cloning vector, Vectors for cloning: Plasmids, Bacteriophage λ , Filamentous phage vectors, cosmids, BAC, YAC and HAC vectors, Shuttle vectors, Expression vectors, Gene expression based on bacteriophage T7 RNA polymerase. Specialist-purpose vectors. 7 h

UNIT-II

Cloning vectors used with *Bacillus subtilis*, Properties of yeast as host for cloning, Types of vectors designed for cloning in yeast, Vectors for cloning in animal cells– SV 40, Adenovirus, Baculovirus, Retrovirus vectors. Types of vectors used in higher plants – Caulimoviruses vectors, Geminiviruses vectors, *Agrobacterium tumefaciens* based Ti plasmid vectors. Ligation of DNA fragments– using DNA ligases, homopolymer tailing, linkers and adaptors. 7 h

UNIT-III

Gene transfer techniques: Introducing genes into prokaryotes - Natural gene transfer methods, Calcium chloride mediated transformation, Transfection with phage vectors. Methods of introduction of foreign DNA in animal system- DNA/calcium phosphate coprecipitate method, Phospholipids as gene-delivery vehicles, Electroporation, Microinjection, Microprojectile. Gene cloning strategies: Construction of genomic and cDNA libraries. Shot gun cloning. Selection and screening of recombinant clones- Methods based on nucleic acid hybridization- Colony hybridization, Plaque lift hybridization, Finding specific clones by functional complementation, Reporter genes. Studying of gene function through protein interactions-Two hybrid screening, Phage display libraries. 7 h

UNIT-IV

Techniques: DNA sequencing methods -Sanger sequencing method, Next generation sequencing methods– Pyrosequencing, Polony sequencing. Polymerase chain reaction and its applications, Different types of PCR (Hot start PCR, Multiplex PCR, Nested PCR, Real-time PCR, *In Situ* PCR, Inverse PCR, Reverse Transcriptase PCR, Methylation-specific PCR). Altering genes- Site-directed mutagenesis- Primer extension method for site directed mutation, PCR based site directed mutagenesis, Transposon mutagenesis, Random mutagenesis. DNA microarrays. Fluorescence *in-situ* hybridization. Analysis of DNA protein interactions- Electrophoretic mobility shift assay, Filter-binding assay, Chromatin Immunoprecipitation (ChIP) assay, DNase I Footprinting, Methylation Interference assay. DNA markers for genome analysis (RFLP, RAPD, AFLP, SNPs). 8 h

UNIT-V

Applications of recombinant DNA technology: Engineering microbes for the production of therapeutic proteins -insulin and growth hormones. Concept of gene knock out technique. Methods developed for the production of transgenic mice and applications of transgenic mice, Applications of recombinant DNA technology in forensic science. Gene Therapy- Gene silencing by RNA interference technology. Biotechnology: Ethical issues and necessity of bioethics. Basic concepts of IPR (Indian context). 7 h

Text Books:

1. Sandy Primrose. 2006. Principles of Gene Manipulation and Genomics. 7th Edition, By Black Well Publishers.
2. Brown T.A. 2004. Gene Cloning and DNA analysis. 2nd edition. By ASM press.

Suggested Reading:

1. Bernard R. Glick, Jack J. Pasternak, Cheryl L. Patten. 2010. Molecular biotechnology: Principles and applications of recombinant DNA, 4th edition, By ASM press.
2. Joseph Sambrook, David William Russell. 2001. Molecular cloning: a laboratory manual, Volume 3, 3rd edition, By CSHL Press, New York.

UNIT- I

Origin of life: Evolutionary biology and origin of life, classification of organisms- diversity of life, communities, relationship of organisms to environment- human impact and genetic variation.

7 h

Genome organization: Prokaryotes, eukaryotes, karyotype, viral genome-DNA & RNA virus, extrachromosomal genome-plasmids, mitochondria and chloroplast, repetitive elements-LINES and SINES.

UNIT- II

Mendelian and non-Mendelian inheritance Transmission Genetics: Chi square analysis, autosomal inheritance and molecular basis- -Mutations-molecular & phenotypic perspective-Population genetics: Hardy-Weinberg equilibrium.

7 h

Gene mapping: Linkage maps, tetrad analysis, mapping with molecular markers and using somatic cell hybrids.

UNIT-III

Microbial genetics: Structure of DNA and flexibility, primosome and replisome organization and function, D-loop replication, operons, positive and negative control, lac, ara and trp operon regulation, Methods of genetic transfers – transformation, conjugation, transduction, mapping genes by interrupted mating, Gametes-Genetics of Virus, Bacteria and yeast.

8 h

Mobile genetic elements: Discovery, simple and complex transposons, insertion sequence in prokaryotes, Transposons, complex transposons (Tn10, Tn5, Tn9 and Tn3 as examples), mechanisms and importance.

