Shri Vile Parle Kelavani Mandal's

MITHIBAI COLLEGE OF ARTS, CHAUHAN INSTITUTE OF SCIENCE & AMRUTBEN JIVANLAL COLLEGE OF COMMERCE AND ECONOMICS (AUTONOMOUS)

NAAC Reaccredited 'A' grade, CGPA: 3.57,
Granted under RUSA, FIST-DST & Star College Scheme of DBT, Government of India, Best College (2016-17), University of Mumbai

Affiliated to the

UNIVERSITY OF MUMBAI

Program: Masters of Science
Biochemistry
Course: M.Sc.

Semester I & II

Choice Based Credit System (CBCS) with effect from the Academic year 2021-22
A.C. No.: 11
Agenda No.: 4 (iii)

PROGRAMME SPECIFIC OUTCOMES (PSO'S)

The two-year full time M.Sc. programme in Biochemistry endeavours to provide students with excellent training in Biochemistry emphasizing on solid foundation along with insight into basic as well as advanced concepts. In addition to theoretical knowledge, considerable emphasis is given on hands on experience in the forefront areas of Biochemistry through practical training.

On completion of M.Sc. in Biochemistry the learners should be enriched with knowledge and be able to-

PSO1: Associate knowledge of Biochemistry with inter-disciplinary understanding of other branches of life sciences.

PSO2: Gain knowledge about the recent advances in the field, so that the learner can independently assess the vast scope of the field.

PSO3: Apply biochemical principles to understand various complex life processes, theoretically and experimentally, while providing biochemical alternatives to combat various human diseases.

PSO4: Pursue students for higher education, especially research and provide trained manpower.

PSO5: Integrate research, innovation and entrepreneurship.

PSO6: Inculcate critical thinking and analytical reasoning skills.

PSO7: Skill enrichment through compulsory internship/research project

PSO8: Adapt to independent working, while still promoting teamwork and collaboration skills

Preamble

The syllabus is framed to give students pursuing M.Sc.-Biochemistry, a sound foundation of the multi-disciplinary subject.

The programme is conceptualised to provide an in depth understanding of modern biology in terms of biochemistry, and the state-of-the-art technological developments and their applications in metabolomics, genomics, proteomics, bioinformatics, clinical research, developmental biology and allied research and development domains. During the program, practical skills and analytical reasoning skills will be honed. Impetus will be provided to encourage intuitive and analytical skills, and research aptitude in order to prepare students for careers in research and development, academia and industry.

The courses are as follows: -

Semester I:	PSMABC101:	Protein Biochemistry, Enzymology and Membrane Biochemistry
	PSMABC102:	Advanced Metabolism
	PSMABC103:	Human Physiology
	PSMABC104:	Analytical Techniques
	PSMABCP11	Practical-I
	PSMABCP12	Practical-II
	PSMABCP13	Practical-III
	PSMABCP14	Practical-IV
Semester II:	PSMABC201:	Advanced Molecular Biology
	PSMABC202:	Advances in Biochemical Sciences-I
	PSMABC203:	Plant Biochemistry and Clinical Biochemistry
	PSMABC204:	Research Methodology and Biostatistics
	PSMABCP21	Practical-V
	PSMABCP22	Practical-VI
	PSMABCP23	Practical-VII
	PSMABCP24	Practical-VIII

Evaluation Pattern

The performance of the learner will be evaluated in two components. The first component will be a Continuous Assessment with a weightage of 25%% of total marks per course. The second component will be a Semester end Examination with a weightage of 75%% of the total marks per course. The allocation of marks for the Continuous Assessment and Semester end Examinations is as shown below:

a. **Details of Internal Continuous Assessment (ICA)**
25% of the total marks per course:

Continuous Assessment	Details	Marks
Component 1 (ICA-1)	Test (MCQ/Subjective) / Assignments/ Project/ Presentation	15 marks
Component 2 (ICA-2)	Test (MCQ/Subjective) / Assignments / Project/ Presentation	10 marks

b. **Details of Semester End Examination**
75% of the total marks per course. Duration of examination will be two and half hours.

Question Number	Description	Marks	Total Marks
Q1 to Q4	Compulsory question 10 marks + Answer any 1 out of 2 questions	10 + 05 x 1	(10 +5) x 4 = 60
Q5	Answer any 3 out of 4 questions	05	15
		Total Marks	**75**

Evaluation Pattern for practical papers

In the Practical Exams, there will be 40% as continuous assessment and 60% as term end component to be conducted as a semester end exam per course. Two Examiners will conduct the practical examination in each course. The average of marks awarded by both the examiners will be considered as final marks.

We profusely thank all the committee members for their efforts in drafting the syllabus.

Note: (i) The duration of each theory lecture will be of 60 minutes. A course consists of 4 modules. For each module the number of hours allotted are 15. The total number of lecture hours for each course will thus be 60.

(ii) There will be one practical per batch for each course. The duration of each practical will be of 4 hours, i.e. of 240 minutes.
For practical component the value of One Credit is double the number of theory hours.

(iii) Thus in a week, a student will study 4 hours of theory and 4 hours of practical's.

Signature
HOD

Signature
Approved by Vice –Principal

Signature
Approved by Principal

Program: M.Sc.-Biochemistry			Semester: I	
Course: Protein Biochemistry, Enzymology and Membrane Biochemistry			Course Code: PSMABC101	
Teaching Scheme			Evaluation Scheme	
Lecture (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment and Evaluation (CAE)	End Semester Examinations (ESE)
4	-	4	25%	75%

Learning Objectives: The objective of this course is to offer detailed knowledge about proteins, the dynamic biomolecules that sustain life through myriad of diverse functions, providing basic and advanced concepts about structures of proteins, their mechanism of folding and methods to engineer them for various applications. One of the main biochemical functions of proteins is its role as enzyme. The objective of the course is to offer detailed knowledge about enzymes that catalyze the entire repertoire of biochemical reactions in life processes, providing basic concepts of their mechanism of action, kinetics, regulation, inhibition and diverse applications. Learners will be acquainted with the various theories for enzyme action and regulation and experimental evidences thereof. They will also acquire insight into catalysis of chymotrypsin and triose phosphate isomerase, convergent and divergent evolution of enzymes and multi-enzyme systems. The course is also targeted to develop understanding about the concepts of enzyme regulation and allosteric enzyme. The course also aims at imparting knowledge about membrane composition, structure-function relationship and its properties as well as comprehends the mechanism of membrane transport. The course is designed to provide an understanding of the process of cellular communication including signal reception, transduction, amplification and response. The course also highlights the signaling pathways that are characteristic of cancerous cells.

Course Outcomes:

After completion of the course, learners would be able to:

CO1: Develop insight into levels of protein structure, mechanism of folding and the consequences of improper folding

CO2: Consider uni-substrate enzyme kinetics and factors affecting enzyme activity, rate of enzyme reactions, analyse the regulation & mechanism of action of seine proteases- Chymotrypsin, lysozyme, carboxypeptidase, triose phosphate isomerase and alcohol dehydrogenase

CO3: Assess the basic properties of membranes and the mechanisms involved in membrane transport

CO4: Interpret the different modes of communication between cells in a multi-cellular organism and describe the integrative communications that regulate metabolism.

Outline of Syllabus: (per session plan)

Module	Description	No of hours
1	Protein Biochemistry	15
2	Enzymology-I	15
3	Enzymology-II	15
4	Membrane Biochemistry and Cell Signalling	15
	Total	**60**
PRACTICALS		**60**

Module	Protein Biochemistry, Enzymology and Membrane Biochemistry	No. of Hours/Credits 60/4
1	**Protein Biochemistry**	**15**
	Polypeptide backbone Covalent and non-covalent interactions: Vander Walls, electrostatic, Hydrogen bonding, and hydrophobic interactions. End-group analysis by chemical and enzymatic methods: Edman and Sanger's Method Chemical basis of protein purification & isolation Dihydryl angles and Ramachandran plot Protein conformations- 1°, 2°, 3° and 4° structures Structure and function of the oxygen binding proteins: hemoglobin and myoglobin	6
	Supersecondary structures: Turns, bends, Protein-Protein interaction (actin, tubulin), domains, motifs; subunits, interfaces, Leucine zipper, Zinc finger, trans-membrane regions. Architecture of folded proteins Helix coil transitions	3
	Dynamic properties and mechanisms of protein folding: Folding pathways, molecular chaperones, heat shock proteins Anfinsen's experiment Levinthal's paradox Prion proteins and their role in neurodegenerative diseases.	5
	Denaturation -Physical and Chemical agents Renaturation	1
2	**Enzymology-I**	**15**
	Kinetics of enzyme action: Concept of ES complex, active site, specificity Derivation of Michaelis-Menten equation for uni- substrate reactions Different plots (LB Plot, Eadiee Hoftsee) for the determination of Km & Vmax and their physiological significances. Importance of Kcat/Km. Kinetics of zero & first order reactions. Significance and evaluation of energy of activation Collision & transition state theories Classification of multi substrate reactions with examples of each class Derivation of the rate of expression for Ping Pong, random & ordered BiBi mechanisms.	6

