

SRI VENKATESWARA UNIVERSITY
S.V.U COLLEGE OF SCIENCES
TIRUPATI - 517 502

DEPARTMENT OF BIOCHEMISTRY



**Re-Structured P.G. Programme (CBCS) as per
NEP 2020, NHEQF and Guidelines of APSCHE
(With effect from the batch of Students
admitted from the academic year 2024-25)
M.Sc Biochemistry (Immunology)**

SRI VENKATESWARA UNIVERSITY:: TIRUPATI
SVU COLLEGE OF SCIENCES, Department of BIOCHEMISTRY
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M.Sc Branch II (B) M.Sc Biochemistry (Immunology)

SEMESTER - I								
S. No	Course	IMT Code	Title of the Course	H/W	C	SEE	IA	Total Marks
1	CC	101	Core Course-1: Intermediary Metabolism I	4	4	70	30	100
2		102	CC – 2(A): Biochemical and Biophysical Techniques	4	3	50	25	75
			CC – 2(B): Food safety and quality management					
3		103	CC – 3(A): Biomolecular Chemistry	4	3	50	25	75
			CC – 3(B): Plant Biochemistry					
4	*P	104	Practical I (related to CC 2 & 3)	6	2	35	15	50
5	SOC	105	Skill Oriented Course – 1(A): Microbiology	4	3	50	25	75
			Skill Oriented Course – 1(B): Inheritance Biology					
6		106	Skill Oriented Course – 2(A): Molecular Biology	4	3	50	25	75
			SOC – 2(B) : Biotechnology and Nanotechnology					
7	*P	107	Practical II (related to SOC 1 & 2)	6	2	35	15	50
			Total	36	20	340	160	500
8	Audit Course	109	Indian Knowledge Systems - 1	4	0	0	100	0

- CC (Core Courses) - 1st Core Course is mandatory and 2nd & 3rd Core Courses Student can choose one from each code
- *SOC (Skill Oriented Courses) – Student can choose one from each code
- *Practical – I relating to 2nd & 3rd Core Courses and Practical - II relating to 1st & 2nd Skill Oriented Courses (SOC)
- Audit Course – Zero Credits but mandatory with only a Pass.

SEMESTER - II								
S. No	Course	IMT Code	Title of the Course	H/W	C	SEE	IA	Total Marks
1	CC	201	Core Course-4: Intermediary Metabolism II	4	4	70	30	100
2		202	CC– 5(A): Molecular Physiology	4	3	50	25	75
			CC–5(B): Molecular Signaling & Immuno-Technology					
3		203	CC – 6(A): Enzymology	4	3	50	25	75
			CC – 6(B): Ecological Principles					
4	P	204	Practical III (related to CC 5 & 6)	6	2	35	15	50
5	SOC	205	Skill Oriented Course–3(A): Nutritional Biochemistry	4	3	50	25	75
			Skill Oriented Course – 3(B) : Nutraceuticals					
6		206	Skill Oriented Course –4(A) : Genetic Engineering	4	3	50	25	75
			Skill Oriented Course – 4(B) : Metabolomics					
7	P	207	Practical IV (related to SOC3 & 4)	6	2	35	15	50
8	OOTC	208	Open Online Trans disciplinary Course-1	-	2	-	100	100
	Total			36	22	340	260	600
9	Audit Course	209	Indian Knowledge Systems - 2	4	0	0	100	0

- CC (Core Courses) – 4th Core Course is mandatory and 5th & 6th Core Courses Student can choose one from each code
- *SOC (Skill Oriented Courses) – Student can choose one from each code
- *Practical - III relating to 5th & 6th Core Courses and Practical - IV relating to 3rd & 4th Skill Oriented Courses (SOC)
- *Open Online Trans disciplinary Course (OOTC) - Students can choose any relevant course of his / her choice from the online courses offered by governmental agencies like SWAYAM, NPTEL, etc.,
- Audit Course – Zero Credits but mandatory with only a Pass

SEMESTER - III								
S. No	Course	IMT Code	Title of the Course	H/W	C	SEE	IA	Total Marks
1	CC	301	Core course-7: Endocrine Biochemistry	4	4	70	30	100
2		302	Core Course – 8(A) : Immunology	4	3	50	25	75
			Core Course – 8(B) : Computational Biology					
3		303	Core Course – 9(A) : Applied and Molecular Immunology	4	3	50	25	75
4	P		Core Course – 9(B) : Cancer Biology					
4	P	304	Practical V (related to CC 8 & 9)	6	2	35	15	50
5	SOC	305	Skill Oriented Course – 5(A) : Technical Writing, Biostatistics, Bioinformatics and Omics	4	3	50	25	75
			SOC– 5(B): Research Methodology Tools Techniques, Research Publication and Ethics					
6		306	Skill Oriented Course –6(A): Clinical Immunology	4	3	50	25	75
			SOC –6(B): In Silico Drug Design and Discovery					
7	P	307	Practical VI (related to SOC 5 & 6)	6	2	35	15	50
8	OOTC	308	Open Online Trans disciplinary Course-2	-	2	-	100	100
			Open Elective (Offered by other Dept.)		2	70	30	100
			IMT 308 Open Elective: Endocrine Biochemistry					
*	Seminar / tutorials / remedial classes and Quiz as part of internal assessment			4				
			Total	36	20	340	260	600

- CC (Core Courses) – 7th Core Course is mandatory and 8th & 9th Core Courses Student can choose one from each code
- *SOC (Skill Oriented Courses) – Student can choose one from each code
- *Open Online Trans disciplinary Course (OOTC) - Students can choose any relevant course of his / her choice from the online courses offered by governmental agencies like SWAYAM, NPTEL, etc.,
- *Practical - V relating to 5th & 6th Core Courses and Practical - VI relating to 5th & 6th Skill Oriented Courses (SOC)'

SEMESTER - IV								
S. No	Course	IMT Code	Title of the Course	H/W	C	SEE	IA	Total Marks
1	OOSDC/SDC	401	Open Online Skill Development Courses/Two Skill Development Courses (Select <u>Any Two</u> out of Three Courses)	-	8			200
			401 a) Immunotechniques	06	4	70	30	100
			401b) Immunological Diseases and Therapeutics	06	4	70	30	100
			401 c) Immunopharmacology (E)	06	4	70	30	100
2	PW	402	Project Work – Orientation classes	12	12	300	0	300
*	Conducting classes for competitive exams, communication skills, UGC / CSIR and NET / SLET examinations			12	-	-	-	-
			Total	36	20	440	60	500
Total Semesters				144	84	1320	880	2200

- Open Online Skill Development Course (OOSDC) - Students can choose any **Two** relevant courses of his / her choice from the online courses offered by governmental agencies like SWAYAM, NPTEL, etc., **to get 8 credits (with 4 credits from each course)**

SEMESTER-I

IMT 101 Core Course 1: Intermediary Metabolism I (Credits 4)

Course Objectives:

The main objectives of this course are to:

1. To understand the metabolism of carbohydrates, and lipids .
2. To impart knowledge of the concepts of regulation of metabolic pathways.
3. To offer basic knowledge on applications in the metabolic pathways

Unit I

Outline of intermediary metabolism, methods of studying metabolism. Glycolysis – Reactions, energy yield and regulation. Entry of other carbohydrates into glycolytic sequence, fermentation, TCA cycle – Reactions, Energetics and Regulation.

Organization of electron carriers and enzymes in mitochondria, mitochondrial respiratory chain, Classes of electron transferring enzyme, inhibitors of electron transport, oxidative phosphorylation, Mechanism of oxidative phosphorylation.

Unit II

Glyoxylate cycle, pentose phosphate pathway-regulation and significance. Glucuronic acid cycle, Breakdown of glycogen, starch and disaccharides, glycogenolysis and its regulation, Biosynthesis of glucose (gluconeogenesis), Futile cycle, glycogen synthesis and its regulation, Regulation of blood glucose homeostasis

Unit III

Bioenergetics - Thermodynamic principles: free energy, enthalpy (H), entropy (S), Free energy change in biological transformations in living systems; high energy compounds, exergonic and endergonic reaction, oxidation – reduction reactions.

Microsomal electron transport – utilization of oxygen by oxygenases, superoxide dismutase, and catalase. Photosynthesis – dark and light reaction Photophosphorylation, and Photorespiration, cyclic and non – cyclic reactions; photochemical events associated with photo system – I and II. C3 and C4 plants.

Unit IV

Lipid metabolism: lipids as energy reserves. Oxidation of fatty acids, Oxidation of odd chain fatty acids, Energy yield and regulation. Ketone bodies, Fatty acid biosynthesis- control of fatty acid synthesis. Formation of monoenoic and polyenoic acids. Biosynthesis of cholesterol, triacyl glycerols, phospholipids, bile acids. Formation of prostaglandins, leukotrienes, prostacyclins. Metabolism of lipoproteins.

Recommended Books:

- 1) Principles of Biochemistry, white. A, Handler, P and Smith
- 2) Biochemistry, Lehninger A.L.
- 3) Biochemistry, David E. Metzler.
- 4) Biochemistry, Lubert Stryer.
- 5) Review of Physiological chemistry, Harold A. Harper.
- 6) Text of Biochemistry, West and Tood.
- 7) Outlines of Biochemistry, Conn and Stump
- 8) Metabolic pathways – Greenberg.
- 9) Mitochondria, Munn.
- 10) Biochemistry, 2nd Edition, G. Zubay.

Expected Course Outcomes: On the successful completion of the course, students will be able to:

1. Understand the concepts of carbohydrate metabolism and its regulation (K2)
2. Understand the concepts of nucleic acid metabolism and its regulation (K2)
3. Apply the knowledge Metabolic Pathways (K3)

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create

IMT 102 Core Course 2(A): Biochemical and Biophysical Techniques (Credits 3)

Course Objectives: The main objectives of this course are to:

1. The main objective of the course is qualitative and quantitative analysis of different molecules taking place in a biochemical reaction.
2. It includes the development of different tools and methods for identification, analysis and examination of physical properties of different biochemical compositions to provide better chemical information.
3. It helps the biochemistry students in understanding the basic science in a variety of applications.

Unit I

Safety and good lab practices, Solutions –Percentage, Molarity, Molality, Normality, pH, Measurement of pH, pKa of functional group in biopolymers such as proteins and nucleic acids.

Microscopy: basic principles of light microscopy, phase contrast microscopy and electron microscopy.

Sedimentation methods: principles of centrifugation, analytical and Ultra-centrifugation/Gradient centrifugation.

Unit II

Concept of half – life and decay constant, units of radioactivity, Radioactivity measuring techniques and correction factors. Application of isotopes in biochemical analysis, isotope dilution techniques and autoradiography. Radioisotopes in biochemistry and medicine. Measurement of radioactivity - GM counter, Liquid Scintillation Counter, γ -Counter, Radioactive disposal, RIA, Chemi luminescence.