UNIT- IV

Genetic testing in individuals and populations-Direct testing-Gene tracking-Population screening-DNA profiling-DNA methylation & gene activity, chromatin modification, dosage compensation, X inactivation in Human female-Use of mouse embryonic stem, gene targeting and gene trapping

8 h

UNIT- V

Genetics of Cancer: Types, causes of DNA mutation, detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants.

6 h

Text Books

Introduction to Genetic Analysis: Griffiths et al. 10th edition, 2011

Principles of Genetics: D. Peter Snustad, Michael J. Simmon, 2008

Suggested Readings

Human Molecular Genetics, 4th Edition 2012 by Tom Strachan, Andrew Read

Human Molecular Genetics: 2010, Peter Sudbery.

BMB-554**GENETIC ENGINEERING LAB****1 CREDIT**

1. Culture of *E. coli* cells & plasmid isolation
2. Preparation of competent cells
3. Calcium chloride mediated transformation
4. Ligation of DNA
5. Polymerase chain reaction
6. Restriction fragment length polymorphism
7. Random amplified polymorphic DNA
8. Cloning of GFP protein

REFERENCE

Joseph Sambrook, David William Russell. (2001). Volume 3, Third edition, By CSHL Press, New York.

BMB 556**IMMUNOLOGY LAB****1 CREDIT**

1. Agglutination reactions- Active bacterial agglutination-Widal Test
2. Agglutination reactions- Passive agglutination -Latex agglutination Test
3. Precipitation reactions on gel-Double Immuno diffusion to check antigen cross reactivity
4. Single Radial Immuno Diffusion (SRID) to determine the quantity of an Antigen
5. Immunoelectrophoresis (IEP) of serum proteins
6. Preparation of antigens from microbes
7. Isolation of antigens by SDS PAGE
8. Isolation and partial purification of IgG fraction from immune serum by ammonium sulphate precipitation and ion exchange chromatography using DEAE cellulose
9. Detection of specific antigens by Indirect ELISA technique
10. Identification of specific antigens by Immunoblotting technique

REFERENCE: Gordon JR. A Practical Guide to cellular and Molecular Research Methods in Immunology, Fifth edition, Saskatchewan 2004.

BMB 530 MOLECULAR BASIS OF CELLULAR DISORDERS 3 CREDITS

UNIT- I

Inflammation and Repair/Wound healing: Acute inflammation-Vascular changes-cellular events-chemical mediators of inflammation-chronic inflammation-morphologic patterns in acute and chronic inflammation-systemic effects of inflammation-wound healing-mechanism of wound healing-pathologic aspects of inflammation and response. 6 h

UNIT- II

Hemodynamic disorders, Thrombosis & Shock: Edema-hyperemia and congestion-hemorrhage-hemostasis and thrombosis-endothelium-platelets-coagulation system-genesis of thrombosis-fate of thrombus-embolism-pulmonary, systemic, amniotic fluid, air and fat-infarction-septic shock. 5 h

UNIT- III

Red & White cell diseases: Normal development of blood cells-anemias-hemolytic-G6PD deficiency-sickle cell-thalassemias-paroxysmal nocturnal hemoglobinuria-megaloblastic-iron deficiency – chronic disease -aplastic-marrow failure-polycythemia-bleeding disorders-leukopenia-reactive proliferation of white cells –neoplastic proliferation of white cells-leukemias & myeloproliferative disorders - plasma cell dyscrasias. 7 h

UNIT- IV

Neoplasia & Transformation: Benign & malignant neoplasm-differentiation and Anaplasia-Invasion and metastasis-epidemiology of cancer incidence- molecular basis of cancer-biology of tumor growth-carcinogenic agents & their cellular interactions- hot defense against tumors-tumor antigens-antitumor effector mechanisms-immunosurveillance-immunotherapy-gene therapy of tumors. Environmental and Nutritional diseases: Magnitude of environmental problem-air pollution-chemical and drug injury-adverse drug reactions-exogenous oestrogens and oral contraceptives-carcinogens-street drugs-physical injuries-mechanical force-temperature related-hyperthermic injuries-pressure related-electrical and radiation injuries- protein calories malnutrition-nutritional excesses and imbalances-obesity-diet and systemic diseases. 15 h

UNIT- V

Hepatic disorders: Hepatic injury-Hepatitis a through E-Alcohol liver disease-Drug and toxin induced liver disease- cirrhosis- pregnancy associated-transplantation associated-adenomas and primary carcinoma. 7 h

Text Books:

1. Cotran, Kumar, Robbins. Pathological Basis of Disease. 8th ed. Prism, India. 2009.
2. William B. Coleman, Gregory J. Tsongalis, Molecular Pathology: The Molecular Basis of Human Disease). Elsevier Publication.

Suggested Readings:

1. Goodman & Gilman. Pharmacological Basis of therapeutics. 11thed, McGraw Hill 2006.
2. Zilva& Pannell. Clinical Biochemistry in Diagnosis & Treatment, Lloyd Luke Publications USA.