	Enzyme Inhibition Dickson Plot for inhibitors Reversible and irreversible inhibition. Competitive, non- competitive, uncompetitive, linear-mixed type inhibitions and their kinetics, determination of Ki and numerical based on the concept. Suicide inhibitor. ***Mechanism of Enzyme Action:*** Acid-base catalysis, covalent catalysis, proximity, orientation effect Strain and distortion theory Site directed mutagenesis of enzymes. Mechanism of action of: Chymotrypsin, lysozyme, carboxypeptidase, triose phosphate isomerase and alcohol dehydrogenase	4 5
3	**Enzymology-II**	**15**
	Enzyme Regulation: General mechanisms of enzyme regulation, product inhibition Reversible (glutamine synthase and phosphorylase) and irreversible (proteases) Covalent modifications of enzymes Mono cyclic and multicyclic cascade systems with specific examples Feedback inhibition and feed forward stimulation ***Allosteric enzymes:*** Qualitative description of concerted and sequential models for allosteric enzymes Half site reactivity, Flip-flop mechanism, positive and negative co-operativity with special reference to aspartate transcarbamoylase & phosphofructokinase Protein-ligand binding measurement, analysis of binding isotherms, Hill and Scatchard plots ***Multienzyme system:*** Occurrence, isolation & their properties:-Mechanism of action and regulation of pyruvate dehydrogenase & fatty acid synthase complexes Enzyme-enzyme interaction, multiple forms of enzymes with special reference to lactate dehydrogenase.	5 5 5
4	**Membrane Biochemistry and Cell Signalling**	**15**
	Membrane Biochemistry Biological membrane; structure and assembly: constituents, bacterial cell envelope, asymmetry flip flop, protein lipid interaction, factors affecting physical properties of membranes. Specialized features like lipid rafts, caveolae and tight junctions	8

	Types and principles of transport mechanisms: Role of Na, K ATPase, Na, K, Cl, voltage and ligand gated ion channels, Types of ATP- dependent transporters. Molecular mechanisms, ion translocating antibiotics, valinomycin, gramicidin, ouabain, group translocation, ionophores, electrical gradient, energy coupling mechanism ***Disorders resulting from abnormalities in membrane structure and functions*** like Familial Hypercholesterolemia Overview of artificial membranes; Liposomes as model membranes and their applications in biology and medicine. ***Cell Signalling*** Classes of Cell Receptors, Modes of cell-cell signalling (endocrine, paracrine and autocrine) Signalling molecules and their receptors Molecular Mechanism of Cell Signalling cAMP Major Intracellular hormones: Steroid hormones, thyroid hormones, Vitamin D_3 and retinoic acid. Nitric oxide, neurotransmitters, plant hormones. Role of Ca^{++} as an intracellular signal, Ca^{++} / Calmodulin dependent protein kinases Pathways of intracellular signal transduction cAMP, cGMP, Phospholipid and Ca. Ras, Raf and JAK/STAT pathway Programmed cell death (apoptosis), proteolytic cascade, adaptor proteins, Bcl-2 family protein, Caspases Cancer Pathways: MAPK, NFκB pathways; Signalling by TGF β factor	7

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

RECOMMENDED READING:

Essential Reading:

1. Nelson, D. L. and Cox, M.M, (2008). Lehninger, Principles of Biochemistry 5th Edition
2. Jeremy M. Berg, John L Tymoczko, Lubert Stryer; Biochemistry; Freeman publishers.
3. Price & Stevens Fundamentals of Enzymology Biochemistry 3rd Edition Oxford University Press

Suggested Reading:

1. Plummer, David T.; Introduction to practical biochemistry; Tata Mc. Graw and Hill publishers.
2. Sawhney, S.K. and Singh, Randhir; Introductory practical biochemistry; Narosa Publishing House.
3. Enzymes; Biochemistry, Biotechnology, Clinical Chemistry (2001) by T. Palmer. Horwood Ltd. Molecular Enzymology (1981) by CW Wharton and R Eisenthal. Wiley
4. Biochemical Calculations (1976) by I.H. Segal. John Wiley & Sons.
5. Understanding Enzymes (1985) by T. Palmer. Ellis Horwood Ltd.

6. C. Branden, T. Tooze. 1999. Introduction to Protein Structure (2nd Ed.), Garland Science, Taylor and Francis Group, New York, USA. ISBN: 978-0-8153-2305-1.
7. T.E. Creighton. 2002. Proteins: Structures and Molecular Properties (3rd Ed.), W.H.Freeman and Company, New York, USA. ISBN 978-0716770305.
8. R. H. Pain. 2000. Mechanisms of Protein Folding, Oxford University Press, Oxford, England. ISBN 978-0716770305

Any other reference sources as recommended by the course instructor.

Practicals PSMABCP11 Practical-I		
	Practical (Hours per week)	**Credit**
	4	**2**
Sr. No.	**Topic**	
1	Proteins: Extraction, isolation, partial purification (if necessary), calculation of percentage yield and performing a confirmatory test for the following. a. Casein from milk b. Albumins and globulins from egg white c. Proteins from germinating seeds	
2	Gel Electrophoresis of serum proteins	
3	SDS-PAGE of proteins	
4	Determination of enzyme activity (in terms of IU/L & Specific activity) in biological tissues- serum, plasma, liver or plant extracts (Any five) a. Alanine transaminase (GPT) b. Aspartate transaminase(GOT) c. Lactate dehydrogenase d. Acid phosphatase e. Alkaline phosphatase	
6	Amylase (Km, optimum pH, optimum temperature) from Sweet Potatoes.	

Program: M.Sc.- Biochemistry			Semester : I	
Course: Advanced Metabolism			Course Code: PSMABC102	
Teaching Scheme			Evaluation Scheme	
Lecture (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment and Evaluation (CAE)	End Semester Examinations (ESE)
4	--	4	25%	75%

Learning Objectives:

Metabolism is an integral part of biochemistry which deals with various biochemical reactions that are taking place in the living organisms. It consists of series of reactions which helps the organisms to sustain life. Metabolism involves many interconnected pathways which ultimately produce energy required for carrying out these reactions within the cell of living organisms. The chemical reactions which comprise of both synthesis as well as degradation of major biomolecules known are referred to as anabolism and catabolism, respectively. These processes are constantly in progress at the molecular level. The nature tries to maintain homeostasis by balancing both the processes and regulating them at various levels.

Course Outcomes:

After completion of the course, learners would be able to:

CO1: Appraise the metabolic pathways and diversity (catabolism as well as anabolism) of carbohydrates, proteins, lipids as well as nucleoproteins and the regulation of metabolism at different levels; relate the crucial role of hormones with regard to the integration of metabolic pathways.

CO2: Analyze conditions of malfunction of the metabolic pathway and its interpretation on health

CO3: Evaluate the energy-yielding pathway in the physiological system and the role of high-energy molecules and the integration of various metabolic pathways and their crosstalk.

Outline of Syllabus: (per session plan)

Module	Description	No of hours
1	Carbohydrate metabolism	15
2	Lipid metabolism and Nucleic acid metabolism	15
3	Protein metabolism and Integration of metabolism	15
4	Bioenergetics	15
	Total	**60**
PRACTICALS		**60**

Module	Advanced Metabolism	No. of Hours/Credits 60/4
1	**Carbohydrate Metabolism**	**15**
	Glycogen Metabolism*:** Synthesis, Breakdown, Regulation, ***Gluconeogenesis: Cori cycle, Glucose-Alanine cycle, Regulation of Gluconeogenesis, Rapaport Luebering cycle & its significance. ***Uronic acid pathway*** Biosynthesis, Degradation Significance Galactose and fructose metabolism Sorbitol pathway, ***Regulation of Blood glucose level*** By liver, Renal regulation Hormonal regulation. Sugar interconversion and nucleotide sugar formation. Biosynthesis of oligosaccharides and glycoproteins ***Energy kinetics of above pathway***	3 3 3 4 2
2	**Lipid Metabolism and Nucleic acid Metabolism**	**15**
	Lipid Metabolism Beta-oxidation of : even chain fatty acids, Odd chain fatty acids Lipid biosynthesis Cholesterol: Biosynthesis, Control, Transport, Utilization Schematic representation of Biosynthesis of eicosanoids Schematic representation of Biosynthesis of membrane phospholipids Lipoprotein Metabolism: Metabolism of chylomicrons, VLDL, LDL, HDL, Transport lipoproteins and membrane lipoproteins Starvation metabolism	8