Separation methods: principle, methodology and application of counter current distribution, paper, thin layer, ion-exchange, gas chromatography, affinity chromatography, gel filtration, HPLC.

Unit III

Electrophoresis - paper, agar, high voltage electrophoresis, iso-electrophoresis, iso-tachopheresis, Northern blot, southern blot, western blot analyses. *In situ* hybridization.

Unit IV

Spectroscopy methods – Concepts of spectroscopy, electromagnetic spectrum, Beer – Lamberts law, principles and applications of colorimetry, UV-VIS spectrophotometry. Concepts of fluorimetry, flame photometry, AAS, AES, Infrared, ESR, NMR, CD & ORD and X – ray Diffraction. Flowcytometry and cell sorting and their applications.

Recommended Books:

- 1) Principles and Techniques of Practical Biochemistry, Ed. Williams and Wilson.
- 2) Techniques in Molecular Biology Ed. Walker & Gastra, Croom Helm.
- 3) Principles of Instrumental Analysis, 2nd Ed. Holt-Sanders.
- 4) An Introduction to Spectroscopy for Biochemistry, Ed. Brown Sn., Academic Press.
- 5) Analytical Biochemistry, Holmes and Hazel Peck, Longman.
- 6) An Introduction to Practical Biochemistry. David t. Plummer, Tata Mac grew – Hill.
- 7) Biophysical Chemistry, Ed. Shall & Wyman, Academic Press Vol II & I.
- 8) A text book of quantitative inorganic analysis including elementary instrumental analysis, Vogel ELBS.
- 9) Biochemical Calculations Seigel, IH, 2nd Ed. John Wiley & Sons Inc.
- 10) Analytical Biochemistry by David Friefelder.

Expected Course Outcomes: On the successful completion of the course, student will be able to:

1. Obtain the knowledge about the microscope handling and the basic difference between the ordinary microscope and electron microscope (K2).
2. Learn the chromatographic techniques, for the separation of the individual compound from the mixture of compound (K3 & K5).
3. Study the interaction between matter and electromagnetic radiation and visible light dispersed according to its wavelength, by a prism (K4& K5).
4. Understand the characterization of surfaces using radioisotopes generally involves observing the manner in which the radioactive species interact with the surface (K1, K2 & K3).
5. Obtain knowledge about the separation and analysis of macromolecules and their fragments, based on their size and charge (K2 & K3).

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create

Practical: Biochemical and Biophysical Techniques (Credits 1)

1. Preparation of buffers and pH measurement.
2. Separation of amino acids by paper chromatography
3. Separation of sugars by TLC
4. Separation of proteins by SDS-PAGE.
5. Absorption spectra of phenol red, amino acids and nucleic acid.
6. Isolation and Spectrophotometric characterization of plant pigments.
7. Verification of Beer's law and determination of molar extinction coefficient using p-nitro phenol.
8. Separation of amino acids by ion-exchange chromatography.
9. Isolation of starch from potatoes.
10. Isolation of cholesterol from brain.

IMT 102 Core Course 2(B): Food safety and quality management (Credits-3)

Course Objectives: Students will be able to

1. Acquire an understanding of relevance of food components,
2. Acquire an understanding of application and detection techniques in food.
3. Apply regulatory techniques in real time scenarios
4. Acquire an understanding in industrial operations in food, role of microbes
5. Food borne diseases

Unit – I

Microbiology of foods and food safety. Factors affecting the growth of microorganisms in food. Role of microorganisms in fermented foods and food industry. Economically important fermentation products.

Food safety and importance of safe food. Factors affecting food safety – Physical, Chemical and Biological. Recent concerns of food safety. Food safety and food service establishments – food safety measures – hygiene and sanitation in food service establishments, licensing and sale.

Unit – II

Food adulteration – common adulterants, classification of adulterants – harmful effects of adulterants – methods for detection of adulterants.

Unit – III

Food packaging – significance and function – classification of packaging material – packing methods – interaction between packaging and food – toxicity hazards. Packaging laws and regulations. Biodegradable materials and environmental issues – labeling requirements, nutritional labeling and coding of foods.

Unit – IV

Risk analysis Risk analysis – HACCP – A food safety assurance system. Food regulations, standards and quality control. Prevention of food adulteration. Consumer protection Act, 1986 – Regulations related to genetically modified foods.

Expected Course Outcomes: On the successful completion of the course, students will be able to:

1. Understand the concepts of carbohydrate metabolism and its regulation (K2)
2. Understand the concepts of lipid metabolism and its regulation (K2)
3. Apply the knowledge about Big Data analytics in Metabolic Pathway Analysis (K3) K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create

Recommended Books:

- 1) Food Microbiology (5th ed.) 2017. by W.C. Frazier & D.C. Tata Mc Graw Hill publishinghouse, New Delhi.
- 2) Adams, MR. Food Microbiology Fundamentals & Frontiers 2018 American Society for Microbiology 5th.
- 3) James M. Jay. 5th ed. 2006. Modern food Microbiology. Food Science text series. Springer publication, US.

Practicals: Food safety and quality management signaling (Credits-1)

1. Determination of fungal and yeast count in a given food sample.
2. Determination of coliforms in the given food samples by presumptive testing.
3. Determination of quality of milk sample of methylene blue reductase test
4. Detection of number of bacteria in milk
5. Analysis of air of processing facility for microbial load.
6. Check the Presence of Rhodamine B in given food sample.
7. Test the presence of sugar in honey
8. Detection of NaHCO_3 (chalk) in Flour.
9. Check the presence of Vanaspati and Rancidity in the ghee
10. Check the milk for the presence of proteins, urea, sugar and starch.

IMT 103 Core Course 3(A): Biomolecular Chemistry (Credits 3)

Course Objectives: The main objectives of this course are to:

1. Emphasizes on various biological macromolecules and its significance in biological systems.
2. Learn the basic functions, structures and biological importance of lifeless chemical compounds in life.
3. Upon successful completion, students should have understood the significance of the complex biomolecules, polysaccharides, lipids, proteins, nucleic acids and porphyrins.

Unit I

Molecular logic of Life – Major constituents of cells, Biomolecules. Carbohydrates: Classification, structure, Chemical properties of carbohydrates, reactions of monosaccharides, formation of glycosidic bond, oligosaccharides, chemistry and biological role of homo and heteropolysaccharides; Structural polysaccharides (Cellulose and Chitin), storage polysaccharides (Starch, Glycogen and Inulin), Mucopolysaccharides, Blood group substances, Peptidoglycons.

Unit II

Amino acids and Proteins: Classification, structure and physico chemical properties of amino acids, Essential and non-essential amino acids, Acid base properties and general reactions of amino acids, Non-protein or unusual amino acids, Peptide bond formation and stability.

Classification of proteins, Purification and isolation of proteins, criteria of purity, structural organization of proteins-Primary, Secondary, Tertiary and Quaternary structure, confirmation of proteins-Ramachandran plot, Denaturation of proteins.

Unit III

Lipids and Porphyrins: Classification and Structure, properties and classification of lipids, fatty acids, waxes, phospholipids, cerebroside and gangliosides, lipoproteins, prostaglandins, leukotrienes, thromboxanes, steroids and bile acids. Structure of Porphyrins, Structure and function of Heme, Cytochromes and Chlorophyll.

Unit IV

Nucleic acids: Purine and Pyrimidine Bases, Nucleosides, Nucleotides, Formation of phosphodiester bond and its stability, Structure of DNA-Watson and Crick model, different forms of DNA, types of RNA, Structure of t-RNA, Denaturation and Renaturation of DNA, melting curves.

Recommended Books:

- 1) Glycoproteins by Hughes R.C., Chapman & Holl.
- 2) Biochemistry – Mechanisms of metabolism Cunningham, E.B., Mc Grew – Hill.
- 3) Nucleic acid – Chargaff & Davidson Vol. II
- 4) The Biochemistry of Nucleic acids; Adams et al., Chapman and Hall.
- 5) Proteins: A guide to study by Physical & Chemical
- 6) Proteins: Structure, function and evolution. Dickerson Geis, 2nd Edn, Benjamin/Cummings, Menlo Park.
- 7) The proteins: Neurath and Hill, 3rd Ed. Academic New York.
- 8) Biochemistry – Zubay C, Addison – Wesley.
- 9) Biochemistry, A Problem Approach, 2nd Ed. Wood, W.B. Addison Wesley.
- 10) Biochemistry of Lipids and Membranes – Vance D, Addison – Wesley.
- 11) Biochemistry, Lehninger A.H.
- 12) Textbook of Biochemistry West, E.S., Todd, Manson & Vanbruggen, Macmillian &co.

- 13) Principles of Biochemistry white- A. Handler and Smith E.L. Mc Graw Hill.
- 14) The carbohydrates: Pigman & Hartman Vol. II – A & II- B.
- 15) Comprehensive Biochemistry – Florkin & stotz, Academic Press.
- 16) Organic chemistry, I.L. Finar, ELBS.
- 17) Organic chemistry by J.P. Cohen. Vol. 3 Edward Arnold.
- 18) Basic Principles of Organic Chemistry by Roberts & Cashino (Benjamin)
- 19) Fundamentals of Biochemistry by Voet and Voet.
- 20) Organic chemistry by Morrison and Boyd Prentice Hall.

Expected Course Outcomes: On the successful completion of the course, students will be able to:

1. Helps to understand about the polysaccharides and its types (K1 & K2).
 2. Gives a clear understanding about the lipids and its role (K1 & K2).
 3. A Clear Knowledge regarding amino acids and protein characterization (K2 & K3).
 4. Provides the structure and properties of Nucleic acids (K2 & K3)
 5. Gives an idea about energy level and its synthesis (K1, K2 & K3).
- K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create

Practicals: Biomolecular Chemistry (Credits 1)

1. General tests of carbohydrates. Specific reactions of selected sugars – Osazones, sucrose, pentoses.
2. General reactions of amino acids and proteins. Precipitation of proteins.
3. Qualitative tests of lipids and steroids.
4. Estimation of amino acids by formal titration.
5. Estimation of tyrosine by Millons – reaction.
6. Estimation of amino acid by Ninhydrin method.
7. Effect of solvent system on the Rf value of two solutes.
8. Estimation of proteins by Lowry methods.
9. Estimation of proteins by Biuret methods.
10. Isolation of mitochondria from Rat liver by Density gradient centrifugation (Demonstration)

IMT 103 Core Course 3(B): Plant Biochemistry (Credits-3)

Course Objectives:

1. To illustrates knowledge of stress adaptations in biological systems.
2. To deliver molecular understanding of primary and secondary metabolic process.
3. To present perspectives of the current tools for application in biological system forbiotechnological research.
4. Demonstrate the concept using different activities for building capacity.

Unit-I

Plant hormones – Types of Plant Hormones and their Functions. Biosynthesis, storage, breakdown and transport; physiological effects and mechanisms of action.

Unit-II

Sensory photobiology - Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; stomatal movement; photoperiodism and biological clocks.