BMB 531**PROTEOMICS**

3 CREDITS

UNIT-I

Proteomics Introduction: Human genome - Genomes to Proteomes - HUPO – Branches of proteomics - Protein extraction Methods: Subcellular fractionation, Density gradients, Ultrafiltration, - Protein fractionation - Affinity purification – Combined Fractional Diagonal Chromatography (COFRADIC) - Removal of interfering compounds, salts, DNA, lipids, Protein solubilization methods, chaotropes, detergents, etc - Preparation of Sample - Sample handling and storage - Protein detection and quantification methods – Stable Isotope Labeling with Aminoacids in Culture (SILAC) - Chemical tagging, fluorescence, negative staining, radio-labeling – Chemical modifications.. 8 h

UNIT II

Structural Proteomics: Protein structure-function relationship – Disulfide bonds, Post translational modifications, Glycosylation, Phosphorylation, other modifications, Applications - methods for detection of protein-protein interactions - Yeast 1, 2 and 3 hybrid systems – Phage display – Surface Plasmon Resonance (SPR) - Fluorescence Resonance Energy Transfer (FRET) - Algorithms for proteomics –OMSSA - SEQUEST - MASCOT. 6 h

UNIT-III

Protein expression: Conjugation, Transformation, Transduction, Transfection - Expression Systems – Plasmids, E.Coli, Yeast, *Pichia pastoris*, Baculovirus - introduction, detection and purification of expressed transgenes - .antibody capture – antibody generation and Engineering – Protein/peptide chemical synthesis –Reconstitution of proteins in lipid vesicles, - Liposomes - Protein-polynucleotide interactions – Biotinylated reactions - Signaling complex. 8 h

UNIT-IV

Proteomic Techniques for Analysis: 2-D gel electrophoresis – Mass Spectrometry – Principles - MALDITOF - RP chromatography /Tandem mass spectrometry - Protein sequence analysis - N-terminal determination methods- Protein modification – Protein microarrays – Tissue microarray – Infra red Protein array with Quantitative Readout (IPAQ)- X-ray crystallography - Nuclear Magnetic Resonance - X-ray Tomography - Data Analysis algorithms - Sequence Analysis algorithms. 8 h

UNIT-V

Proteomic approach for Clinical studies: Protein Biomarker Discovery and Validation - Body fluid profiles, blood disease profiles, diabetes profiles, infectious diseases, stroke and myocardial infarction, nervous system, Alzheimer, low abundance and hydrophobic proteins. High through put techniques to identify protein molecules in sample - Emerging technologies: Proteomics in Biotechnology - Microfluidics. 6 h

Text Books

1. Twyman, R.M. Principles of Proteomics. BIOS Scientific Publisher, New York. 2004.
2. David O'Connor and David Homes, Proteomics, Scion Publishing Limited, Bloxham, Oxfordshire OX15 4FF.
3. Richard J. Simpson, Proteins and Proteomics: A laboratory Manual, Cold spring Harbor Laboratory Press, Cold Spring Harbor, New York.

Suggested Reading:

1. Westermeier, R and T. Naven. Proteomics in Practice: A Laboratory Manual of Proteome Analysis. Weinheim: Wiley-VCH, 2002.

BMB 419 BIostatistics & Scientific Writing
(Soft Core)

3 CREDITS

UNIT- I

Introduction- definition of statistics-population and universe- the sample and population- statistical inference- parameter and statistics
Handling of bulky data- construction a histogram- interpretation of histogram- the normal distribution- the mean-mode-and standard deviation- representing the normal curve as straight line- uncertainties in estimating a mean.

8 h

UNIT- II

Proportion data- Examples of Proportion data- MPM- sterility testing of medicines- animal toxicity- infection and immunization studies e.g., LD50, ED50, PD50 statistical treatment to proportion data- Chi-square test- goodness of fit to normal distribution.
Count data- Examples of count data (bacterial cell count, radioactivity count, colony and plaque count, etc.). Statistical treatment to count data- poisson distribution- standard error- confidence limits of counts.

11 h

UNIT- III

Analysis of variance- Introduction –procedure-F and t test.

4 h

UNIT- IV

Correlation regression and line fitting through graph points- standard curves- correlation- linear regression (fitting the best straight line through series of points)- standards curves and interpolations of unknown y-values thereon.

5 h

UNIT- V

Methodology for writing science report and oral presentation- compilation of experimental record- program of writing- use of vocabulary- use of good english-art of illustration- report writing- editing and correcting- technique of oral presentation.