	Fatty liver Ketosis Ketogenesis (Ketone bodies Formation) Ketolysis (Ketone bodies utilization) ***Nucleotide Metabolism:*** Biosynthesis and degradation of purine and pyrimidine nucleotides- *De novo* and salvage pathways and their regulation Purine catabolism-Adenine nucleotide catabolism and Guanine nucleotide catabolism, Uric acid metabolism. Deoxyribonucleotide Formation. Nucleoside and nucleotide kinases. Nucleotide Metabolizing Enzymes as a function of cell cycle and rate of cell division. Nucleotide coenzyme synthesis.	7
3	**Protein Metabolism and Integration of Metabolism**	**15**
	Biosynthesis & catabolism of **:** Glycine, Alanine, Aspartic acid, Glutamic acid, Serine, Proline, Hydroxyproline Catabolism of threonine and basic amino acids Metabolism of: Aromatic amino acids, Sulphur containing amino acids, Branched chain amino acid	6
	Formation of specialized products from amino acids and their functions Glutathione, Creatine, creatinine Biogenic amines (dopamine, norepinephrine, tyramine, serotonin, melatonin, GABA, Histamine) Polyamines (Putrescine, Spermodine, Spermine) Amino Acids as neuro-transmitters	5
	Integration of Metabolism Highly interconnected pathways: Control sites Organs with unique metabolic profiles: Brain, muscles, adipose tissue, kidney, liver Metabolic changes during food intake and starvation	4
4	**Bioenergetics**	**15**
	Concept of free energy Standard free energy Determination of ΔG for a reaction. Relationship between equilibrium constant and standard free energy change, Biological standard state & standard free energy change in coupled	3

	reactions. Biological oxidation-reduction reactions, redox potentials, Relation between standard reduction potentials and free energy change (derivations and numericals included). ***High energy phosphate compounds*** Introduction, Phosphate group transfer, Free energy of hydrolysis of ATP and sugar phosphates along with reasons for high ΔG. Energy charge. Role of High Energy phosphates in Bio-energetics and energy capture, ***Theories ATP Biosynthesis*** Chemical coupling hypothesis, Conformational coupling hypothesis, Chemiosmotic theory ***Electron Transport Chain in Plants, Eukaryotes and Prokaryotes*** Complexes and their components, Q cycle, Inhibitors and uncouplers ***Mechanism of Oxidative Phosphorylation*** Malate-Aspartate shuttle, Glycerol phosphate shuttle P/E ratio ***Energetics of the individual metabolism of biomolecules*** Numerical problems based on the above	3 3 2 2 2

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

RECOMMENDED READING:

Essential Reading:

1. Nelson, D. L. and Cox, M.M, Lehninger, Principles of Biochemistry 5th Edition Macmillan
2. Murray et al Harper's Illustrated Biochemistry 31st edition McGraw Hill

Suggested Reading:

1. Greenberg David M –Metabolic Pathways. Vols 2 & 3,3rd edn. Academic Press, New York
2. Henry Richard et al – Clinical Chemistry, Principles and Techniques, 2nd edition, Harper and Row, New York
3. Kamal SH – Clinical Biochemistry for Medical Technologies, Churchill Livingston, London
4. Todd et al – Clinical Diagnosis and Management, 17th edition, WB Saunders, Philadelphia
5. Stokes Joan et al – Clinical Microbiology, Edward Arnold, London
6. Harper's Illustrated Biochemistry- 31st edition, McGraw Hill.
7. Rao Ranganathan – Text book of biochemistry 3rd edition, Prentice Hall, New Delhi
8. Biochemistry- Lubert Stryer, Macmillan
9. Lehninger Principles of Biochemistry- Nelson D. L. And Cox M. M., Macmillan
10. Textbook of Medical Biochemistry- M.N. Chatterjea and Rana Shinde, Jaypee Brothers Medical publishers (P) Ltd.

Any other reference resources as recommended by the course instructor.

Practicals PSMABCP12 Practical-II		
	Practical (Hours per week)	**Credit**
	4	**2**
Sr. No.	**Topic**	
1	Glucose Tolerance Test	
2	Blood sugar estimation by Folin-Wu method (Fasting and PP)	
3	Lipid Profile: (Case study) a) Estimation of serum Total cholesterol b) Estimation of HDL, c) Estimation of Triglycerides d) Estimation of LDL by calculation.	
4	Serum Uric Acid Estimation (Caraway method)	
5	Gastric Function Tests	
6	Estimation of CSF – Glucose, Protein & Chlorides	
7	Estimation of Malondialdehyde (MDA), (Thiobarbituric Acid Method)	
8	Urine Protein estimation	

Program: M.Sc.-Biochemistry			Semester: I	
Course: Human Physiology			Course Code: PSMABC103	
Teaching Scheme			Evaluation Scheme	
Lecture (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment and Evaluation(ICA)	Semester End Examinations (ESE)
4	--	4	25%	75%

Learning Objectives:

The objective of this interdisciplinary course is to describe human physiology, biochemistry, and pathophysiology to provide an insight into the working of the body. Learners examine the mechanisms of organ function, organized around the central theme of homeostasis – how the body meets changing demands while maintaining the internal consistency necessary for all cells and organs to function. Course content focuses on cell physiology, musculoskeletal, lymphatic, respiratory system, endocrine, and circulatory systems.

With the help of fundamental information learners will be able to understand various disorders associated with the organ systems listed above. At the end of this course the learners will be able to appreciate the anatomical and physiological aspects of the human body.

Course Outcomes:

After completion of the course, learners would be able to:

CO1: Associate the physiological functions with the underlying structure and composition of the musculoskeletal, lymphatic, respiratory, endocrine, circulatory systems, and body fluids.

CO2: Appraise the functional aspects of the body systems at molecular level.

CO3: Assess the biochemical interrelationships within and between anatomical, and physiological systems of the human body and relate the organ function to disorders/ diseases.

Outline of Syllabus: (per session plan)

Module	Description	No of Hours
1	Endocrinology	15
2	Signal transduction	15
3	Biochemistry of tissues	15
4	Body fluids in Heath and Disease	15
	Total	**60**
PRACTICALS		**60**

Module	Human Physiology	No. of Hours/Credits 60/4
1	**Endocrinology**	**15**
	Endocrinology, Hierarchy of Mammalian Endocrine System, Classification of Hormones, Functions of hormones and their regulation., Chemical signaling - endocrine, paracrine, autocrine, intracrine and neuroendocrine mechanisms.	3
	Biosynthesis, Storage, Secretion, Transport , disorders (overview) and Metabolic effects (including hypo and hyper conditions) of hormones of Thyroid gland, Pituitary, Parathyroid, Adrenal Medulla, Adrenal Cortex, Gonads, Kidneys, GI Tract.	10
	Inactivation and degradation of hormones	2
2	**Signal Transduction**	**15**
	Hormone receptors Extracellular and intracellular; receptor- hormone binding; Scatchard analysis; G proteins and G protein coupled receptors, second messengers - cAMP, cGMP, IP3, DAG, , NO.	4
	Ca^{2+} - as internal hormone	3
	Effector systems Adenyl cyclase, guanyl cyclase, PDE, PLC. Protein kinases (PKA, PKB, PKC, PKG);	2
	Receptor regulation and cross talk	2
	Steroid and thyroid hormone receptor mediated gene regulation..	4
	Regulatory pathways (positive, negative, feedback loops)	
	Molecular endocrinology Regulation of growth, stress, digestion, obesity and hunger (leptin & ghrelin), renal function, cardiovascular system [angiotensin, BNP, endothelin 1 (ET-1), leptin]	
	Endocrinology of fertility (Changes in menstruation, pregnancy & menopause).	
	Medical uses of steroid hormones (contraception, IVF, HRT, hydrocortisone, anabolic steroids). Erythropoietin	
3	**Biochemistry of tissues**	**15**
	Bone Composition, formulation, Structure and functions. Factors affecting bone metabolism, bone remodelling Osteoporosis, osteomalacia	3
	Connective Tissue Connective Tissue- Biosynthesis, composition, structure. Metabolism of Collagen and its Disorders-Ehler's Syndrome (Type I to VII), Osteogenesis Imperfecta (Type I to IV), Paget's disease	3
	Tissues of respiratory system	3