Unit-III

Solute transport and photo assimilate translocation – uptake, transport and translocation of water, ions, solutes and macromolecules from soil, through cells, across membranes, through xylem andphloem; transpiration; mechanisms of loading and unloading of photo-assimilates.

Secondary metabolites - Introduction to primary and secondary plant metabolites. Classification of secondary metabolites. Functions of secondary metabolites Biosynthesis of terpenes, phenols and nitrogenous compounds and their roles.

Unit-IV

Stress physiology – Responses of plants to biotic (pathogen and insects) and abiotic (water, temperature and salt) stresses. Stress and determined hormones ABA as a signaling molecule Cytokinin as a negative signal. Oxidative stress: Relative Oxygen Species (ROS), role of scavenging systems (SOD catalase etc.).

Expected Course Outcomes: On the successful completion of the course, students will be able to:

1. Helps to understand about plant hormones synthesis, transport and physiological functions (K1 & K2).
2. Gives a clear understanding about the role of plant hormone on growth and abscission of plant growth with their mechanism of action at molecular level (K1 & K2).
3. A Clear Knowledge regarding plant transport through cells membranes and pith (K2 & K3).
4. Helps to understand about the structure and functions of secondary metabolites (K2 & K3)
5. Gives an idea about of biotic and abiotic stress adaptations (K1, K2 & K3).

Practical: Plant Biochemistry (Credits 1)

1. Thistle Funnel Experiment
2. Determination of Osmotic Pressure
3. Effect of carbon di oxide concentration on the rate of photosynthesis
4. Estimation of Sugar
5. Estimation of Chlorophyll
6. Demonstration of anaerobic respiration

Recommended Books:

- 1) Biochemistry & Molecular Biology of Plants. Authors: Buchanan BB, Gruissem W and Jones RL (2000), American Society of Plant Physiologists.
- 2) Lehninger Principles of Biochemistry, Authors: David L. Nelson and Michael M. Cox.
- 3) Plant Physiology. Authors: Taiz L, and Zeiger E, (2006), Sinauer Associates, Inc. Biochemistry. Authors: Berg JM, Tymoczko, JL, and Stryer L (2006). W. H. Freeman.
- 4) Plant Pathology. Authors: Agrios GN 5 ed; 2005, Elsevier Academic Press.

IMT 105 1(A) Skill Oriented Course 1(A): Microbiology (Credits 3)

Course Objectives: The main objectives of this course are to:

1. Provide knowledge about microbial culture techniques.
2. Learn the concepts of different energy sources.
3. Understand the basic concepts of food fermentation and its industrial applications.
4. Understand the concepts for diagnosing infectious diseases and assessment of antimicrobial activity.

Unit I

Microorganisms and their place in the living World; Historical developments of microbiology (Spontaneous generation, Germ theory of disease and Koch's postulates). Nomenclature and broad classification of bacteria as per Bergey's manual of systematic bacteriology; General characteristics of Actinomycetes, Rickettsiae, Mycoplasmas, Spirochetes. Difference between prokaryotic and eukaryotic cells. Ultra structure of bacterium and endospore.

Unit II

Nutritional requirements in microorganisms: Modes of nutrition – phototrophy, chemotrophy, methylotrophy, organotrophy, mixotrophy, saprophytic, symbiotic and parasitic modes of nutrition. Isolation of microorganisms – Direct and indirect Methods of maintenance of culture. Growth and kinetics of bacterial cells; Normal and biphasic growth curve, batch and continuous cultures, chemostats. Preservation of cultures (glycerol stocks, freeze drying), Culture collection centers in India.

Unit III

Control of microorganisms: Fundamentals of control, control by physical and chemical agents. Antibiotics and other chemotherapeutic agents. Microbiology of Food, Water, Sewage and Biogas. Water and Sewage treatment. Food and water-borne infections. Estimation of BOD and COD and their importance. Outlines of the Ames Test.

Unit IV

Introduction to Virology: Classification, Morphology, size, ultra structure and life cycle of some representative viruses (ØX 174, T4, SV40, λ-Phase, M13 and HIV). Methods of culturing of viruses, Isolation, purification and characterization. Biology of sub viral agents – Viroids, Prions, Satellite viruses.

Recommended Books:

- 1) Microbiology by Pelczar, Chan and Kreig 5th Ed. Mc Graw – Hill
- 2) General Microbiology: Boyd, R.F., Times Mirror / Mosby College.
- 3) Review of Medical Microbiology: Jawetz et al., 16th Ed. Maruzen Asian.
- 4) A text book of Microbiology, R.C. Dubey and D.K. Maheswari, S. Chand Co.
- 5) Pharmaceutical Microbiology, By Hugo and Russell, Blackwell Scientific
- 6) An Introduction to Viruses by S.B.Biswas, Vikas Publishing House.
- 7) Microbial world (5th Ed.) RY. Stainer, Hamshire – Macmillan Press.
- 8) Microbiology 4th Ed. Prescott, Harley, Klein (Mc Graw Hill)
- 9) Diseases of Crop Plants – G. Rangaswamy.
- 10) Plant Pathology – J.C. Walker.
- 11) Fundamentals of Microbiology - M. Fiebisher.
- 12) Text book of Microbiology – William Burrows
- 13) Biology of Microorganisms – Sandes T. Lyles
- 14) Instant notes in Microbiology – Nicklin et al
- 15) Microbial Ecology – Atlas

Expected Course Outcomes: On the successful completion of the course, students will be able to:

1. Students will be able to apply culture techniques for isolation of microbes from various sources and preserve the isolates (K3).
 2. Students will gain knowledge about different energy sources such as inorganic compounds, organic compounds and visible radiation for organisms (K2).
 3. Students will learn about fermentation in food industry (K2).
 4. Students will learn about the isolation and identification of microbes from textiles (K3).
- K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate;

Practicals: Microbiology (Credits 1)

1. Structure, Handling and calibration of Microscope.
2. Methods of Sterilization: Autoclave (Moistened – heat sterilization), Oven (dry heat sterilization).
3. Preparation of Media for Bacteria.
4. Methods for isolation and cultivation of pure cultures: serial dilution, pour plate, spread plate and streak plate.
5. Bacterial growth curve: *E. coli*.
6. Methods of staining: Gram, acid fast and bacterial spore.
7. Determination of antibiotic sensitivity with selected antibiotics
8. Starch hydrolysis assay for the identification amylase – producing microorganisms.
9. Water analysis for bacteria and determination of B.O.D. of water.
10. Isolation and quantification of phages from sewage by plaque assay.

Recommended Books:

- 1) Microbiology laboratory Manual 4th Ed. By Cappuccino
- 2) Microbiology laboratory Manual (2001) by Aneja K.M.
- 3) Laboratory Manual in Microbiology by P. Gunasekaran (1996), New Age Publ.
- 4) Molecular Cloning by Sam Brook.

IMT 105 Skill Oriented Course 1(B): Inheritance Biology (Credits-3)

Course Objectives:

1. Identify and describe the process and purposes of the cell cycle, meiosis, and mitosis, as well as predict the outcomes of these processes.
2. Transmission genetics problems, make accurate predictions about inheritance of genetic traits, and map the locations of genes
3. To identify the parts, structure, and dimensions of DNA molecules, RNA molecules, and chromosomes, and be able to categorize DNA as well as describe how DNA is stored
4. To describe what causes and consequences of DNA sequence changes and how cells prevent these changes, as well as make predictions about the causes and effects of changes in DNA
5. To describe applications and techniques of modern genetic technology, as well as select the correct techniques to solve practical genetic problems

Unit - I

Introduction to Genetics Brief history/basic concepts of genetics, Cell division and chromosomes. Mendelian genetics/monohybrid, dihybrid cross. Mendelian genetics/trihybrid cross, probability. Modification of Mendelian ratios/incomplete and codominance. Modification of Mendelian ratios/incomplete and codominance. Structure of Gene. Atavism. (<https://www.slideshare.net/vanessaceline/introduction-to-genetics>).

Unit – II

Chromosome abnormalities Diploid chromosomes number- Sex differentiation and sex determination. The X chromosomes, Barr bodies, the Lyon hypothesis. Aneuploidy and polyploidy: Gene deletion, duplication, inversions and translocation. Sex Linkage in Drosophila and Man, Sex Influenced and Sex Limited Genes - Non-Disjunction and Gynandromorphs - Cytoplasmic Inheritance. Kappa particles in Paramecium, Milk Factor in Mice. (Blended mode of teaching)

Unit- III

Blood groups and Crossing over Blood Groups and their Inheritance in Human - Linkage and Crossing Over: Drosophila - Morgans' Experiments - Complete and Incomplete Linkage, Linkage Groups, Crossing Over types, Mechanisms - Cytological Evidence for Crossing Over, Mapping of Chromosomes - Interference and Coincidence.

Unit – IV

Nature and Function of Genetic Material Fine Structure of the Gene - Cistron, Recon, Muton - Mutation - Molecular Basis of Mutation, Types of Mutation, Mutagens, Mutable and Mutator Genes. Chromosomal Aberrations - Numerical and Structural Examples from Human.

Expected Course Outcomes: On the successful completion of the course, students will be able to:

1. Students will be able to gain knowledge on classical genetics and Mendelian laws and structure and function of gene.
2. Students will gain knowledge about dominance and co- dominance and competence and other characters deviated from Mendelian laws
3. Students will learn about chromosome abnormalities and sex linked and sex influenced genes (K2).
4. Students will learn about the non disjunction of chromosomes and gynandromorphs (K3).
5. Concept of benzers experiment on the concept of linkage and mechanism of crossing over. (K3)

Recommended Books:

- 1) Genetics by Verma, P.S. and V. K. Aggarwal.
- 2) Genetics by Russell P.J.
- 3) Genetics analysis and principles by Brooker R.J and McGraw Hill.
- 4) Basic Genetics by Miglani G.S.
- 5) Genetics: Analysis of genes and genomes by Hartl D.L and Jones E.W.

Practicals: Inheritance Biology (Credit-1)

1. Study of microscope.
2. Study of cell structure
3. Mitosis and Meiosis cell division.
4. Experiments on epistatic interactions including test cross and back cross.
5. Experiments on probability and Chi-square test.
6. Study of models on DNA and RNA structures.

Course outcome

1. Identify and describe the process and purposes of the cell cycle, meiosis, and mitosis, as well as predict the outcomes of these processes.
2. Transmission genetics problems, make accurate predictions about inheritance of genetic traits, and map the locations of genes.
3. To identify the parts, structure, and dimensions of DNA molecules, RNA molecules, and chromosomes, and be able to categorize DNA as well as describe how DNA is stored.
4. To describe what causes and consequences of DNA sequence changes and how cells prevent these changes, as well as make predictions about the causes and effects of changes in DNA.
5. To describe applications and techniques of modern genetic technology, as well as select the correct techniques to solve practical genetic problems.