7 h

Text Book:

1. Green. R. H. Sampling Design and Statistical Methods for Environmental Biologists .John Wiley & Sons, 1979.

Suggested Reading:

1. Snedecor G. W. & Cochran W. G. Statistical methods. 8th ed. Iowa State Press, 1989.
2. Thomas Glover, Kevin Mitchell. Introduction to Biostatistics. 1st ed. McGraw –Hill Science, 2001.
3. Matthews. Successful Scientific writing: A step-by- step Guide for Biomedical Scientists. 2nd ed. Cambridge University Press, 2001.
4. Jerrold H. Zar. Biostatistical Analysis. 4th ed. Pearson Education, 2006

UNIT I

History and Scope of Microbiology: Contributions of Antonvan Leeuwenhoek, Joseph Lister, Paul Ehrlich, Edward Jenner, Louis Pasteur, Robert Koch and Alexander Fleming ; spontaneous generation, germ theory of disease, Koch's postulates; Microscopy – lenses and bending of light; microscopic resolution; Microscopes- bright field, dark field, fluorescence, phase contrast and electron microscopes. Fixation and staining-principle and uses of simple staining-acidic and basic stains, differential staining-Gram's, negative and spore stains. 6 h

UNIT II

Microbial diversity: Carl Woese's three domain classification system. Major groups of bacteria- Archaeobacteria, Eubacteria- Bergey's Manual of Systematic Bacteriology – identification of bacteria based on phenetic, physiologic/metabolic characteristics and molecular phylogeny. Classification of Viruses; General account on major groups of Fungi, Protozoa and algae; Economic importance of fungi and algae. 6 h

UNIT III

Structure and functions of Prokaryotic cellular components- cell wall composition of Gram positive and Gram negative bacteria, cell membrane, Cytoplasm, nucleoid, plasmids, types of inclusion bodies, endospore formation, flagella, pili, capsule and slime layer; Types and replication of animal viruses-DNA, RNA viruses; bacteriophages - Lysogeny and Lytic cycle; virus like agents- satellites, viroids and prions. 8 h

UNIT IV

Bacterial growth; sterilization methods-physical and chemical methods-disinfectants antiseptic agents; Culture media - composition and uses of solid, liquid, simple complex, differential and selective media; continuous and synchronous culture bacterial growth kinetics; Effect of pH, temperature and radiation on growth Antimicrobial agents: antibacterial, antiviral antifungal antihelminthic and antiprotozoan drugs; development of antibiotic resistance in microbes 8 h

UNIT V

Major microbial diseases in humans: Respiratory diseases-diphtheria, tuberculosis, pneumonia, Influenza and mumps; Skin diseases-measles, chickenpox, human papilloma virus, herpes Virus and dermatophyte (tinea) infections; Diseases affecting GIT- Oral thrush, typhoid, cholera, shigellosis, amoebiasis, giardiasis, hepatitis and pathogenic *E. coli* infections; Genitourinary infections – Trichomoniasis, syphilis, HIV, candidiasis; Diseases caused by protozoan and helminthic parasites- malaria, filariasis, trypanosomiasis and leishmaniasis. 8 h

Text Books:

1. Prescott, Harley and Klein- Microbiology-7th edition; Publisher: McGraw Hill science 2007
2. Gerard J. Tortora, Berdell, R. Funke, Christine L. Case, , Microbiology: An Introduction. 11th edition, Publisher: Benjamin Cummings. 2012.

Suggested Reading:

Jacquelyn G. Black. Microbiology-Principles and explorations 8th edition: Publisher John Wiley & Sons 2012

UNIT – I

Automation in the clinical biochemistry: Precision, reliability, reproducibility and other factors in quality control. Values in health and diseases. 6 h

UNIT- II

Kidney function tests, osmolarity and free water clearances, acute and chronic renal failure. 8 h

Liver function tests: clinical features and test based on bile pigments level, plasma changes, SGOT, SGPT, prothrombin time.

UNIT- III

Disorders of carbohydrate metabolism: Diabetes mellitus, insulin receptors and c-peptide, assay of insulin, proinsulin and insulin antibodies. Hemoglobin A1c; fructosamines, insulin tolerance test. Glycogen storage diseases, galactosemia, fructosuria, pentosuria. 6 h

UNIT- IV

Prenatal Diagnosis: Newborn screening: PKU, cystic fibrosis and sweat tests. 8 h
Prenatal diagnosis of diseases, amniotic fluid and fetal blood examination.
Acetylcholinesterase and other tests on amniotic fluid.
Karyotyping, Chromosomal abnormalities by cytogenetics.

UNIT – V

Molecular diagnosis of genetic defects: DNA probes; restriction fragment length polymorphism (RFLP); polymerase chain reaction (PCR); amplification of mRNA. 8 h
Diagnosis of genetic diseases by molecular biology techniques (cystic fibrosis, Hemachromatosis, thalassemias, sickle cell diseases), Clinical diagnosis of AIDS.

Text Books

1. Handbook of Clinical Biochemistry, Swaminathan, R. 2nd ed. Oxford University Press; 2011.
2. Text book of Medical. Biochemistry, Chatterjee, M.N. and Rana Shinde, 8th ed. Jaypee Medical Publishers, 2012.