	Cells and functional anatomy of respiratory system, mechanics of respiration, principles of gaseous exchange - oxygen & carbon-dioxide transport, regulation of respiration, hypoxia, oxygen therapy & toxicity, artificial respiration ***Tissues of Cardiovascular system*** Specialized tissues of the heart, heart as a pump, coronary circulation, cardiac output, cardiac cycle Electrocardiogram-arrhythmias. ***Tissues of renal system*** Structure and function of kidney – Structure of nephron, glomerular filtration, tubular reabsorption of glucose, water and electrolytes. Tubular secretion. Urine formation, renal mechanisms for the control of blood volume, blood pressure, micturition Over-view of disorders associated with the systems stated above	3 3
4	**Body Fluids in Health and Disease**	**15**
	Composition, Functions and disorders (overview) Blood and Plasma, Lymph, Cerebrospinal fluid, Gastric juice Pleural fluid, Saliva, Sweat, Tears, Synovial fluid, ***Blood Chemistry*** CBC and Electrolyte panel, Hematopoiesis Myeloid, Lymphoid and Erythroid cell development Blood Coagulation cascade, intrinsic and extrinsic pathways Free radical metabolism, Generation of free radicals, damage produced by reactive oxygen species (ROS), Free radical scavenger systems Enzymatic & nonenzymatic. (three of each type)	5 2 2 2 2

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

RECOMMENDED READING:

Essential Reading:

1. Tortora Gerard J. Tortora's Principles of Anatomy and Physiology, 15th edition, Wiley
2. Guyton & Hall Textbook of Medical Physiology,3rd edition, Elsevier
3 Prafull Godkar Textbook of Medical Microbiology and Parasitology, Bhalan

Suggested Reading:

1. Bruce M. Koeppen, Bruce A. Stanton Berne and Levy Physiology7th edition Elsevier
2. Chatterjee.C. C ,CC Chatterjee's Human Physiology, Volume 1 and 2, 12th edition, Medical Allied Agency
3. Martin C.R., Endocrine Physiology,2nd edition, Oxford University Press) N.Y
4. E. Frieden, H. Lipner, Biochemical Endocrinology of the Vertebrates, Prentice Hall
Any other reference sources as recommended by the course instructor.

Practicals PSMABCP13 Practical-III		
	Practical (Hours per week)	Credit
	4	2
S. No.	Topic	
1.	Hematology	
(i)	Hematological test-	
	a) Collection of Blood	
	b) Bleeding time	
	c) Clotting time,	
	d) Hemoglobin estimation by Drabkin's method	
	e) Packed Cell Volume (PCV)	
	f) Erythrocyte Sedimentation Rate (ESR)	
	g) RBC count	
	h) WBC count	
	i) Total and differential WBC count.	
	j) Erythrocyte indices	
2.	Cardiovascular system	
	a) Examination of Arterial Pulse	
	b) Determination of Arterial blood pressure using sphygmomanometer	
	c) Analyzing – Electrocardiogram-Case study	
	d) Blood Pressure –Measurement- Effect of exercise and postural variation on BP.	
3.	Respiratory System	
	a) Volumetric measurements in Respiration -Case study	
	b) Use of respirometer	
	c) Arterial Blood Gas analysis (ABG)- Case study	
4.	Excretory system	
	a) Estimation of normal constituents of urine	
	b)Estimation of abnormal constitucnts of urine	

Program: M.Sc. Biochemistry			Semester: I	
Course: Analytical Techniques			Course Code: PSMABC104	
Teaching Scheme			Evaluation Scheme	
Lecture (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment and Evaluation (CAE)	End Semester Examinations (ESE)
4	-	4	25%	75%

Learning Objectives: As different biomolecules play different roles. It is mandatory to separate, isolate such molecules and analyze the properties and characteristics of those. Analytical techniques help reveal different methods of separation and isolation of macro and micro molecules along with their estimation. In the proposed curriculum spectroscopic, chromatographic, centrifuge and electrophoretic techniques have been discussed in detailed giving weightage to their applications. Nanostructures are advantageous since their high surface areas can be used to capture clinically relevant biomarkers through molecular recognition processes. Nanotechnology has the potential to transform biomedical research. Hence, it is vital to learn nanotechnology bases approaches for precisely measuring and perturbing living system to enable multimodal interfaces, which may yield new therapeutic strategies for personalized medicine. The curriculum is designed to view these aspects of nanotechnology techniques.

Course Outcomes:

After completion of the course, learners would be able to:

CO1: Relate the basic principles of analytical tools and techniques with their potential applications in science and industrial world.

CO2: Demonstrate the operation of spectrophotometers, chromatography, microscopy, centrifuge and electrophoresis.

CO3: Apply the knowledge of advanced techniques to interpret research, diagnostic and industrial data.

Outline of Syllabus: (per session plan)

Module	Description	No of Hours
1	Spectroscopic Techniques	15
2	Chromatography Techniques	15
3	Nanotechnology Techniques	15
4	Protein Isolation and Characterization	15
	Total	**60**
PRACTICALS		**60**

Module	Analytical techniques	No. of Hours/Credits 60/4
1	**Spectroscopic Techniques**	**15**
	Design of spectrophotometers- Single beam, Double beam and split beam.	1
	Errors in spectrophotometric analysis.	
	Applications- Basic concepts or principles, overview of components, calibration and applications of-	
	UV-visible spectroscopy;	1
	Flame Photometry;	1
	Fluorimetry and Phosphorimetry (Spectro fluorimeters and phosphorimeters);	2
	IR-Single beam, double beam	2
	FTIR	1
	Raman spectroscopy	2
	NMR	2
	MS	2
	AAS	1
2	**Chromatography Techniques**	**15**
	Introduction to Chromatography- separation procedure, Development procedure, classification terminology,	1
	Basic concepts in chromatography: requirements of an ideal detector, types of detectors in LC and GC, comparative account of detectors with reference to their applications (LC and GC respectively), qualitative and quantitative analysis.	1
	Concept of plate and rate theories in chromatography: efficiency, resolution, selectivity and separation capability. Van Demeter equation and broadening of chromatographic peaks. Optimization of chromatographic conditions.	2
	High Performance Liquid Chromatography: Principles, Instrumentation, operation, calibration, accuracy and applications. Normal phase and reversed phase with special reference to types of commercially available columns (Use of C8 and C18 columns). Diode array type and fluorescence detector, Applications of HPLC.	5
	Supercritical Liquid Chromatography: Properties of SFE/SFC, Instrumentation, operation, advantages and applications	5
	Gas Chromatography: Principles, Instrumentation of GC with special reference to sample injection systems – split/split less, column types, solid/ liquid stationary phases, column switching techniques, temperature programming, Thermionic and mass spectrometric detector, operation, calibration, accuracy and	1

	Applications. Processing Chromatography data: Chromatogram, Chromatography software.	
3	***Nanotechnology Techniques***	**15**
	Nanotechnology: Definition, Different classes of nanomaterials, synthesis of nanomaterials, nano structures and **applications,** Nanophotonics, Imaging & diagnostic techniques from nano to Micro scale Characterization using optical and chromatography techniques ***Microscopy:*** Scanning Probe Microscopes – scanning 21unneling microscope (STM), atomic force microscope (AFM), magnetic force microscope (MFM), scanning near field microscope (SNOM), Electron Microscopy: SEM, TEM ,CCD camera and application Diffraction Techniques: X-ray diffraction (XRD) Photoluminescence Spectroscopy: X-ray and UV photoelectron spectroscopies (XPS)/Auger electron spectroscopy	5 6 4
4	**Protein Isolation and Characterization**	**15**
	Purification of Proteins/ Enzymes: Centrifugation: Principles, Working and Applications of: Preparative (Differential and density gradient) and Analytical Ultracentrifugation Density gradient materials-types & characteristics Ammonium Sulphate Precipitation and dialysis ***Electrophoresis*** Basic principles, factors affecting electrophoresis, types of support media, types of solubilizers General principles, instrumentation, working and applications of electrophoretic techniques: Zone, Disc, SDS-PAGE, Capillary, 2-D, Pulsed Field Gel, Diagonal, Isoelectric Focussing, immuno-electrophoresis Gel Documentation System Numericals/Case Study based on the above concept ***Sequencing Techniques*** Basic Principles and Instrumentation, working and applications of: Protein Sequencing Techniques, Western Blotting	4 8 3

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

RECOMMENDED READING:

Essential Reading:

1. Upadhyay; Upadhyay; Nath, Biophysical Chemistry- Principle and Techniques, Himalaya Publishing House, New Delhi.
2. Wilson K & Walker J, Principles and Techniques of Practical Biochemistry, Cambridge Low Price Edition
3. Pelczar Michael J.; Chan Jr., E.C.S., Krieg, Noel R, Microbiology,5th edition, TMH

Suggested Reading:

1. Van Holde KE, Principles of Physical Biochemistry, Prentice Hall
2. Freifelder, D., Physical Biochemistry, 2nd edition, W.H. Freeman and Co. NY. USA
3. Rodney Boyer, Experimental Biochemistry, Pearson Publishers
4. Plummer, David T., Introduction to practical biochemistry, Tata Mc. Graw and Hill publishers
5. Pattabhi. V. and Gautham N, Biophysics, Narosa Publishing House, India.
6. Ananthanarayanan and Panniker, Textbook of Microbiology, 5th Edition, Orient Longman
7. De Robertis, E.D.P. and De Robertis, E.M., Cell and Molecular Biology, 8th edition, Lippincott

Any other reference sources as recommended by the course instructor.