IMT 106 Skill Oriented Course 2(A): Molecular Biology (Credits 3)

Course Objectives: The main objectives of this course are to:

1. Familiarize the students with specific characteristics of Molecular Biology, know the analytical methods commonly used in Molecular Biology.
2. Obtain hands on experience in some of the important molecular biology techniques and to learn the basic principles of recombinant DNA technology.

Unit I

Central dogma in molecular biology and its verification. Conservative, semi conservative and dispersive mode of DNA replication, Uni and bidirectional DNA replication, discontinuous synthesis of DNA, DNA primers, DNA polymerase I, II & III, DNA ligase, AP endonuclease, Topoisomerases and telomerase.

Inhibitors of DNA synthesis, fidelity of replication. Mechanism of replication of *E. coli* DNA. 'θ' and 'σ' replication, Replication of 'λ' Phage DNA, Phage T₇ and single stranded DNA. DNA repair and recombination. Bidirectional and unidirectional replication.

Unit II

Structure and functions of prokaryotic and eukaryotic RNA polymerase. Inhibitors of Transcription. DNA binding motifs. Biosynthesis of prokaryotic and Eukaryotic m-RNA, r-RNA, and t-RNA.

Post transcriptional modifications of RNA- capping, adenylation and splicing. Role of *hn* RNA, *sn* RNA and *sn* RNP in processing of RNA.

Gene expression models in prokaryotes: operon, operator, promoter, attenuator, repressor, co-repressor, inducer, apoinducer, gratuitous inducer, induction and repression. Lac operon, His- operon, Trp- operon of *E. coli*.

Unit III

General features of the genetic code, Deciphering of the genetic code - Nirenberg and Khorana's work. Co-linearity of gene and protein. Wobble hypothesis and deviation from wobble hypothesis. Mitochondrial genetic code and evolution of genetic code.

Unit IV

Composition of Prokaryotic and eukaryotic ribosomes. Polysomes and organelles ribosomes.

Amino acid activation, protein chain initiation, elongation, and termination. Mechanism of protein synthesis in relation to gene action. Inhibitors of protein synthesis. Post translation modification of proteins. Synthesis of secretory and membrane proteins – signal sequence hypothesis. Mi and Si RNA mediated translation control.

Recommended Books:

- 1) Molecular Biology of the Gene by Watson
- 2) Genetics by G. Zubay
- 3) Molecular Biology of the Cell by Albert Bruce *et al.*, 5th Ed.
- 4) Cell Molecular Biology by Baltimore
- 5) Molecular Biology by D Friefelder
- 6) Molecular Genetics by D Friefelder
- 7) Genes VIII by Benjamin Lewin. Oxford Univ. Press. London.
- 8) Cell and Molecular Biology 2nd Ed. By P.K. Gupta, Rastogi Publ.
- 9) Cell and Molecular biology by De Robertis and De Robertis. 8th Ed.
- 10) Molecular Genetics by Sambamurty
- 11) Cell and Molecular Biology 2nd Ed. By S C. Rastogi.

Online Content:

- 1) [https://bio.libretexts.org/Bookshelves/Cell_and_Molecular_Biology/Book%3A_Cells_-_Molecules_and_Mechanisms_\(Wong\)](https://bio.libretexts.org/Bookshelves/Cell_and_Molecular_Biology/Book%3A_Cells_-_Molecules_and_Mechanisms_(Wong))
- 2) <https://nptel.ac.in/courses/102/106/102106025/#>
- 3) <https://www.easybiologyclass.com/molecular-biology-online-tutorials-lecture-notes-study-materials/>
- 4) <https://www.mooc-list.com/tags/molecularbiology?title=MOLECULAR+PHYSIOLOGY>

Expected Course Outcomes: On the successful completion of the course, students will be able to:

1. It trains the students to gain the concepts of Central Dogma of Molecular Biology (K2).
2. Helps the students to understand, evaluate and analysis the cellular processes Replication, Transcription and Translation (K2, K3 & K5)
3. Aids in the technical understanding of the cellular mechanisms of heredity, gene expression and protein synthesis (K2, K3 & K5).
4. Understand and familiarize in the modern molecular biological techniques and its applications (K2, K3, K4 & K5).

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create

Practicals: Molecular Biology (Credit 1)

1. Isolation of DNA and RNA from bacteria.
2. Isolation and determination of DNA from bacteria, plant and animal cells.
3. DNA estimation by Diphenylamine method.
4. Determination of DNA and purity by UV absorption method.
5. Isolation and determination of RNA content from yeast.
6. RNA estimation by Orcinol method
7. Determination and analysis of melting curve of DNA (T_m of DNA)
8. Isolation and concentration determination of plasmid DNA from *E. coli*

IMT 106 Skill Oriented Course 2(B): Biotechnology and Nanotechnology (Credit 3)

Course Objectives: The main objectives of this course are to:

1. Emphasizes to learn about the principles involved in fermentation technology, fermentors.
2. Exposure to learn the concepts involved in making immobilized enzymes and their use in various product synthesis.
3. Provides basic concepts about vaccines and in vitro culturing.
4. Provides knowledge about transgenic plants and animals and their applications.

Unit I

Immobilized enzymes and their applications. Protein engineering. Production of glucose from starch, use of glucose isomerase in confectionary industry, use of lactase in dairy industry, production of invert sugar from Glucose and sucrose.

Use of protease in food, detergent and leather Industries, Biosensors (glucose oxidase in enzyme electrodes).

Unit II

Isolation, preservation and maintenance of industrial microorganisms, batch, continuous culture techniques, Types of fermenters. Industrial production of alcohol, acids (Lactic and Acetic), solvents (acetone and Butanol), antibiotics (penicillin), Vitamins (Riboflavin), amino acids (glutamic acid) and single cell protein (SCP).

Unit III

Animal and plant cell /tissue culture techniques: Micro propagation, somatic cell culture, soma clonal variations, somatic cell hybridization, protoplast fusion, genetic transformation.

Methods of gene transfer, vector and vector less methods, production of transgenic plants and animals and their applications.

Unit IV

Nano technology: Green Synthesis and characterization of metallic nanoparticles using plants and microorganisms Structural analysis and their applications in agri biotechnology. Nano fertilizers -A way forward for green economy. Nanobiosensors –Next generation diagnostic tools in Agriculture. Development of Nano formulations for crop improvement.

Recommended Books:

1. Fermentation Technology (2nd Ed.) Standury (Pergman Press).
2. Biotechnology: Textbook of Industrial Microbiology 2nd Ed. by Wulf Crueger and Anneliese Crueger (2000).
3. Molecular Biotechnology: Principles and Applications of Recombination DNA (1996) Bernard R. Glick and Jack. J. Pasternak (Panima Publishing Corporation)
4. Principles of Gene Manipulation: An Introduction to Genetic Engineering (5th Ed.)
5. Principles of Biotechnology (1985) Alen Weisman (Surrey University Press)
6. Concepts in Biotechnology (1996) Ed. D. Balasubramanian, K. Dharmalingam, J. Green and K. Jayaraman (University Press)
7. Industrial Microbiology, Miller and Litsky, Mc Graw – Hill, 1976.
8. Industrial Microbiology, L.E. Casida, JR New Age International (1995)
9. Industrial Microbiology (Prescott & Dunn), Ed by G. Reed, CBS Publishers.
10. Immobilized Enzymes (1978) by Ichiro Chibata, Halsted Press Book.

Expected Course Outcomes: On the successful completion of the course, student will be able to:

1. Learn the immobilization process of cells and enzymes, and types (K1 & K2).
 2. Understand about industrial production of various products used for human welfare (K1 & K2).
 3. Understand about plant tissue culture, plant secondary metabolites, elicitation and methods involved in gene transfer of plants and machine learning in the analysis of plant (K2, K3 & K4).
 4. Students will learn about transgenic animals and plants (K2, K3 & K4).
- K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create

Practicals: Biotechnology and Nanotechnology (Credits 1)

1. Lactic acid fermentation by *Lactobacillus*
2. Production of enzymes by microorganisms – Amylase, protease
3. Fermentation process during curdling, estimation of lactose, lactic acid, protein, bacterial count
4. Synthesis and characteristics of nanoparticles
5. Callus propagation, organogenesis, transfer of plants to soil
6. Synthetic seed preparation
7. Protoplast isolation and culture
- 8.

Audit course 109: Indian Knowledge System I: Indian Health Sciences (Audit Course)

SEMESTER II

IMT 201 Core Course 4: Intermediary Metabolism II (Credits 4)

Course Objectives: The main objectives of this course are to:

1. To understand the, lipids, nucleic acids and proteins metabolism.
2. To impart knowledge of the concepts of regulation of metabolism.
3. To offer basic knowledge about an overview of metabolic pathways and their regulations analysis.

Unit I

Nucleic acid metabolism. Synthesis of nucleotides and its regulation, Biosynthesis and degradation of purines and pyrimidines and its regulation. Salvage pathway, Lesch-Nyhan Syndrome, Synthesis of ribonucleotides, deoxy-ribonucleotides and its regulation. Inter-conversion of nucleotides. Nucleotides as metabolic regulators.

Unit II

Nitrogen cycle, Biological Nitrogen fixation. Nitrate and ammonia utilization, ammonia excretion, synthesis of glutamine. Formation of nitrogenous excretion products.

Urea cycle. Amino acids as precursors – formation of Polyamines, Creatine, Histamine.

Unit III

Amino acid degradation, transamination, oxidative deamination, pathways of degradation of different amino acids, biosynthesis

of essential and non-essential amino acids. Regulation of amino acid biosynthesis.

Unit IV

Inborn errors of amino acid metabolism – Phenylketonuria, Alkaptonuria, Maple-Syrup urine disease. Biosynthesis and degradation of Heme, Glutathione, γ - glutamyl cycle, gramicidin. Disorders of lipid metabolism – Gauchers disease, Tay-Sachs disease, Hypo and Hyper lipoproteinemia.

Recommended Books:

1. Principles of Biochemistry, White. A, Handler, P and Smith
2. Biochemistry, Lehninger A.L.
3. Biochemistry, David E. Metzler.
4. Biochemistry, Lubert Stryer.
5. Review of Physiological chemistry, Harold A. Harper.
6. Text of Biochemistry, West and Todd.
7. Outlines of Biochemistry, Conn and Stump
8. Metabolic Pathways – Greenberg.
9. Mitochondria, Munn.
10. Biochemistry, 2nd Ed, G. Zubay.

Expected Course Outcomes: On the successful completion of the course, students will be able to:

1. Understand the concepts of metabolism of amino acids and urea cycle (K2)
 2. Understand the concepts of nucleotide metabolism and regulation mechanism (K2)
 3. Apply the knowledge about overview of Metabolic Pathways and their regulation Analysis (K3)
- K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create

IMT 202 Core Course 5(A): Molecular Physiology (Credits 3)

Course Objectives: The main objectives of this course are to:

1. Know the various aspects of brain and neurotransmitters.
2. Understand the functioning of neurotransmitters and drugs on brain.
3. Know the aspects related to biochemistry of vision.
4. Assimilate the concepts of muscle contraction and muscle functioning.