Suggested Reading

1. Tietz Fundamentals of Clinical Chemistry and Molecular Diagnostics, Carl A. Burtis, David E. Bruns. 7th ed. Elsevier, 2014.
2. Practical Clinical Biochemistry, Harold Varley, Interscience Publishers Inc, 2002
3. Clinical Chemistry: Theory, Analysis and Correlation. Kaplan, L.A. and Pesce, A.J., 4th ed. Mosby, 2003.
4. Lecture Notes Clinical Biochemistry (8th Edition). Simon Walker, S., Ashby, P. , Rae, P., and Beckett, G., Blackwell, 2010.
5. Textbook of Biochemistry With Clinical Correlations. Devlin, D.M., (Ed). Wiley-Liss, 2010.

1. Introduction to sterilization techniques- sterilization of glass wares, autoclaving.
2. Preparation of liquid and solid media
3. Isolation of Bacteria and fungi from soil samples – serial dilution technique
4. Establishment of pure cultures by spread plate, streak plate technique and pour plate techniques
5. Identification of bacteria by morphological and Biochemical characteristics
6. Smear preparation and staining of bacteria- simple staining, Grams staining and spore staining
7. Measurement of bacterial population by spectrophotometer and colony counting methods
8. Determination of Bacterial growth curve
9. *In vitro* antibiotic sensitivity tests for selected bacterial cultures
10. Methods for preserving microbial cultures: slant, glycerol stock and lyophilization

REFERENCE:

Cappuccino Sherman. Microbiology A Laboratory Manual, Sixth Edition. Pearson education, 2004.

Unit I

Overview of Genomics: Introduction to Genomics, Structural genomics; Organelle genome-mitochondria and chloroplast; C- value, number of genes and complexity of genomes, Comparative genomics, Concepts of metagenomics Conservation and diversity of genomes. 6 h

Unit II

The Genome project: History, organization and goals of human genome project, Strategies for sequencing genomes, Genetic and physical map, DNA segment nomenclature, Human genome diversity, Organization of human genome: Mitochondrial genome, Gene density, CpG islands, RNA-encoding genes, Functionally identical/similar genes, Diversity in size and organization of genes, Annotation. Human Microbiome Project, 16S rRNA analysis, Synthetic Genomes. 8 h

Unit III

Functional genomics -of microbes, plants and animals; transcriptome analysis methods, microarrays and serial analysis of gene expression. Basic concepts of identification of disease genes, gene silencing, role of bioinformatics-OMIM database, reference genome sequence, integrated genomic maps, gene expression profiling, identification of SNPs. 8 h

Unit IV

Molecular markers in genome analysis- for disease monitoring, Tools for genome analysis- RFLP, RAPD, AFLP, SSLPs, STR, EST and SNPs, Linkage and Pedigree, disease prognosis, genetic counseling. 6 h

Unit V

Pharmacogenomics: pharmacogenetics, cancer genomics; immunogenomics; somatic cell genomics; biochemical genomics; single cell analysis, genetics of globin triplet repeat disorders, polygenic inheritance; Effects of drugs in individual and susceptibility, Personalized medicine, Ethics and issues of synthetic life. 8 h

Text Books

1. Introduction to Genomics, Arthur M. Lesk, Oxford, 2nd ed. 2012.
2. Bioinformatics and Functional Genomics, Jonathan Pevsner, Wiley-Blackwell, 2nd ed. 2009.

Suggested Reading

1. Understanding the Human Genome Project, Michael A. Palladino, Benjamin Cummings, 2nd ed. 2005.
2. Concepts in Pharmacogenomics, Martin M. Zadanowicz, ASHP, 1st ed. 2010.
3. (2003). From Genes to Genomes. Dale & Schartz, Wiley. 2003.
4. An Introduction to Molecular Human Genetics. Pasternak. Fitzgerald. 2000.
5. Principles of Genome Analysis & Genomics. Primrose & Twyman Blackwell, 2003.

BMB 529 STEM CELL AND REGENERATIVE BIOLOGY 3 CREDITS
(SOFT CORE)

UNIT- I

Introduction – Definition and Criteria for Stem Cells; Pluripotent, Multipotent and Totipotent Stem cells; Primordial Germ Cells, Embryonic Stem Cells; Amniotic Fluid Derived Stem Cells; Cord Blood Stem Cells. 4 h

UNIT- II

Biology and Mechanisms – Molecular Basis of Pluripotency, Mechanisms of Self Renewal, Chromatin signature of pluripotent cells, Cell cycle regulators in Stem Cells; Stem Cell Niches, Change of Phenotype and Differentiation, Senescence of Dividing Somatic Cells, Aging and stem cell renewal, Quiescent Stem Cells. 8 h

UNIT – III

Tissue and Organ Development – Differentiation in Early Development, Potency, Commitment, Polarity and the specification of asymmetric divisions, induction, competence determination and differentiation, morphogenetic gradients, cell fate and cell lineages, Epigenetic silencing and lineage commitment; Cellular differentiation of the Nervous system, Neuronal and Glial Progenitors in Adult Brain, Epithelial Stem Cells; Adult Progenitor Cells, Mesenchymal Stem Cells, Plasticity; De-differentiation, Cancer Stem Cells. 8 h