Practicals PSMABCP14 Practical-IV		
	Practical (Hours per week)	**Credit**
	4	**2**
S. No.	**Topic**	
1.	Estimation of:	
	a) Proteins by Bradford &Folin-Lowry methods	
	b) Amino acids by Ninhydrin method	
	c) Glucose by Anthrone & Folin-Wu methods.	
	d) Percentage Purity of Start from Starch Hydrolysate by Willstatter's method	
2.	Buffers and Microscopy:	
	a) pka values of Ala or Gly by Titration Curve	
	b) Microscopy: (Permanent Slides may be used) i. Gram Staining ii. Spores Staining iii. Capsule Staining iv. Acid Fast Staining	
3.	Chromatography: a. Ascending and Circular paper for Amino Acids and Sugars b. TLC of Oils c. HPLC d. HPTLC	
4.	Electrophoresis: Hemoglobin Electrophoresis (Normal/Abnormal)	
5.	Purification of serum proteins, molecular weight determination, subunit determination	
6.	Separation of proteins by affinity chromatography	
7.	Protein purification by ion exchange chromatography	
8.	Nano encapsulation of plant products.	

Program: M.Sc. Biochemistry			Semester : II	
Course: Advanced Molecular Biology			Course Code: PSMABC201	
Teaching Scheme			Evaluation Scheme	
Lecture (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment and Evaluation (CAE)	End Semester Examinations (ESE)
4	-	4	25%	75%

Learning Objectives:

Molecular biology takes a learner in depth to biological and /or medicinal processes through the investigation of underlying molecular mechanisms. It gives an understanding of chemical and molecular processes that occur in and between cells. It is important to understand and utilize the scientific vocabulary used molecular biology to explain the concept of central dogma of cells and outline the process that control it. The current curriculum will help learner to link the advances in cell and molecular biology to a better indulgent of diseases.

Course Outcomes:

After completion of the course, learners would be able to:

CO1: Relate the structural aspects of the prokaryotic and eukaryotic genome with functionality of mutated DNA the mutations and numerical structural aberrations in chromosomes.

CO2: Summarize the process, molecular mechanism and significance of DNA replication, DNA damages and its repair systems.

CO3: Evaluate the working machinery of central dogma of the cell.

CO4: Apply the knowledge of regulation of transcription and translation on gene expression through the action of regulators, inducers and inhibitors.

Outline of Syllabus: (per session plan)

Module	Description	No of hours
1	Structural Aspects of genetic material and mutation	15
2	Replication and Repair	15
3	Transcription and Translation	15
4	Processing and Regulation	15
	Total	**60**
PRACTICALS		**60**

Module	Advanced Molecular Biology	No. of Hours/Credits 60/4
1	**Structural Aspects of genetic material and mutation**	**15**
	Basic concepts of genomics	5
	Conformational variants of DNA and their physiological roles	
	RNA as catalyst.	
	Organization of Microbial Genomes	
	Organization of Eukaryotic Genomes,	
	C-value paradox ,Nucleic acid re-association kinetics and its significance and Cot value;	
	Highly repetitive, moderately repetitive and unique sequences	
	Minisatellites., LINES and SINES, Alu sequences and pseudogenes.	
	Transposons and retroposons.	
	Genetic code	2
	Nature and characteristics of genetic code	
	Hargobind Khorana's work on genetic code,	
	Colinearity of genes and proteins	
	Mutations	3
	Types of mutations- Spontaneous and Induced	
	Analysis of mutation and its effect on biological functioning	
	Physical, chemical and Biological agents causing mutations	
	Mutational hot spot, reverse mutations	
	Site directed mutagenesis	
	Ames test	
	Chromosomal abnormalities	5
	Structural and numerical abnormalities	
	Euploidy and aneuploidy (Autosomal and Sex chromosomes)	
	Monosomies (Turner syndrome,) Disomies and trisomies (Down , Patua, Edward, Syndrome, XXX, Kilnefilters syndrome), Fragile X syndrome, Cri-du chat syndrome, Philadelphia chromosome– Causes and symptoms	
2	**Replication and Repair**	**15**
	Replication	4
	Modes of replication; Meselson and Stahl's experiment Semi-conservative replication,	
	Replicons, primosome, replisomes and their role	
	Enzymes and proteins involved in replication	
	Properties of prokaryotic and eukaryotic DNA polymerases	
	Leading and lagging strand, okazaki fragment	
	Mechanism	3
	Prokaryotic and eukaryotic replication	
	Unidirectional , bidirectional and DNA looping	
	Basic differences between prokaryotic and eukaryotic DNA	

	replication. Licensing factor and regulation of eukaryotic DNA replication. Replication of ends of linear DNA- telomeres and telomerase. Fidelity of replication Inhibitors of replications ***DNA Repair*** Different types of DNA damages, Recognition of DNA damage Types of DNA repair systems Photoreactivation Excision repair, SOS repair Base flipping, Mismatch repair, Recombination repair, Diseases associated with DNA repair problems. Significance of DNA repair in cells	8
3	**Transcription and Translation**	**15**
	Transcription Promoters, Enhancers and other regulatory elements of transcription Prokaryotic and Eukaryotic RNA polymerases Sigma cycle Mechanism of transcription (Prokaryotic and Eukaryotic) Promotor recognition Elongation Termination- rho dependent and rho independent	7
	Translation Mechanism of translation– (Prokaryote and Eukaryotes) Activation of tRNA Initiation- Role and mechanism of initiation factors, Shine dalgarno sequence ***Elongation***- Role and mechanism of elongation factors, A site, P site and E site; peptide bind formation; Translocation Termination- Role and mechanism of release factors and molecular mimicry Fidelity of translation process. Ribosome skipping/ jumping during translation	8
4	**Processing And Regulation**	**15**
	Post-transcriptional processing in prokaryotes and eukaryotes 5'-Capping and poly A tailing Mechanism of RNA splicing- spliceosomes Self splicing	5

	Maturation of rRNA and tRNA. Role of anti-termination proteins and their interaction with RNA polymerase, Mechanism of anti-termination. Inhibitors of transcription and applications as anti-microbial drugs ***Post translational processing*** Signal hypothesis Post translation modification Mode of action of various antibiotics in the inhibition of protein synthesis. ***Regulation of gene expression*** Regulation of gene expression in lambda phage. Regulation of gene expression in bacteria *lac* operon *trp* operon Regulation of gene expression in eukaryotes Hormonal control of gene expression; Role of methylation in regulating gene expression; Alternate promoters; NF-κB; Regulatory RNAs, Epigenetics- Mechanism	4 6

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

RECOMMENDED READING:

Essential Reading:

1. Peter Russell, iGenetics A: Molecular Approach, 3rd edition, Pearson Publication
2. T.A. Brown,Gene Cloning and DNA Analysis: An Introduction, 6th edition, Wiley Publication
3. Lewin B, Gene XI, 11th edition, Oxford University Press`

Suggested Reading:

1. J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levin, R.Losick., Molecular Biology of the Gene, 7th edition, Pearson Publication
2. S Benjamin Cummings, R.F. Weaver, Molecular Biology, 4th edition, McGraw Hill
3. L. Harvey, B. Arnold, Z.S. Lawrence, M. Paul, D. Baltimore, J.E. Darnell, Molecular Cell Biology, 7th edition, W. H. Freeman & Co, New York, USA
4. T.A. Brown, Gene Cloning and DNA Analysis: An Introduction, 6th edition, Wiley Publication
5. Maloy SR, Cronan JE & Freifelder D,Microbial Genetics, 4th edition, Jones& Bartlett
6. Carl Wu and C. Allis, Nucleosome Histone and Chromatin; Part-A, Vol 512, 1st Edition, Academic Press
7. Lodish et al., Molecular Cell Biology, 6th edition, W.H freeman

8. Strick Berger, Genetics,nn3rd edition, McMillan
9. T A Brown, Introduction to Genetics: A Molecular Approach, 1st Edition, Garland Science
10. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, P.Walter, Molecular Biology of the Cell, 6th edition, Garland Science, New York, USA
11. J. Darnell, E. James. 2003 , Molecular Cell Biology, 2nd Edition, W.H. Freeman and Co.
12. Jha A.P., Genes and Evolution, 2000, Macmillan, Delhi
13. Winchester A.M, Genetics: A Survey of Principles of Heredity, 5th Edition, Oxford IBH Public Co,
14. G. M. Cooper, The Cell: A Molecular Approach, 6th Edition, Sinauer Associates, Inc. Massachusetts, USA.
15. M.M. Cox, D.L. Nelson, Lehninger's Principles of Biochemistry, 7th Edition, W.H. Freeman and Company

Any other reference sources as recommended by the course instructor.