Unit 1

Bio-membranes - composition of Membranes. Membrane lipids, proteins and carbohydrates. Molecular structure of membranes, fluid mosaic model of biological membranes. Membrane transport: Active transport, Active transport of Na^+ K^+ (sodium potassium ATPase) Ca^{2+} (Ca^{2+} - ATPase). Basic concepts of cell signaling and transduction, different signaling molecules, second messengers, calcium, calmodulin, inositol phosphate, cAMP, cGMP, NO. Signal cascades. Homeostasis.

Unit II

Presynaptic events at the neuromuscular junction: cholinergic and non-cholinergic synapses. Chemical composition of brain, formation, structure and biochemistry of myelin, chemistry of major brain lipids, lipid composition, Special nervous system proteins. Drugs acting on brain - antidepressants and benzodiazepines.

Biochemistry of vision: Structure, Composition, Metabolism and blood supply to the eye, lens and retina, rods and cones. Photochemistry of vision. Role of vitamin A in vision. Processing of visual information.

Unit III

Neurotransmitters - chemistry, synthesis, storage and release of neurotransmitters, transmitter action, chemical events at synapses, post synaptic events. Various classes of neurotransmitters-Glutamate, GABA, catecholamines (Epinephrine, norepinephrine and dopamine), serotonin, acetyl choline.

Structure and function of muscle – skeletal muscle structure, Biochemical characterization and extracellular matrix.

Plasmalemma, sarcoplasmic reticulum and myofibrils, actin, myosin, streptomycin, troponin, muscular contraction, sliding filament mechanism, oxidative and anaerobic metabolism.

Unit IV

Circulatory System: Blood composition, Heart-Structure. Electrical activity, Heartbeat, Arterial system, micro circulation and lymphatics, cardiac cycle and cardiac output, control of circulation.

Respiratory system: Mechanics of respiration, gas exchange in the lungs, control of breathing.

Excretory System: Kidneys – Glomerular filtration, tubular function, formation of urine, regulation of water and mineral balance.

Recommended Books:

1. Basic Neurochemistry 5th Ed. By Siegel.
2. Essentials of Neural Science and Behavior by Kandel.
3. Neurobiology molecules, Cells and Systems by Mathews.

Course Outcomes: On the successful completion of the course, students will be able to:

1. Gives an idea about the brain and its organization (K1 & K2).
2. Helps to collect information about neurotransmitters and drugs, and their role in brain (K1 & K2).
3. Gives a clear understanding about the biochemistry of vision and aging related problems (K1 & K2).
Clear Knowledge on disorders of brain, eye and muscle (K2 & K3).
5. Provides clear understanding of muscle types and muscular disorders (K2 & K3).

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create

Practicals: Molecular Physiology (Credit 1)

1. Complete blood picture: RBC count.
2. Complete blood picture: TLC.
3. WBC differential count.
4. Erythrocyte sedimentation Rate (ESR).
5. Packed cell volume (PCV)
6. Determination of Haemoglobin (Hb).
7. Mean cell Haemoglobin and Mean cell RBC volume.
8. Osmotic fragility of RBC

IMT 202 Core Course 5(B): Molecular Signaling & Immuno-Technology (Credits 3)

Course Objective:

1. Stages of mitosis and meiosis, highlighting similarities and differences, understand the cancer and cell cycle.
2. Understand the basic principles of signal transduction mechanisms, in particular the concepts of response specificity, signal amplitude and duration, signal integration and intracellular location
3. Understand the structure and function at the molecular and cellular level of the immune defence, provide the knowledge about the transfusion and transplantation immunological reactions able to provide an overview for polyclonal, monoclonal and humanized antibodies and production of hybridoma
4. To gain a deep knowledge about the immunization/vaccination, immunological disease and immunotherapy.
5. Discuss immunological techniques and their applications in biotechnical industry, the key roles of mitosis and meiosis during the life cycle. Compare and contrast different life cycle strategies, focusing on the human life cycle.

Unit I

Cell cycle and Cancer biology: Mitosis and meiosis, their regulation, steps in cell cycle, and control of cell cycle. Check points in cell cycle, regulation and control of cell cycle, inhibitors Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, Angiogenesis, interaction of cancer cells with normal cells, apoptosis, therapeutic interventions of uncontrolled cell growth.

Unit II

Cell signaling Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant two-component signaling systems.

Quorum sensing in bacteria- Chemotaxis, Role of acyl homolactone serine in quorum sensing, types of quorum sensing, regulation of quorum sensing.

Unit III

Hybridoma technology: Production, purification and characterization of monoclonal antibodies. Application of monoclonals in biomedical research, clinical diagnosis, treatment and drug targeting.

Transplantation immunology –relationship between donor and recipient, immune response to graft rejection, clinical characteristics of allograft rejection. Transplantation antigens. MHC class I & II as targets of graft rejection, Tests for histocompatibility antigens, prolongation of allografts, graft versus host disease.

Unit IV

Immunoprophylaxis: Types of vaccines – Conventional (BCG, Salk, Influenza, DPT) DNA vaccines, Glycoconjugate vaccines, Deletion vaccines, DC based vaccines, basis of attenuation. Recent developments in vaccine technology, Vaccine delivery system

and approaches to enhance immunogenicity, immuno modulators and immunomodulation, adjuvant, cytokines / interleukins based immune therapy.

Recommended Books:

- 1) Basic Immunology: Functions and Disorders of the Immune System 6th Edition by Abul K. Abbas, Andrew H. Lichtman, Shiv Pillai, Publisher : Elsevier; 6th edition (April 24, 2019)
- 2) Roitt's Essential Immunology (Essentials) 13th Edition by Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt, Publisher: Wiley-Blackwell; 13th edition (January 17, 2017).
- 3) Introductory Immunology, 2nd: Basic Concepts for Interdisciplinary Applications 2nd Edition, Publisher : Academic Press; 2nd edition (February 27, 2019)
- 4) Clinical Immunology: Principles and Practice 5th Edition by Robert R. Rich, Thomas A Fleisher, William T. Shearer, Harry Schroeder, Anthony J. Frew, Cornelia M. Weyand: Elsevier; 5th edition (March 27, 2018)
- 5) Hancock, J. T. Cell signalling. 2a ed. Oxford University Press, 2005.
- 6) Lodish, H., Berk, A., Zipursky, S., Matsudaira, P., Baltimore, D. and Darnell, J.E Molecular Cell Biology, W.H. Freeman and Company, 2000.
- 7) Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. Molecular Biology of the Cell, Garland Publishing, 2002.
- 8) Molecular Cell Biology by Harvey Lodish, Arnold Berk, Chris A. Kaiser and Monty Krieger, 2012.
- 9) Becker's World of the Cell (8th Edition) by Jeff Hardin, Gregory Paul Bertoni and Lewis J. Kleinsmith 2011.
- 10) Cell and Molecular Biology: Concepts and Experiments by Gerald Karp, 2009
- 11) Physical Biology of the Cell by Rob Phillips, Jane Kondev, Julie Theriot and Hernan Garcia, 2012
- 12) The Cell: A Molecular Approach, Fifth Edition by Geoffrey M. Cooper and Robert E. Hausman, 2009.
- 13) Molecular biology of cell- Bruce Alberts, Cell Biology – Karp, Cell signaling by John T Hancock (Oxford).
- 14) Atlas of Immunology, J.M. Cruse, R.E. Lewis. 2000. CRC Press, New York.
- 15) Clinical Immunology by Chaper, Harvey, Shah, Snowden. 2006. Blackwell Publishers, New York

Expected Course Outcomes: On the successful completion of the course, students will be able to:

1. Understanding of detailed mechanism in cell cycle and its regulation cell cycle check points (K1, K2 & K3).
2. Course material will help in understanding of various cell signaling mechanisms in cell (K2)
3. The course will advance the knowledge of hybridoma technology and mono clonal antibodies production (K2 & K3).
4. Students will thoroughly understand the concepts of Immuno-prophylaxis and immuno-modulators (K2 & K4).
5. Students will gain advance knowledge on vaccine productions.

Practicals: Molecular Signaling & Immuno Technology (Credits 1)

1. Isolation of cell organelles
2. Normal and cancer cells-cytotoxicity assay (Trypan blue dye exclusion)
3. Agglutination Widal (slide & tube) test for typhoid fever VDRL test for syphilis
4. Purification of IgG by Sephadex G column chromatography
5. Purification of antibodies by ammonium sulfate precipitation and dialysis
6. Dot ELISA
7. Sandwich ELISA
8. Antigen capture ELISA
9. Antibody capture ELISA
10. Rocket Immuno electrophoresis

IMT 203 Core Course 6(A): Enzymology (Credits 3)

Course Objectives: The main objectives of this course are to:

1. To understand the classification of enzymes and fundamentals of enzyme assay. Also, understanding of kinetics of enzyme catalyzed reactions and derivation of Michaelis Menten equation.
2. To advance the knowledge on mechanism of enzyme action as well as regulation of enzyme action with relevant examples.

Unit I

Classification of enzymes, protein confirmation, specificity and active site. Units of enzyme activity, enzyme coupled kinetic assay. Compartmentation of enzymes. Factors affecting velocity of enzyme catalyzed reactions – effect of pH, temperature, enzyme concentration and substrate concentration. Kinetics of enzyme catalyzed reactions.

Enzyme kinetics of single substrate reactions, study state assumption, Michalis – Menten, Lineweaver Burk, Eadie Hofstee, Hanes plots.

Unit II

Enzyme inhibition: irreversible, reversible, competitive, non-competitive, un – competitive and partial inhibition.

Determination of K_i values, substrate inhibition, feedback inhibition and allosteric inhibition. Kinetics of enzymatic reactions having two or more substrates – single displacement reactions, double displacement reactions (Ping-Pong).

Unit III

Types of enzyme catalysis mechanisms, acid-base catalysis, electrostatic catalysis, covalent catalysis, metal ion catalysis, proximity and orientation. Effects, preferential transition state binding.

Catalytic mechanisms of chymotrypsin, Trypsin, Carboxypeptidase, Ribonuclease and Lysozyme. Catalytic RNA (Ribozyme), abzymes, synzymes.

Mechanism of catalysis with coenzymes – Pyridoxal phosphate, flavin nucleotides, thiamine pyrophosphate, biotin, tetrahydrofolate, lipoic acid.

Unit IV

Enzyme Regulation: General mechanisms, allosteric enzymes – AT case, cooperativity phenomenon, Sigmoidal kinetics and their physiological significance, Symmetric and sequential models for action of allosteric enzymes and their significance.

Feedback inhibition. Reversible and irreversible covalent modifications of enzymes, cyclic and cascade systems, Zymogens, Isoenzymes, multienzyme systems – pyruvate dehydrogenase, fatty acid synthase complex.