UNIT – IV

Stem Cell Technology – Characteristics and Characterization of Human Pluripotent Cells; Fluorescence and Magnetic bead Assisted Cell Sorting, Derivation, Characterization and Maintenance of Murine and Human Embryonic Stem Cells, Differentiation of Embryonic Stem Cells; Derivation of Induced Pluripotent Stem Cells; Derivation and Differentiation of Human Embryonic Germ Cells; Genomic Reprogramming, Fate Mapping of Stem Cells. 8 h

UNIT – V

Stem Cells and Regenerative Medicine - Neural Stem Cells in Neurodegenerative Diseases; Hematopoietic Stem Cell Transplantation; Epithelial Stem Cells and Burns; Stem Cells and Heart Disease; Pancreatic Stem Cells and Diabetes; Liver Stem Cells and Cell Therapy for Liver Disease; Embryonic Stem Cells in Tissue Engineering, Stem Cell Banking, Ethical Concerns in Stem Cell Research. 8 h

Text Book:

Essentials of Stem Cell Biology, Third Edition – Edited by Robert Lanza and Anthony Atala. Academic Press, CA, USA (2013)

Stem Cell Biology - Edited by Daniel R Marshak, Richard L. Gardner and David Gottlieb. Cold Spring Harbor Press, NY, USA (2001)

Suggested Readings:

Stem Cell Now by Christopher Thomas Scott, Pearson Education, NJ, USA (2006).

UNIT – I

Introduction – Growth characteristics of cancers cells; Morphological and ultrastructural properties of cancer cells. Types of growth-hyperplasia, dysplasia, anaplasia and neoplasia. Nomenclature of neoplasms. Differences between benign and malignant tumors. Epidemiology of cancer. 5 h

UNIT- II

Cancer biology and biochemistry- Aberrant metabolism during cancer development; Paraneoplastic syndromes; Tumor markers; cellular protooncogenes- oncogene activation. 8 h
Growth factors-EGF, TNF- α and TGF- β and growth factor receptors–Signal transduction in cancer – Role of transcription factors.

UNIT- III

Carcinogenesis- radiation and chemical carcinogenesis- stages in chemical carcinogenesis- Initiation, promotion and progression. 8 h
Free radicals, antioxidants in cancer; Viral carcinogenesis -DNA and RNA Viruses and human cancer; Cancer endocrinology.

UNIT- IV

Cell Cycle Regulation-Tumor suppressor genes p53, p21, Rb, BRACA1 and BRACA2. Telomeres, Telomerase, and Immortality; cell- cell interactions, cell adhesion-invasion and metastasis - VEGF signaling, angiogenesis; Epigenetics-Role of DNA methylation in gene silencing- epigenetic silencing of tumor-suppressor genes; 10 h
Apoptosis in cancer-Cell death by apoptosis–role of caspases;
Death signaling pathways-mitochondrial and death receptor pathways.

UNIT- V

Strategies of anticancer drug therapy – chemotherapy - gene therapy. 8 h
Immunotherapy and Radiotherapy; Stem Cells and Cancer.

Text Book:

1. The Biological Basis of Cancer: R. G. McKinnell, R. E. Parchment, A. O. Perantoni, G. Barry Pierce, I. Damjanov. 2nd Edition, Cambridge University Press, 2006.
2. The Biology of Cancer: R. A. Weinberg. Garland Science. 2006.

Recommended Reading:

1. The Molecular Biology of Cancer: S. Pelengaris, M. Khan. Blackwell Publication. 2002
2. The Cancer Hand Book: Malcolm R. Alison. Nature Publishing Group. 2003

UNIT - I

Developmental Neurobiology: Organogenesis and neuronal multiplication, axonal and dendritic growth, glial multiplication and myelination, growth in size, regeneration and repair mechanisms, plasticity. 5 h

UNIT – II

Neuromorphology and neurocellular anatomy: Central nervous system – General features of neurons, cellular organization of neurons, Dendritis and Axons, neurotubules, neurofilaments, synapse neuralgia, astrocytes, oligodendrocyte, ependymal cells, Schwann cells. 10 h

Peripheral nervous system (PNS): Muscle, nerve endings, sensory receptor and effector endings; peripheral nerves, spinal and cranial nerves: Plexuses ganglia, afferent pathways and sense organs.

Spinal cord: Topographical anatomy, spinal nerves, spinal meninges, joint reflexes, gray and white matter of spinal cord.