Practicals PSMABCP21 Practical-V		
	Practical (Hours per week)	**Credit**
	4	**2**
Sr. No.	**Topic**	
1	DNA Isolation (comparative study)	
2	DNA estimation	
3	RNA isolation	
4	RNA estimation	
5	Pedigree	
6	Karyotyping	
a	Normal Male and Female	
b	Numerical Abnormalities- Down's syndrome, Edward syndorme, Patau syndrome, Cri-du chat syndrome	
c	Structural abnormalities	
7	Bacterial mutagenicity assay (Ames test)	
8	Mutagenesis -case study	
9	Demonstration experiments (Case study Based)	
a	Determination of Base composition	
b	Staining of cellular DNA and RNA and microscopic examination	
c	Study of mutation in *E.coli* by UV	

Program: M.Sc. Biochemistry			Semester : II	
Course: Advances in Biochemical Sciences-I			Course Code: PSMABC202	
Teaching Scheme			Evaluation Scheme	
Lecture (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment and Evaluation (CAE)	End Semester Examinations (ESE)
4	-	4	25%	75%

Learning Objectives:

This course will provide learners with excellent foundation on of the concepts as well as advancement in the field of industrial and applied biochemistry. In addition to the theoretical knowledge the learner will be getting hands on experience which will allow them to use various tools and methods for their career ahead. The exposure to plant and animal tissue culture, their applications in production of vaccines, drug designing/ delivery and diagnostics, will benefit the learners to pursue research in the area or opt for their career ahead. The knowledge about neurobiochemistry and developmental biology will also be helpful and open up new horizons for the learners. The learners will be empowered with clear understanding of the basic concepts of bioinformatics and will provide them knowledge of the recent advances so that they can independently assess the vast scope in the field.

Course Outcomes:

After completion of the course, learners would be able to:

CO1: Develop the knowledge about neuromorphology and neurocellulary anatomy and neurophysiology and neurological disorders

CO2: Interpret the concept of pre and post embryonic development and analyze molecular events of embryogenesis and medical implications.

CO3: Integrate the knowledge about various techniques used in ATC and PTC and apply it for the practical applications.

CO4: Assess different applications of bioinformatics, acquire skills of using various databases and their application, appraise protein sequence analysis and computational methods.

Outline of Syllabus: (per session plan)

Module	Description	No of hours
1	Neuro-muscular Biochemistry	15
2	Stem Cells, cancer and ageing	15
3	Developmental Biology	15
4	Bioinformatics	15
	Total	**60**
PRACTICALS		**60**

Module	Advances in Biochemical Sciences-I	No. of Hours/Credits 60/4
1	**Neuro-Muscular Biochemistry**	**15**
	Neuromorphology and Neurocellulary Anatomy	1
	CNS- Structural aspects of neuron, dendrites, axon, neuroglial cells	
	PNS- Spinal and cranial nerves, plexus ganglia, gray and white matter	
	of spinal cord	
	Chemical composition of brain	4
	Formation, structure and biochemistry of myelin sheath	
	Energy metabolism- normal oxygen consumption by	
	the brain	
	Role of cerebral circulation, local cerebral blood flow	
	Blood Brain CSF Barrier-characteristics	
	Neurophysiology	3
	Membrane potential at steady state	
	Graded potential	
	Generation and propagation of action potential	
	Transmission at synapse	
	Cholinergic and non-cholinergic synapse	
	Chemistry, synthesis, storage and release of nervous neurotransmitters	
	Muscle	3
	Structure and composition of muscle fibres	
	Mechanism of muscle contraction and relaxation.	
	Energy source for muscular work	
	Neuromuscular junctions	
	Neurological disorders	4
	Headache, facial pain, migraine, epilepsy, multiple sclerosis, Myasthenia Gravis.	
	Neurodegenerative disorders; Parkinson's and Alzheimer's diseases, senile dementia	
	Muscular dystrophies	
	Biochemical theories of mental disorders	
2	**Stem Cells, Cancer and Ageing**	**15**
	Stem Cell system:	5
	Types of stem cells and their properties:	
	Embryonic and adult stem cells.	
	Totipotent, multipotent, pluripotent stem cells	
	Stem cells of epithelial skin, skeletal muscle, heart, adult live, pancres, GI tract	
	Role of stem cells in development	
	Cancer stem cells and stem cell markers,	

	Cultivation of stem cells and Stem cell engineering Stem cell research: Therapeutic applications od stem cells Problems and ethics in stem cell research ***Cancer*** Biochemistry of cancer Characteristics of cancer cells Classification of tumors- Benign, malignant – stage and tissue affected Cancer Metastasis Carcinogens- physical, chemical and biological Tumor development- Cancer as a multistep process (Knudson's hypothesis) Cancer critical genes- Mechanism of action, functions and regulation Proto-oncogenes Oncogenes Suppressor genes Oncogenic viruses Cancer treatment- present and future. ***Ageing*** Definition Symptoms *Ageing theories:* Free radical theory, Glycation theory Molecular and Biochemical mechanism of ageing Mitochondria and protein damage & maintenance Telomeres and telomerase in ageing Cellular senescence in ageing Longevity genes-Sirtuins Biomarkers of ageing Methods to show ageing Treatments- Regenerative medicine, rejuvenation	5 5
3	**Developmental Biology**	**15**
	Basic concepts of development : Concepts- Potency, commitment, specification, induction, competence, Morphogenetic gradients, Cell fate and cell lineages ***Gametogenesis, fertilization and early development*** Production of gametes Cell surface molecules in sperm-egg recognition in animals; Zygote formation Morphogenesis: Implantation, cleavage, blastula formation, gastrulation and formation of germ layers in animals ***Molecular events of embryogenesis:***	2 6 2

	Nieuwkoop center, Spemann-Mangold organizer theory Mesodermal induction. ***Medical implications of developmental biology:*** Genetic errors of human development- Prader Willi syndrome, Williams syndrome Induced pluripotency in-vitro fertilization Environmental assaults on human development, Design of future medicines like therapeutic cloning and regeneration therapy	5
4	**Bioinformatics**	**15**
	Introduction to Bioinformatics Central Dogma of Molecular Biology Human Genome Project- Ethical, legal and social issues Bioinformatics- Need and applications on various fields of Biology Introduction to Next-Generation Sequencing technology (NGS) Introduction to Databases- Biological application and Classification	4
	Biological Databases and retrieval techniques Nucleotide Databases- Genbank, Unigene Literature Database- Pubmed, Medline Protein Sequence Databases- Swissprot, PIR Protein Structural Databases- PDB, SCOP, CATH Metabolic pathway database- KEGG, Metacyc Other databases- OMIM, Taxonomy	4
	Genomic and protein sequence analysis Pair wise sequence alignment, gaps, gap-penalties, scoring matrices- PAM, BLOSUM, Local and global sequence alignment Nucleotide and Protein sequence analysis using BLAST and variants Introduction to multiple sequence alignment- Progressive algorithms- Clustal programss	3
	In-silico Protein structure prediction Introduction to protein structure Protein-protein interaction, RASMOL Computational methods in protein Secondary structure prediction Computational methods in protein Tertiary structure prediction Homology modelling	4

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

RECOMMENDED READING:

Essential Reading:

1. Tortora & Derrickson, Principles of Anatomy and Physiology, 15th Edition, Wiley
2. Scott F Gilbert, Developmental Biology, 10th Edition, Sinauer Associates Inc. U.S.
3. Dan E. Krane, Michael L. Raymer, Fundamental Concepts of Bioinformatics, 1st Edition, Pearson education

Suggested Reading:

1. Brady, Siegel, Albers, Price (Editors), Basic Neurochemistry: Principles of Molecular, Cellular, and Medical Neurobiology, Eighth edition, Academic Press.
2. Crossman and Neary, Neuroanatomy: An Illustrated Color Text , Eighth edition, Churchill Livingstone.
3. Balinsky, An introduction to Embryology, Fifth Edition, Saunders
4. Kalthoff, Analysis of Biological development, 1st Edition, McGraw Hill
5. HS Chawla, Introduction to plant Biotechnology 2nd Edition, Oxford & IBH Publishing Co. New Delhi
6. Edited by AK Srivastava, Animal Biotechnology, 2018, Oxford & IBH Publishing Co. New Delhi
7. Dr. Seema Sambrani, A text Book of animal and tissue culture, 1st Edition, Vision
8. Teresa Attwood and David J.Parry,, Introduction to Bioinformatics, 1st Edition, Pearson smith publication
9. David W. Moun, Bioinformatics: Sequence and Genome analysis, 2004, Reprint, CBS Publishers & Distributors,
10. Jonathan Pevsner, Bioinformatics and Functional Genomics, 1st Edition, Wiley-Liss
11. Des Higgins, Willice, Taylor Sequence structure and Database, 1st Edition, Oxford Press
12. David W. Mount, Sequence and Genome Analysis, 1st Edition, Oxford and IBH Publishing Co.
13. Susan Barnum, Biotechnology, An Introduction, International student Edition, Vikas Publishing House

Any other reference sources as recommended by the course instructor.