Recommended Books:

1. The enzymes Dixon & Webb, 3rd ed. Longman.
2. Understanding enzymes: Palmer T., Ellis Harwood Ltd.
3. Enzyme Kinetics: Roberts D.V., Cambridge Univ. Press.
4. Enzyme structure and mechanism. Alan Fersht, Freeman & Co.
5. Principles of Enzymology for Food Sciences: Whitaker Marc Dekker.
6. The enzyme Boyer 3rd Ed. Academic Press.
7. Methods in Enzymology Ed. Colowick and Kaplan, Academic Press (continuing series)
8. Text book of Biochemistry with Clinical Correlations (4th edition) – Thomas M. Devlin.
9. Fundamentals of enzymology 3rd edi. Nicholas C. Price and Lewis Stevens.
10. Biological chemistry; H.R. Mehler & E.H Cordes Harper & Rev.
11. Enzymes and Metabolic Inhibitors Vol. I & II J. Webb Acada. Press
12. Enzyme Kinetic Siegel Inter Science – Wiley.
13. Biochemistry Chemical reactions of living cells by David E. Matzler. Vol.I.
14. Enzyme Catalyzed Reactions by G.H. Gray.

Online Content:

- 1) Introduction to Data Mining, Pang-NingTan (2018) Pearson Education India
- 2) <https://books.google.co.in/books?id=64GVEjpTWIAC>
- 3) <https://www.udemy.com/course/enzymology/>
- 4) <https://www.classcentral.com/course/swayam-enzymology-19860>
- 5) <https://www.mooc-list.com/course/biochemistry-biomolecules-methods-and-mechanisms-edx>

Expected Course Outcomes: On the successful completion of the course, students will be able to:

1. Understanding of detailed mechanism in enzyme regulation with relevant examples (K1, K2 & K3).
 2. Course material will help in understanding of nomenclature and classification of enzymes and also the fundamentals of enzyme assay (K2)
 3. The course will advance the knowledge of students on the mechanism of enzyme action (K2 & K3).
 4. Students will thoroughly understand the Kinetics of enzyme assay and derivation of velocity equations (K2 & K4).
 5. Students will gain knowledge in various immobilization techniques and industrial application of enzymes (K2, K3 & K5)
- K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create

Practicals: Enzymology (Credits 1)

1. Assay of Amylase from saliva
2. Assay of Urease from Horse – gram
3. Assay of Acid phosphatase
4. Assay of serum alkaline phosphatase
5. Assay of SDH from Liver
6. Assay of Invertase from Yeast
7. Assay of Trypsin
8. Assay of LDH from serum (Isoenzymes)
9. Enzyme Kinetics (Determination of V-max, Km and Ki).
10. Effect of pH, Temperature, Activators, Inhibitors, Immobilization of enzymes (demonstration only).

Recommended Books:

1. Hawk's Physiological Chemistry
2. Practical Biochemistry by T Plummer
3. Practical Biochemistry by J Jayaraman
4. Klemir and others: Practical Biological Chemistry
5. Practical Biochemistry - Koch and Hank Dunn and Drell
6. Practical Biochemistry - Sawheny.
7. Varley's Practical Clinical Biochemistry – Ed. Alan W. Gowenlock (Heinemann Medical Books, London).

IMT 203 Core Course 6(B): Ecological Principles (Credits-3)

Course Objectives: The main objectives of this course are to:

1. To understand the components of environment. : Ecosystem structure, energy flow
2. To advance the knowledge on community Ecology and Ecological Succession
3. To advance the knowledge on Population ecology of r and K selections
4. To study the Environmental pollution and biodiversity management.

Unit-I

The Environment: Physical environment; biotic environment; biotic and abiotic interactions. Habitat and Niche: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement
Ecosystem Ecology: Ecosystem structure; ecosystem function; energy flow and mineral cycling (C, N, and P); primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine).

Unit-II

Community Ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones. Ecological Succession: Types; mechanisms; changes involved in succession; concept of climax

Unit-III

Population Ecology: Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); concept of metapopulation – demes and dispersal, interdemec extinctions, age structured populations.

Unit-IV

Applied Ecology: Environmental pollution; global environmental change; biodiversity: status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches

Recommended Books:

- 1) Goldstein, M. & D. Dellasala, 2020. Encyclopedia of World's Biomes. Elsevier. 3500p. 5 vols. Sher, A.A & M. C. Molles. Jr. 2022. Ecology: Concepts and Applications, 9th Edition. Mc Graw Hill. ISBN10:
- 2) Archibold, O.W. 1995. Ecology of World Vegetation. Chapman & Hall, London. Reference Books: Friday, A & D.S. Ingram (Gen. Eds.) 1985. The Cambridge Encyclopedia of LifeSciences, Cambridge Univ. Press, Cambridge. Ecosystems of the World Series - Nos.1,2,3,4,5,6,7,8,12,13, & 14 Elsevier, Amsterdam.
- 3) Singh, J.S., Singh, S.P. & Gupta, S.R. 2014. Ecology, Environmental Science and Conservation. S. Chand & Company Pvt. Ltd., New Delhi. 929p.
- 4) Malcolm L. Hunter, Jr., James P. Gibbs, Viorel D. Popescu. (2021). Fundamentals of Conservation biology (4th edition). Wiley.
- 5) Fred Van Dyke, Rachel L. Lamb (2020). Conservation Biology: Foundations, Concepts, Applications. Springer International Publishing 6
- 6) Anna A. Sher, Richard B. Primack · (2019) an Introduction to Conservation Biology. Oxford University Press
- 7) Krishnamurthy KV (2018) an Advanced Textbook on Biodiversity – Principles and Practice, Oxford and IBH Publishing, New Delhi.
- 8) Singh JS, Singh SP and Gupta SR (2014) Ecology, Environmental Science and Conservation. 4th Edition. S. Chand & Company Pvt. Ltd.
- 9) Peter Stiling (2015). Ecology: Global Insights & Investigations 2nd Edition. McGraw-Hill International edition

Expected Course Outcomes:

On the successful completion of the course, students will be able to:

1. Understanding ecosystem and C O N P cycles in Ecosystems (K1, K2 & K3).
2. Course material will help in understanding of major aspects in Community Ecology, Population Ecology (K2)
3. The course will advance the knowledge of Environmental Pollution and its hazards (K2 & K3).
4. Students will thoroughly understand the concepts of biodiversity.

Practicals: Ecological Principles (Credit-1)

1. Isolation of microbial nucleic acids
2. Extraction of microbial DNA from aquatic sources
3. Extraction of microbial DNA from soil
4. Gel purification of soil DNA extracts
5. Extraction of DNA from Rhizosphere
6. Preparation of radioactive probes and non-radioactive probes (Demonstration)

IMT 205 Skill Oriented Course 3(A): Nutritional Biochemistry (Credits 3)

Course Objectives: The main objectives of this course are to:

1. The main objective of this course is to introduce about Dietary requirements and energy content in foods needed for human body
2. The course aims to give exposure to learn about malnutrition, starvation, protein metabolism in prolonged fasting and diseases that occur due to malnutrition.
3. This course teaches about inherited metabolic disorders and naturally borne food toxicants and allergy causing foods.

Unit I

Principle food components, Balanced diet, Nutritional Requirement, recommended daily requirements, Recommended dietary allowances (RDA), Body composition and energy requirements, Measurement of energy expenditure, direct and indirect calorimetry, BMR

Unit II

Nitrogen balance and muscle protein turnover, essential and non-essential amino acids, Protein requirement, Biological value of

proteins, Protein calorie deficiency state, Kwashiorkor and Marasmus.

Essential fatty acids, energy value of food, phospholipids in nutrition, Starvation.

Unit III

Mineral Nutrients, Micro nutrients and Macro nutrients, dietary sources, deficiency symptoms and recommended dietary allowances of trace elements and macro minerals (Calcium, Phosphorus, Magnesium, Iron, Sodium, Potassium, Iodine, Zinc).

Nutrition for infants, children, pregnant and lactating women and in old age. Role of nutrition in colorectal cancer. Nutrition and diseases: Cancer, obesity, diabetes, stress, etc.

Unit IV

Nutraceuticals and Functional Foods: Sources of Nutraceuticals. Properties, structure and functions of various Phytonutraceuticals (Glucosamine, Lycopene, Carnitine, grape products, flaxseed oil as nutraceuticals). Anti-nutrients and Dietary fibers in nutrition. Nutraceutical remedies for common disorders like Bronchitis, circulatory problems, hypoglycemia, Nephrological disorders, Liver disorders, Osteoporosis.

Recommended Books:

1. Harper's Biochemistry
2. Trace Elements by Underwood
3. The Book of Human Nutrition by MS. Bamji N. Prahlad Rao and V. Reddy.
4. Essentials of food and nutrition, Vol. 1 and 2, by M.S.Swaminathan
5. Nutritional Biochemistry by Truemen.
6. Casarett and Doull's Toxicology. The Basic Science of Poisons 5th Ed. By Klaasen.

Online Content:

1. https://nptel.ac.in/content/storage2/courses/126104004/LectureNotes/Week-5_03-Balanced%20diet%20and%20food%20groups.pdf
2. https://nptel.ac.in/content/storage2/courses/126104004/LectureNotes/Week-1_01-Relationship%20between%20Food,%20Nutrition%20and%20Health%201-A.pdf

Expected Course Outcomes: On the successful completion of the course, students will be able to:

1. To learn energy content in foods. The techniques involved in the measurement of energy expenditure, Dietary requirements of carbohydrates, dietary fiber and dietary lipids (K1 & K2).
2. To learn essential and non-essential amino acids, protein reserves in human body, Protein malnutrition, techniques for the study of starvation, concepts for weight reduction diets (K1, K2 & K4).
3. To know about nutritional requirement during pregnancy, lactation, infants and children, Nutritional significance of dietary calcium, phosphorus, magnesium, iron, iodine, zinc and copper (K1, K2 & K4).
4. To learn about the role of diet and nutrition in the prevention and treatment of diseases, learn about inherited metabolic disorders (K1, K2 & K4).
5. To learn naturally occurring food borne toxicants, Allergy causing foods and management (K1, K2). K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create

Practical: Nutritional Biochemistry (Credits 1)

1. Isolation of casein from milk and estimation.
2. Determination of moisture content of foods/food grain powders
3. Isolation of lactose from skimmed milk and its estimation.
4. Determination of reduced Ascorbic acid by DCPIP method.
5. Determination of calcium in food.
6. Determination of Iodine value of edible oil by Titrimetry.
7. Estimation of fructose in the fruit juice and honey.
8. Determination of acid value by Titrimetry.
9. Determination of available lysine in food.
10. Estimation of copper in food.

IMT 205 Skill Oriented Course 3(B): Nutraceuticals (Credits 3)

Course Objectives: The main objectives of this course are to:

1. The objective of this course learn about macro and micro nutrients in Dietary requirements and their deficiency diseases.
2. The course aims to give exposure malnutrition, starvation, and lifestyle diseases
3. This course teaches nutraceuticals as functional foods and their importance in health
4. The course teaches Nutraceutical remedies for various lifestyle diseases.