UNIT- III

Neurotransmitters: Acetylcholine, Dopamine, Norepinephrine, Serotonin, Histamine, Epinephrine, Gamma-aminobutyric acid, Glycine, Glutamate, Aspartate, NO₂, and CO - Chemistry, synthesis, storage and release of neurotransmitters, transmitter action, synaptic modulation and mechanism of neuronal integration. Secondary Messengers: Importance of cyclic nucleotides and protein phosphorylations in nervous system. Involvement of protein kinases and calcium in neuronal metabolism. 12 h

Neuropeptides: Classes of neuropeptides, mode of action, role of neuropeptides in obesity and pain neuropeptide receptors.

UNIT- IV

Learning and Memory: Correlation of behavioral and biochemical events, measurement of learning and memory, agents affecting learning and memory, biochemical correlates of excitation, learning and behavior. 5 h

UNIT- V

Neurodegenerative diseases: Parkinson's, Alzheimer's disease, amyotrophic lateral sclerosis, senile dementia. Psychopharmacology and Biochemical theories of Mental Disorder: Chemistry of neuroleptics and anxiolytics, antidepressants, hallucinogenic agents, biochemical theories of mental disorders. 10 h

Text Books:

1. Basic Neurochemistry: Principles of Molecular, Cellular, and Medical Neurobiology (Eighth Edition, 2012, Elsevier Inc.) Edited by: Scott T. Brady, George J. Siegel, R. Wayne Albers and Donald L. Price. ISBN: 978-0-12-374947-5
2. Elements of Molecular Neurotoxicology: Smith C. U. M, 7th ed. 2003.

Suggested Readings:

1. Guyton and Hall Textbook of Medical Physiology: 12e (Guyton Physiology), 2010: John E. Hall | ISBN-10: 1416045740 | ISBN-13: 978-1416045748.
2. John E. Hall PhD (Author) Ganong's Review of Medical Physiology, 24th Edition, 2012 (Lange Basic Science): Kim E Barrett, Susan M. Barman, Scott Boitano, Heddwen L. Brooks. ISBN-10: 0071780033 | ISBN-13: 978-0071780032.
3. Neuroanatomy, 4th Revised edition, 2010 : Alan R. Crossman, David Neary. ISBN-10: 0702030864 | ISBN-13: 978-0702030864.

UNIT- I

The stages of animal development, Human spermatogenesis and oogenesis, 8 h
Structure of the human sperm and the egg, Molecular events during mammalian fertilization:
Action at a distance, Induction of the mammalian acrosomal reaction, Translocation and
capacitiation, Hyperactivation and chemotaxis, Fusion of genetic material in mammals,
Prevention of Polyspermy.

UNIT- II

An introduction to early developmental processes in mammals: The unique nature of 8 h
mammalian cleavage, Mammalian gastrulation, Formation of extra embryonic membranes,
Mammalian anterior-posterior axis formation, Mammalian dorsal-ventral and
left-right axes formation.

UNIT- III

Chromosomal sex determination in mammals: Primary and secondary sex determination, 8 h
Temperature-dependent sex determination in reptiles, Induction and competence.
Postembryonic development- Metamorphosis of frog: Morphological changes associated
with metamorphosis, Biochemical changes associated with metamorphosis,
Epimorphic regeneration of Salamander limbs.

UNIT- IV

Embryological origins of the gene theory, Mechanism of X chromosome inactivation, 6 h
Theories of ageing: Evolutionary theories of ageing, Integrated theory of ageing in the
nematode *Caenorhabditis elegans*.

UNIT- V

Properties of stem cells, Pluripotency of human embryonic stem cells, Embryonic stem cell 6 h
lines, Hematopoietic stem cells, Markers commonly used to identify stem cells, Embryonic
stem cells and their applications.

Text Books

1. Balinsky, B.I. An Introduction to Embryology. W. B. Saunders Publishing Company. 2004.
2. Scott F. Gilbert. Developmental Biology. Sinauer Associates, INC Publishers, Sunderland. 2000.

Recommended reading

1. Jonathan, M.W. Essential Developmental Biology. Wiley Blackwell Publishers, 1991.
2. Longo, F.J. Fertilization. Chapman and Hall publishers, New York. 1997.

*SYLLABUS FOR
Ph.D. DEGREE PROGRAMME*

Pre-Ph.D. Examination

PAPER I – RESEARCH METHODOLOGY

UNIT I - ANALYTICAL METHODS

9 h

Principle and techniques of UV-VIS spectrophotometry. Beer- Lambert's law – quantitative methods of analysis coupled – assays – Kinetics – Protein estimation methods. Spectrofluorimetry – Flame – Atomic absorption spectrophotometry

Microscopy basic principle and applications – Light – Compound – Scanning Electron Microscopy (SEM) - Transmission Electron Microscopy (TEM) – Scanning Tunneling Microscopy (STM) – Fluorescence Microscopy – Confocal Microscopy

Principles – Techniques and Applications of Electron Spin Resonance – Nuclear Magnetic resonance - Circular Dichroism (CD) – Optical Rotatory Dispersion (ORD)

UNIT II – GENOMICS AND PROTEOMICS

10 h

Introduction to Genomics – DNA/RNA isolation methods - Nucleic acid hybridization techniques – southern – dot blot analysis – Nucleus run on – DNA foot printing - amplification techniques – polymerase chain reaction - RT-PCR, Real Time RT – PCR techniques – DNA micro array.