Practicals PSMABCP22 Practical-VI		
	Practical (Hours per week)	**Credit**
	4	**2**
Sr. No.	**Topic**	
1	Sterilization techniques.	
a	Preparation of culture media and autoclaving	
b	Use of different sterilization methods- dry heat, radiations, liquid chemicals, filtration	
2	Preparation of media and plating Cell viability using Trypan blue	
3	Effect of harsh conditions on cell viability	
4	Permanent slides of muscle tissue	
5	Permanent slides of Nervous system	
6	Case studies on neurological disorders.	
7	Application based questions on neuromuscular study	
8	Application based questions on developmental biology	
9	Case studies on cell lines in developmental biology	
10	Application based on morphogensis	
11	Fractionation of different cell organelles from animal and plant tissues	
12	Bioinformatics –I: Biological information retrieval from databases	
a	Data retrieval from NCBI- Pubmed, Nucleotide, UniGene, Protein, Mapviewer, SNP, OMIM	
b	Data retrieval from EBI- SwissProt, PIR, ENA, Taxon	
c	Data retrieval using InterPro, SCOP	
13	Bioinformatics II	
a	Sequence and Structure analysis	
b	Database Similarity Search using BLAST variants	
c	Multiple Sequence Alignment- Clustal Omega, T-Coffee	
d	Structure Visualization using RASMOL	

Program: M.Sc. Biochemistry			Semester : II	
Course: Plant Biochemistry and Clinical Biochemistry			Course Code: PSMABC203	
Teaching Scheme			Evaluation Scheme	
Lecture (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment and Evaluation (CAE)	End Semester Examinations (ESE)
4	-	4	25%	75%

Learning Objectives:

The objective of the course is to familiarize learners with the pathophysiology and molecular basis of human diseases and their diagnosis using biochemical and enzymological methods.

The course also deals with photosynthesis, plant physiology, plant hormone and developments and their response to biotic and abiotic stress. The course aims at providing deep understanding of metabolic processes in plants and the role of different biosynthetic pathways in plant growth and development. Learners will also learn about stem cells, their role in development and its significance in regenerative medicines, current applications and advancement in stem cell research. Learners also get insight into inborn errors of metabolism and diseases associated with organs and tests performed in order to diagnose the same.

Course Outcomes:

After completion of the course, learners would be able to:

CO1: Develop advanced understanding about plant biochemistry, tissue culture techniques and biochemical diagnostics

CO2: Interpret the physiological aspects of various human diseases with special emphasis on metabolic disorders and analyse the various aspects of diagnostic enzymology that rely on the measurement and profiling of the activity of various enzymes

CO3: Integrate and extend the knowledge of plant biochemistry and its application to tissue culture.

Outline of Syllabus: (per session plan)

Module	Description	No of hours
1	Plant Biochemistry	15
2	Plant tissue culture and Animal tissue culture	15
3	Clinical Biochemistry-I	15
4	Clinical Biochemistry-II	15
	Total	**60**
PRACTICALS		**60**

Module	Plant Biochemistry and Clinical Biochemistry	No. of Hours/Credits 60/4
1	**Plant Biochemistry**	**15**
	General features of photophosphorylation:	3
	Historical background and Hill's reaction.	
	Role of photosynthetic pigments and light harvesting systems in plants and microbes.	2
	Bacterial photophosphorylation in purple bacteria and Green sulfur bacteria. Photophosphorylation in plants.	5
	Molecular architecture of Photosystem I and Photosystem II:	
	The Z-scheme of photosynthetic electron flow.	
	Cyclic photophosphorylation and its significance.	
	Carbon fixation reactions:	
	Calvin cycle and regulation, C4 cycle and Crassulacean acid metabolism (CAM), Photorespiration, Photo inhibition of photosynthesis, Photosynthetic carbon reduction (PCR) cycle	3
	Plant Hormones:	
	Growth regulating substances and their mode of action, molecular effects of auxin in regulation of cell extension, effects of gibberllic, abscisic acids and cytokinins in the regulation of seed dormancy, germination, growth and development.	2
	Stress metabolism in plants	
	Environmental stresses, salinity, water stress, heat, chilling, anaerobiosis, pathogenesis, heavy metals, radiations and their impact on plant growth and metabolism, criteria of stress tolerance	
2	**Plant tissue culture and Animal tissue culture**	**15**
	Plant Tissue Culture (PTC)	1
	Principles, Techniques and applications	
	Techniques and Methodology	2
	Culture media, types, characteristics, composition	
	Primary culture	
	Cell lines- finite and continuous	
	Primary Explant technique	
	Callus culture	
	Anther and Pollen culture	
	Protoplast culture	2
	Embryo rescue technique	
	Micropropagation	
	Protoplast fusion and Somatic hybridization	2
	Suspension cultures	
	Applications	
	Plant derived secondary metabolites	

	Biopharmaceuticals Use of PTC in production of transgenics. ***Animal Tissue Culture (ATC)*** Principles, Techniques and applications ***Techniques and Methodology*** Serum & protein free defined media and their applications Measurement of viability and cytotoxicity Organ, organotypic and histotypic cultures Transfection using eggs Cultured stem cells and nuclei in development of transgenic animals ***Frontiers of fertility research:*** Cryopreservation of sex gametes & embryos Ethical issues in embryo research ***Applications of ATC*** Hybridoma technology – Monoclonal antibodies, selection of hybrids, hybridomas Purification and application of monoclonal antibodies. Production of vaccines Pharmaceutical drugs	3 2 1 2
3	**Clinical Biochemistry-I**	**15**
	Disorders of Carbohydrate Metabolism Diabetes mellitus, glucose and galactose tolerance tests, sugar levels in blood, renal threshold for glucose, factors influencing blood glucose level, glycogen storage diseases, pentosuria, galactosemia ***Disorders of Lipids*** Plasma lipoproteins, cholesterol, triglycerides & phospholipids in health and disease, hyperlipidemia, hyperlipoproteinemia, Gaucher's disease, Tay-Sach's and Niemann-Pick disease, ketone bodies, Abetalipoproteinemia ***Inborn Errors of Metabolism*** Phenylketonuria, alkaptonuria, albinism, tyrosinosis, maple syrup urine disease, Lesch-Nyhan syndrome, sickle cell anemia, Histidinemia ***Digestive diseases*** Maldigestion, malabsorption, creatorrhoea, diarrhoea and steatorrhoea ***Disorders of liver and kidney*** Jaundice, fatty liver, normal and abnormal functions of liver and kidney	4 3 3 3 2
4	**Clinical Biochemistry-II**	**15**
	Diagnostic Enzymes : Enzymes in health and diseases Biochemical diagnosis of diseases by enzyme assays Liver Function test : SGOT, SGPT, CPK, cholinesterase, LDH	3

	Abnormalities in Nitrogen Metabolism – Uremia, hyperuricemia, porphyria and factors affecting nitrogen balance Porphyrins – Biosynthesis and degradation of porphyrins. Production of bile pigments ***Blood Clotting*** – Disturbances in blood clotting mechanisms – haemorrhagic disorders – haemophilia, von Willebrand's disease, purpura, Rendu-Osler-Werber disease, thrombotic thrombocytopenic purpura, disseminated intravascular coagulation, acquired prothrombin complex disorders, circulating anticoagulants. ***Renal Function test*** ***Gastric and Pancreatic Function test*** ***Enzyme tests in determination of myocardial infarction, muscle dystrophy & bone disorders***.	3 4 1 2 2

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

RECOMMENDED READING:

Essential Reading:

1. Nelson, D. L. and Cox, M.M Lehninger, Principles of Biochemistry, 5th Edition, Macmillan Education
2. M.N. Chatterjea, Rana Shinde, Textbook of Medical Biochemistry 6th Edition, Jaypee Publishing
3. Jeremy M. Berg, John L Tymoczko, Lubert Stryer, Biochemistry, 5th Edition, Freeman publishers

Suggested Reading:

1. Caroline Bowsher, Martin steer, Alyson Tobin, Plant Biochemistry, 2nd Edition Garland Science, Taylor and Francis Group, New York, USA.
2. Plummer, David T, Introduction to practical biochemistry, 1st Edition, Tata McGraw and Hill publishers
3. Sawhney, S.K. and Singh, Randhir, Introductory practical biochemistry, 1st Edition,Narosa Publishing House
4. Buchann, Biochemistry and molecular Biology of plant, 2nd Edition, I K International
5. P.M Dey and J.B. Harborne, Plant Biochemistry, 2nd Edition, Academic Press
6. DM. Vasudevan, Sreekumari S., Kannan Vaidyanathan, Textbook Of Biochemistry for Medical Students, 9th Edition, Jaypee Brothers Medical Publishers
7. Guyton and Hall, Textbook of Medical Physiology, 14th Edition, Elsevier Publication

Any other reference sources as recommended by the course instructor.