Unit-I:

Macronutrients: Water balance, Diet and composition, nutritive values of food. Carbohydrates, protein and lipids- Physiological function, energy values of foods, basal metabolism, nutritive evaluation of proteins and nitrogen balance, energy requirements and nutritional requirements for all age groups. Dietary fiber and its significance.

Micronutrients (Vitamins and trace elements): Vitamins- fat and water soluble, sources, requirements, physiological role deficiency and toxicity symptoms. Minerals and trace elements- physiological role, requirements and toxicity symptoms of calcium, copper, iron, iodine, zinc, cobalt, selenium, fluorine, manganese, magnesium and molybdenum.

Unit -II:

Nutraceuticals or Functional foods: Nutraceuticals and phytochemicals- definition, nutraceuticals in controlling diseases, natural occurrence and physiological importance of phytochemicals, antioxidants, flavanoids, carotenoids, saponins, tanins, phenols, omega 3-fatty acids, glucosides, organosulphur compounds.

Unit -III:

Nutritional disorders: Disorders due malnutrition, Protein energy malnutrition, Marasmus, Kwashiorkor. Hyper tension, cardiovascular diseases, diabetes, obesity, eating disorders- anorexia and bulimia

Unit -IV:

Phytonutraceuticals (Glucosamine, Lycopene, Carnitine, grape products, flaxseed oil as nutraceuticals). Anti-nutrients and Dietary fibers in nutrition. Nutraceutical remedies for common disorders like Bronchitis, circulatory problems, hypoglycemia, Nephrological disorders, Liver disorders, Osteoporosis.

Expected Course Outcomes: On the successful completion of the course, students will be able to:

1. Nutritive value of functional foods nutritional requirements for all aged group persons in the society.
2. Knowledge on macro and micro elements and their role in metabolic pathways and deficiency diseases.
3. Role of phyto-chemicals and nutraceuticals as remedies for common disorders

Practical: Nutraceuticals (Credits 1)

- 1) Isolation of casein from milk and estimation.
- 2) Determination of moisture content of foods/food grain powders
- 3) Isolation of lactose from skimmed milk and its estimation.
- 4) Determination of reduced Ascorbic acid by DCPIP method.
- 5) Determination of calcium in food.
- 6) Determination of Iodine value of edible oil by Titrimetry.
- 7) Estimation of fructose in the fruit juice and honey.
- 8) Determination of acid value by Titrimetry.
- 9) Determination of available lysine in food.
- 10) Estimation of copper in food.

Recommended Books:

- 1) Phytochemicals as bioactive agents-Wayne R.Bidlack (CRCpress)
- 2) Text Book of Biochemistry with clinical correlation- Thomas M.Devlin (JohnWiley) 2nd & 4th Edition
- 3) Principles of human nutrition and dietetics Volume-I & II by M.Swaminathan
- 4) Principles of Biochemistry-Lehninger, Nelson and Cox, CBS publishers.

IMT 206 Skill Oriented Course 4(A): Genetic Engineering (Credits 3)

Course Objectives: The main objectives of this course are to:

1. To study about the DNA modifying enzymes and Vectors used in recombinant DNA technology
2. Understanding the cloning strategies and preparation of probes. In addition, acquiring thorough knowledge about confirmation of rDNA expression by various techniques, including blotting and immunological screening.
3. Upon completion of the course, students might also be thorough about various types of sequencing techniques as well as on biotechnological applications of rDNA technology.

Unit I

Introduction to genetic engineering, cloning, cloning vectors - plasmids, phage vectors, shuttle vectors and cosmids.

Enzymes in genetic engineering: Restriction endonucleases, types, property and applications, RNA and DNA polymerases, nucleases, kinases, phosphatases, ligases, topoisomerases, methylases and gyrases. Linkers and adaptors.

Unit II

RNA isolation, preparation and use of cDNAs. Screening and determination of nucleotide sequences. Construction of cDNA and genomic library, site-directed mutagenesis. Polymerase chain reaction (PCR) in recombinant DNA technology, Chromosome walking

Unit III

Maxam and Gilbert chemical degradation and Sanger's dideoxy chain termination methods of nucleotide sequencing, Restriction mapping, restriction fragment length polymorphisms (RFLP) linkage and recombination between molecular and phenotypic markers, Random amplified polymorphic DNA (RAPDs) Using PCR. Human genome project, Microarray.

Cloning of specific genes and their expression in bacteria and eukaryotic system. Genetic Engineering- Applications in Medicine, Agriculture and Industry.

Unit IV

RNAi technology for gene knock out studies, Social and moral implications, national and international guidelines/regulations. RNA technology for gene knockout mechanism. CRISPER CAS 9 technology. Next generation sequencing.

Recommended Books:

1. Genes and probes, A Practical Approach series (1995) by BD. Hames and SJ Higgins, Oxford Univ. Press.
 2. Gel Electrophoresis of Nucleic acids, A Practical Approach (1990) by D Rickwood and BD Hames. Oxford Univ. Press.
- Refer the books already mentioned for other Molecular Biology course.
3. Recombinant DNA – James D Watson et al.
 4. Gene Cloning – T. A. Brown.
 5. From Genes to Genomes – J.W. Dala and Schantz
 6. Gene Biotechnology – S.N. Jogdand
 7. Medical Biotechnology - S.N. Jogdand
 8. Principles of gene manipulations – R. W. Old and S.B. Primerose
 9. Genes – Lewin B.
 10. PCR-Technology: Principles and application of DNA amplification – H.A. Erlich.

Expected Course Outcomes: On the successful completion of the course, students will be able to:

1. The course material will provide a clear understanding about DNA modifying enzymes and their uses in RDNA technology (K1 & K2).
 2. Students will advance their knowledge of host cells and vectors that are highly suitable for rDNA-based expression of desirable genes (K1 & K2).
 3. The course will provide a detailed understanding of cloning strategies and various methods adopted for confirmation of rDNA expression (K1 & K2).
 4. Students will learn about advances in sequencing techniques and their advantages (K1 & K2).
 5. Course material provides detailed understanding of Biotechnological applications of rDNA technology (K1, K3 & K4).
- K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create

Practicals: Genetic Engineering (Credit 1)

1. Agarose gel electrophoresis for isolation of various forms of plasmid.
2. Determination of restriction activity on DNA.
3. Amp^r plasmid transformation in *E. coli*.
4. Isolation of phage M₁₃.
5. Isolation of single and double standard M₁₃ DNA.

IMT 206 Skill Oriented Course 4(B): Metabolomics

Course Objectives:

The main objectives of this course are to:

1. To study about Biomolecules metabolism (Catabolism, Anabolism) and their regulatory pathways.
2. To learn about carbon fixation in C3 and C4 plants. Photo synthesis process
3. To study about Lipids and oils biosynthesis and transport different oxidation and regulation of fatty acids
4. To study detail account on nitrogen cycle, Nitrogenase enzyme
5. To study about the ketogenic and glucogenic amino acids and their metabolic disorders

Unit I

Catabolism, Anabolism - Glucose as fuel-Major and Minor metabolic pathways-Glycolysis. Regulation of glycolysis. Fermentation. Metabolism of maltose, lactose, sucrose, fructose, mannose and galactose. Pentose phosphate pathway and its significance. Glucuronic acid pathway and ascorbic acid pathway. TCA cycle: pyruvate dehydrogenase complex, Reactions of the TCA cycle and regulation. Amphibolic pathway. Anapleotic reaction. Gluconeogenesis and regulation. Futile cycles in carbohydrate metabolism. Glycogen metabolism and regulation. Biosynthesis of Starch. CO₂ Fixation, C3 and C4 pathways (Hatch- Slack pathway). Disorders of carbohydrate metabolism- glycogen, lactose, galactose and fructose.

Unit II

Lipid digestion, absorption and transport. Fatty acid oxidation - Fatty acid activation, Transport across the mitochondrial membrane. Oxidation: oxidation of unsaturated, odd-chain fatty acid, peroxisomal β -oxidation. Regulation of fatty acid oxidation α -oxidation and ω -oxidation. Degradation of triacylglycerol and phospholipids, ketone bodies-formation and utilization. Biosynthesis of Fatty acids- Transfer of Mitochondrial acetyl Co-A to cytosol, formation of malonyl Co-A, Fatty acid synthase complex, biosynthesis and regulation of fatty acid synthesis.

Biosynthesis of prostaglandins. Biosynthesis of Triacylglycerols and its regulation. Biosynthesis of glycerophospholipid sphingophospholipids and sphingoglycolipids. Biosynthesis of cholesterol and its regulation. Lipoprotein metabolism. Chylomicrons-VLDL, LDL, HDL. Integration of carbohydrate and lipid metabolism.

Unit III

Nitrogen cycle. Non-biological and biological nitrogen fixation. Nitrogenase system. Utilization of nitrate ion, ammonia incorporation into organic compounds. Synthesis of glutamine and regulatory mechanism of glutamine synthetase. General metabolic reactions of amino acids. Amino acid transamination, deamination. Role of folic acid, vitamin B1, B6, and B12 in amino acid metabolism. Krebs urea cycle, regulation of urea cycle. Ketogenic and glucogenic amino acids. Metabolic defects of amino acid metabolism.

Unit IV

Biosynthesis degradation and regulation of purine and pyrimidine nucleotides, chemical inhibition of biosynthesis of nucleotides. Biosynthesis of deoxy ribonucleotides, regulation of ribonucleotide reductase. Salvage pathway. Disorders of purine and pyrimidines nucleotide metabolism.

Biosynthesis and degradation of porphyrin (Heme). Porphyrins (Fixation of sulphur and sulphur cycle). Non-ribosomal peptide synthesis-glutathione, Biosynthesis of nucleotide coenzymes – nicotinamide coenzymes, Flavin coenzymes and coenzyme– A.

Expected Course Outcomes:

1. On the successful completion of the course, students will be able to:
 2. The course material will provide a clear understanding about carbon fixation and Bio molecules Metabolism (K1 & K2).
 3. Students will advance their knowledge on lipids biosynthesis and transport and Fatty acids oxidation and regulation pathways in metabolic studies.
 4. The course will provide a detailed understanding of Nitrogen cycle and ammonia formation, nitrification and incorporation of N₂ in amino acids and proteins
 5. Students will learn about nucleic acids biosynthesis and degradation and metabolic disorders (K1 & K2).
- Course material provides detailed understanding of metabolism and metabolic disorders.