Introduction – Purification methods – Centrifugation – basic principles – Centrifugation units – types of centrifuges – centrifugation methods – sedimentation velocity - sedimentation equilibrium – cell fractionation methods.

Chromatography – types – thin layer, paper, adsorption, partition, ion–exchange, affinity, Gas–liquid, - HPLC principles – instrumentation and accessories – detection methods, qualitative & quantitative aspects – applications. Protein electrophoresis – pulsed field – capillary – isoelectric focusing – blotting methods – application in Life Sciences & Biotechnology.

UNIT III – BIOSTATISTICS

8 h

Biostatistics – definition of statistics – population and universe – sample and population. Handling of bulky data – construction of histogram - interpretation of histogram – Normal distribution – Poisson's distribution – Mean, Median and Mode - Standard Deviation- Standard Error. Experimental Design – Clinical Research Designs, Randomized Block Designs.

Analysis of Experimental Results - Sampling distribution - Chi square test - student's T test, - ANOVA. Correlation regression and line fitting through graph points – standard curves – correlation – Linear regression analysis – fitting the best straight line through series of points. Proportion data – Examples of proportion data – Statistical treatment to Proportion data – MPM – LD50 - ED50 - PD50.

UNIT IV – BIOINFORMATICS AND COMPUTER APPLICATIONS

8 h

Computer Forms of biological information - Types of Nucleotide Sequence - Sequence databases: Nucleic acid sequence databases - Protein sequence databases: Uniprot-KB: SWISS-PROT, TrEMBL, UniParc; Sequence file formats: Various file formats for biomolecular sequences: GenBank, FASTA, GCG, MSF etc. Proteomics tools at the ExPASy server, GCG utilities and EMBOSS, Computation of various parameters

Sequence Analysis: Basic concepts of sequence similarity, definitions of homologues, orthologues, paralogues and xenologues - Basic concepts of sequence alignment: Measurement of sequence similarity; Identity, Similarity and homology. Pairwise Sequence Alignment, Needleman and Wunsch, Smith and Waterman algorithms for Pairwise Alignments, gap penalties, use of pairwise alignments for analysis of Nucleic acid and protein sequences and interpretation of results.

UNIT V: RESEARCH ETHICS AND INTELLECTUAL PROPERTY RIGHTS

9 h

Regulatory Procedures: Good laboratory practice, Good manufacturing practice and FDA regulations - Regulations for recombinant DNA research and manufacturing process – Biosafety and Bioethics –

Intellectual Property Rights on Biotechnology by Singh KC, BCIL , New Delhi

Regulations for clinical trials, Documentation and Compliance, in India and selected countries - Rules for import and export of biological materials.

IPR - Definition - Forms of IPR Protection, WTO - Definition - Functions - International Treaties for IPR Protection - Other forms of IPR protection : Copyright - Trademark - Designs - Importance in Indian Scenario and laws in India for IPR protection

Patents - Definition - conditions for patentability - test of novelty patents - composition of a patent - Patenting of Biotechnological discoveries

References:

1. Freifelder D.M. Physical Biochemistry – Application to Biochemistry and Molecular Biology, 1982.
2. Wilson & Walker. Principles and Techniques in Practical Biochemistry. 5th ed. Cambridge Univ. Press, 2000.
3. West & Todd Biochemistry. 4th ed. Oxford and IBH.
4. Honst Friebolin. Basic One and Two – dimensional spectroscopy. VCH Publ.1991.
5. Murphy D.B. Fundamental of Light Microscopy & Electron Imaging. 1th ed. Wiley-Liss, 2000.
6. Pierre Crabbe. ORD and CD in Chemistry and Biochemistry: An Introduction. Academic Press, 1972.
7. Paddock S.W. Confocal Microscopy methods & protocols. 1st ed. Human Press, 11999.
8. Green.R.H. Sampling Design and Statistical Methods for Environmental Biologists John Wiley & Sons, 1979.
9. Snedecor G.W & Cochran W.G. Statistical methods 8 th ed. Iowa State Press, 1989.
10. Thomas Glover et al. Introduction to Biostatistics 1 st ed. McGraw – Hill Science, 2001
11. Bioinformatics: Sequence and Genome Analysis by Mount D., 2004 Cold Spring
12. Harbor Laboratory Press, New York.
13. Bioinformatics- a practical guide to the analysis of Genes and Proteins by Baxevanis, A.D. and Francis Ouellette, B.F., 1998, John Wiley & Sons, UK.
14. Introduction to bioinformatics by Teresa K. Attwood, David J. Parry-Smith, 1999, Pearson Education.
15. Intellectual Property Rights by Deborah E. Bouchoux, Delmar Cenage Learning, 2005