Practicals PSMABCP23 Practical-VII		
	Practical (Hours per week)	**Credit**
	4	**2**
Sr. No.	**Topic**	
1	Biochemical/ Clinical Analysis: Estimation of: (from blood/plasma/serum/urine) a. Cholesterol by Zak and Zaltsky Method b. Calcium (Ca) by Clark and Collip Method/ Trinder Method c. Iron (Fe) by Dipyridyl Method d. Copper (Cu) by Dithiocarbonate Method c. f. Phosphorus (P) by Fiske- Subbarao Method	
2	Pigments (Separation of the following pigments on TLC slides): a. Curcumin from Turmeric b. Carotenes from carrots c. Chlorophylls from spinach	
3	Extraction, isolation, partial purification (if necessary), calculation of percentage yield and performing a confirmatory test for the following Carbohydrates: a. Cellulose from Grass b. Starch from Potato c. Pectin from apples/bananas/oranges	
4	Extraction, separation and determination of absorption spectra of plant pigments	
5	Qualitative and quantitative analysis of: Saliva (α-amylase)	
6	Experiments on blood : Determination of A/G ratio in serum	

Program: M.Sc. Biochemistry			Semester : II	
Course: Research Methodology and Biostatistics			Course Code: PSMABC204	
Teaching Scheme			Evaluation Scheme	
Lecture (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment and Evaluation (CAE)	End Semester Examinations (ESE)
4	-	4	25%	75%

Learning Objectives:

The objective of this interdisciplinary course in research methodology and biostatistics is to inculcate and lay a strong foundation for research and its analysis. Learners will gain knowledge on the development of research designs based on the type of research. They then can develop the ability to formulate research proposals and conduct research. The course content focuses on gaining insight into the statistical tools used for analysis. The learner will gain insight into formulation of research hypothesis. With the help of fundamental information, the learners will be able present research with statistically drawn conclusions.

Course Outcomes:

After completion of the course, learners would be able to:

CO1: Develop knowledge and apply it on various kinds of research, objectives of doing research, research process, research designs and sampling

CO2: Assess the appropriate statistical methods required for a particular research design.

CO3: Evaluate the research findings with appropriate statistical tools.

Outline of Syllabus: (per session plan)

Module	Description	No of hours
1	Research Methodology	15
2	Biostatistics-Introduction	15
3	Theory of Probability	15
4	Hypothesis Testing	15
	Total	**60**
PRACTICALS		**60**

Module	Research Methodology and Biostatistics	No. of Hours/Credits 60/4
1	**Research Methodology**	**15**
	Strategies, planning and analysis	3
	Scientific problem	
	Objectives of research	
	Short term and long term goals	
	Research conditions	
	Research design- characteristics of a good research design, types of research design	
	Repeatability, reproducibility and reliability	
	Experimental protocols	
	Literature search	3
	Information literacy	
	Systematic literature search	
	How to formulate a query: PICO	
	Search techniques	
	Methodology filters	
	Critical appraisal	
	Impact factor	
	Medical and scientific internet	
	Principal bibliographic databases	
	Citation style	
	Reference management software e.g. Mendeley, Zoreto	
	Ethics in science	3
	Introduction to ethics	
	Scientific conduct and misconduct	
	Authorship issues	
	Plagiarism	
	Basic principles of human research ethics- international regulation	3
	Ethics of animal research- CPCSEA, Institutional ethics committee, OECD guidelines	3
2	**Biostatistics- Introduction**	**15**
	Introduction- definition, scope and limitations	2
	Measurement scales, variables & their measurements	2
	Collection of data, classification & tabulation-diagrammatic & graphical representation	2
	Measures of central tendency -mean, median, mode, geometric mean	2
	Measures of dispersion- Range, Q.D., M.D., variance, standard deviation	2

	Correlation and Regression analysis: Correlations and regressions-: Relation between two variables, scatter diagram, definition of correlations & their equations, interpretation of regression coefficients, principles of least squares, Two regression lines, curve fitting Karl Pearson's coefficient of correlation, Spearman's coefficient of correlation	3
	Sampling-sampling frame, importance of probability sampling, simple random sampling, systemic sampling, stratified random sampling, cluster sampling	2
3	**Theory of Probability**	**15**
	Random experiments, sample space of an experiment, event, mutually exclusive events, exhaustive events, independent events, additional theory(statement only), conditional probability, multiplication theorem(statement only), Bayes' theorem.	5
	Discrete distribution- Binomial distribution, Poisson distribution	5
	Continuous distribution- Normal distribution and its properties, Sampling distribution	5
4	**Hypothesis Testing**	**15**
	Hypothesis testing Null and alternate hypothesis Type-I & Type-II errors Level of significance, Power of test p value	3
	Parametric Tests Large sample Tests Testing significance of single population mean Testing significance of single population proportion Testing significance of two population mean Testing significance of two population proportion Small sample Tests Testing significance of single population mean Testing difference between two independent normal population mean Testing difference between two correlated normal population mean Testing significance of correlation coefficient χ^2 test Testing single population variance Testing Goodness of fit Testing association between two attributes F-test- Testing equality of variance ANOVA- one-way classification, two-way classification	8
	Introduction To Non-Parametric Tests Rank test-sign test	4

	The Wilcoxon Signed-Rank test for location Testing single population mean Testing difference between correlated match pair) population means Testing difference between two independent population means The Mann-Whitney Test (Mann-Whitney-Wilcoxon test -for equality of medians) The Kolmogorov-Smirnov Goodness- of -Fit Test The Kruskal-Wallis One-Way Analysis of Variance by Ranks The Friedman Two-Way Analysis of Variance by Ranks	

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

RECOMMENDED READING:

Essential Reading:

1. CR Kothari, Research methodology, Methods and techniques, 4th Edition, New Age International (P) Limited
2. Jerrold Zar, Biostatistical Analysis, 4th Edition, Pearson Education Limited
3. P. N., Malhan Arora (P. K.), P. K. Malhan, Biostatistics, 2012, Himalaya Publishing House W.W. Daniel and C.S Cross
4. Biostatistics- A Foundation for Analysis in the Health Sciences, 11th edition, Wiley

Suggested Reading:

1. Quinn & Keough, Experimental Design and Data Analysis for Biologists, 2002, Cambridge University Press
2. Davies OL & Goldsmith PL, Statistical methods in research and production, 4th edition, Longman
3. Elsevier Academy Online

Practicals PSMABCP24 Practical-VIII		
	Practical (Hours per week)	**Credit**
	4	**2**
Sr. No.	**Topic.**	
1	Preparation of Research Proposal for Minor / Major Research Projects to be submitted to the funding agencies	
2	Review of Research work being carried out at any five National/ International Research Centers or Institutes	
4	Learner will be required to: a. Access at least five scientific websites to collect relevant information with respect to the topics from the syllabus assigned to him or her by the teacher. A one [page summary per website visited (i.e. a total of five pages) should be entered in the journal as a part of practical IV. Teacher should encourage that different topics from the theory syllabus are given to learner and learner would access as far as possible different web sites form information collection. b. Select any two research papers from any leading nation and international scientific journals (not older than two years) and present these papers in his or her biochemistry department as if it his/her own research work. A one page summary per research work. A one-page summary per research paper presented (i.e. a total of two pages) should be entered in Journal as a part of practical IV. (Teacher may help learners in selecting such research papers from the scientific journals available at their respective colleges or at other institutions/libraries). A compilation of research papers entitled "Papers in Bio-chemistry" edited by John Herriott, Gary Jacobson, Julius Marmur and William Parson published by Eddison-Wesley Publications Co. Menlo Park, California, USA may be referred to for classical original papers in biochemistry representing milestone discoveries in bio-chemistry such as Krebs Cycles, Structure of Myoglobin and Haemoglobin, etc. c. Research paper given to learners to prepare presentation for poster/newspaper(for layman)	
4	Elsevier Academy Online Certificate Courses – At least seven modules	
5	Review Article alone or in groups	
6	Statistical problem on concepts of Biostatistics	
7	Research Reading Club to analyze published research articles	