Recommended books:

- 1) Principles of Biochemistry – A.L.Lehninger (CBS Publishers).
- 2) Biochemistry – Lubert Stryer (5th & 6TH Edition).
- 3) Principles of Biochemistry – General aspects – Smith et al., (8th edition).
- 4) Harper's Review of Biochemistry – Martin et al., (Lange).
- 5) Text Book of Biochemistry with clinical correlation – Thomas M.Devlin (JohnWiley) 2nd & 4th Edition.
- 6) Text Book of Biochemistry – West and Todd, 1966 (MacMillian).
- 7) Biochemistry 2nd ed. C.K.Mathews and K.E.Van Holde (1995) (Benjamins/Cummings).
- 8) Biochemistry 2nd ed Donald Voet and J.G.Voet (1994) (John Wiley).
- 9) Biochemistry – The Chemical Reactions of Living Cells Vol-II, David E. Metzler.
- 10) Biochemistry – J.L. Zubay
- 11) Biochemistry – Garrett and Grishame C.M. (Saundes College publication)- 2nd Edition.
- 12) Biochemistry and Molecular biology of plants by Buchanan, Grussem, and Jones.
- 13) American Society of Plant Physiologists. Rockville, Maryland.
- 14) Introduction to plant Biochemistry. IInd Ed. Goodwin and Mercer, CBS Publication, New Delhi
- 15) Plant Biochemistry by Dey, PM and Harborne JB, Academic Press, New York.

Practicals: Metabolomics (Credit 1)

1. Estimation of blood glucose.
2. Estimation of blood urea.
3. Estimation of creatine in serum.
4. Estimation of calcium and phosphorus in the serum
5. Estimation of uric acid in serum.
6. Estimation of serum total proteins.
7. Estimation of bilirubin
8. Estimation of vitamin-C
9. Estimation of serum albumin.
10. Estimation of serum total cholesterol.

OOTC 208 Open Online Trans Disciplinary Course 1 (Credits 2)**Audit course 209 Indian Knowledge System 2: Indian Agriculture; (Credits 0)**

SEMESTER III

IMT 301 Core Course 7: Endocrine Biochemistry (Credits 4)

Course Objectives: The main objectives of this course are to:

1. This course presents an introduction and provides a comprehensive, balanced introduction to Endocrine glands, their secretions and functions.
2. To enable the students to learn or to know the biological, physiological activities along with the mechanism of action of various hormones.

Unit I

Endocrine system – organization of the endocrine system. General features and classification of hormones, mechanism of action of hormones, hypothalamic hormones, chemistry, biosynthesis, Secretion, physiological functions, regulation and disorders of anterior and posterior pituitary hormones, LH, FSH, Growth hormone, prolactin, oxytocin, Vasopressin. Hormones of the pineal gland – Serotonin and melatonin.

Unit II

Thyroid hormones – chemistry, biosynthesis, secretion, physiological function, regulation and disorders, hypo and hyperthyroidism, tests for thyroid function. Antithyroid drugs and calcitonin.

Parathyroid gland – Parathormone and disorders of Parathormone. Role of calcitonin in calcium and phosphate homeostasis in blood.

Unit III

Pancreatic and gastrointestinal hormones – Biosynthesis, secretion, physiological functions and regulation of insulin and glucagon. Role of insulin and glucagon in carbohydrate, lipid and protein metabolism. Disorders of pancreas. Gastrin, secretin, Cholecystokinin.

Unit IV

Adrenal hormones – Chemistry, biosynthesis and functions of adrenal medullary and adrenal cortical hormones. Cortisol, corticosterone, aldosterone, adrenaline, nor-adrenaline, Disorders of adrenal hormones.

Hormones of reproduction – Gonadal hormones (testosterone), chemistry, biosynthesis and physiological functions of androgens, estrogens and progesterone, inhibin.

Hormonal regulation of menstrual cycle, placental hormones, contraception, reproductive disorders.

Recommended Books:

1. Text book of Biochemistry and Human Biology by Talwar G.P., Prentice Hall India.
2. Human Physiology and Mechanism of distance. Guyton 3rd Ed. Iggushoen/Seunders.
3. Clinical Biochemistry, Vol. 1 and 2, Williams *et al.*, Heinemann Medical, 1978.
4. Lynchs Medical Laboratory Technology by Raphael, S. S., 4th Ed. Iggushoen/Seunders.
5. Text Book of Endocrinology, William.
6. General Endocrinology – Turner.
7. Biochemical Endocrinology of the Vertebrates – E. Fruden and H. Lines.
8. Foundation of Modern Biochemical Series, Prentice Hall Inc., 1971.
9. Metabolic and Endocrine Physiology – Jay Teppermann.
10. Metabolic Pathways – Green Berg.
11. Intermediary Metabolism and its regulation – Lerner
12. Principles of Biochemistry – White A., Handler P and Smith.
13. Receptors and Hormone action. Receptors and Recognition series. Medical physiology by A.C. Guytom.

Expected Course Outcomes: On the successful completion of the course, student will be able to:

Obtain a deep knowledge regarding Endocrine glands and their secretions (K1 & K2).

Gives an idea about structure and functions of endocrine glands (K1 & K2)

Provides knowledge about Hormone and its regulation (K2, K3 & K4)

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create

IMT 302 Core Course 8(A): Immunology (Credits 3)

Course Objectives: The main objectives of this course are to:

1. The study of immunology helps the students in understanding the immune system in all organisms, especially the physiological functioning of the immune system in states of both health and disease.
2. To understand the malfunctions of the immune system in immunological disorders such as autoimmune disease, hypersensitive, immune deficiency and transplant rejection.
3. To understand the physical, chemical and physiological characteristics of the components of the immune system in *in vitro*, *in situ* and *in vivo*.

Unit I

Lymphoid organs (primary and secondary), organization of the immune system, Types of immunity – Natural and acquired, specific and non-specific immune response. Cells and organs of the immune system, antigenic determinants/Epitopes. Haptens, adjuvants, classification, structure and biological functions of immunoglobulins, Isotypes, allotypes and idiotypes. Theories of antibody formation.

Unit II

Active and passive immunity, Humoral and cell mediated immune response, T-Cell and B-Cell activation. Antigen processing and presentation.

T-Cell and B-Cell receptors, Complement system, Alternate and classical pathways of complement activation. Complement fixation tests. Types of Interferons and Cytokines. Major Histocompatibility Complex: MHC in mice and HLA in man-fine structure and functions.

Unit III

Transplantation: Terminology, Auto graft, Isograft, Allograft, Xenograft, Immunological basis of transplantation reactions, GVH reaction, Immuno suppression, General mechanisms of Immune suppression, Immune suppression, drugs (azothioprine, methotrexate, cyclophosphamide, cycosporin-A, Steroids). Blood groups: AB, Rh system, Lewis-Luthern systems, significance, practical application of immuno methodology in blood transfusions, Erythoblastosis faetalis.

Disorders of immune response – Autoimmune diseases – Hashimoto's thyroiditis, Rheumatoid arthritis (RA), Systemic lupus erythomatosis (SLE). Immuno deficiencies – Introduction, primary and secondary deficiencies. T-cell, B-cell and combined immune deficiencies, Compliment system deficiency. SCID, AIDS. Cancer immune therapy.

Unit IV

Hypersensitivity reactions: Antibody mediated type II, anaphylactic reactions, Antibody mediated, type II cytotoxic reactions, Immune complex reactions Type – III, T-cell mediated delayed type hypersensitivity Type-IV. Immunological tolerance and tolerance induction.

Antigen-antibody interactions, precipitation reactions – immune diffusion, radial immuno diffusion, immuno electrophoresis, immunofluorescence, Western blotting, Radioimmunoassay (RIA) and ELISA – Principle, Methodology and applications. Hybridoma Technology, Production of polyclonal and monoclonal antibodies and their application,

Recommended Books:

- 1) Essential immunology – Ivan M. Roitt.
- 2) Immunology – a short course elibezamini and Sidney Leskowitz, Alan R. Lisi Inc. New York, 1988.
- 3) Immunology III, Joseph A. Bellanti Igaku – Shein Saunders International Ed. 1985.
- 4) Immunology at a glance J.H. L. Playfeir 4th Ed. Blackwell Scientific Publication 1987.
- 5) Acids to Immunology D.M. Wier Churchill, Livingtons 1986.
- 6) Fundamentals of Immunology, Myrvik and Weiser, 1984.
- 7) Fundamentals of Immunology, Bier *et al*, Springer 1986
- 8) Textbook of Biochemistry and Human Biology, Talwar G.P. Prentice Hall, 1980.
- 9) Basic and Clinical Immunology – Stites *et al*., 4th Ed. Lange 1982.
- 10) The Immuno-system, Mc Connell *et al*., Blackwell Scientific 1981.
- 11) Fundamentals of Immunology – William C. Boyed (Wiley Toppan)
- 12) Introduction to Immunology – John W. Kinball.
- 13) Fundamentals of Immunology – Otto S. View and others.
- 14) Immunology – D.M. Weir.
- 15) Immunology – Janis Kuby,

Expected Course Outcomes: On the successful completion of the course, students will be able to:

1. Obtain the knowledge about the immune system, as a host defense system comprising many biological structures and processes within an organism that protects against disease (K1 & K2).
2. Concentrate on the antigen and antibody reactions and immunological techniques (K1 & K2).
3. Understanding about the two branches of the immune system such as humoral immunity and cellular immunity, cytokines and complement system (K1 & K2).
4. Clear about the hypersensitivity reaction or intolerance undesirable reactions produced by the normal immune system, including allergies and autoimmunity (K1 & K2).
5. Obtain the knowledge about the hybridoma technology is to produce large numbers of identical antibodies (monoclonal antibodies) and a recombinant DNA technology that involves inserting the DNA encoding an antigen that stimulates an immune response (K1, K3 & K4).

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create

Practicals: Immunology (Credit 1)

1. Separation of serum and plasma
2. Lymphocyte separation and identification of viable lymphocytes.
3. Fluorescent antibody technique
4. Raising of antibodies to soluble antigen in rabbits.
5. Single Radial Immunodiffusion.
6. Ouchterlony Double Immunodiffusion.
7. Rocket immunoelectrophoresis.
8. Cross over Immunoelectrophoresis.
9. Graber and Williams Immunoelectrophoresis.
10. Haemeagglutination tests for identification of human blood groups.

IMT 302 Core Course 8(B): Computational Biology

Course Objectives: The main objectives of this course are to:

1. Know the various disciplines of Bioinformatics and biological databases.
2. Understand the molecular modeling, drug design and Molecular visualization.
3. Know the aspects Proteomics, its significance and applications.
4. Assimilate the concepts of System Biology tools and Metabolomics.
5. Acquire knowledge on Genomics, HGP, and ELSI.

Unit-I

Introduction to Bioinformatics: Various disciplines and applications of Bioinformatics- Databases, Genome analysis, fundamentals of genomics, proteomics, metabolomics, phylogenetics, structure prediction, drug design, pharmacogenomics.

Biological Databases: General introduction, need of DB, database searching options- sequence alignment, An overview of Public molecular DATABASES (EMBL, GenBank, DDBJ, GSDB) - SWISS-PROT database, PDB, Database querying NCBI.

Unit-II

Molecular Modeling & Drug Design: Homology modelling, Model building tools- Preparation of alignment and template files. Building protein 3-D model with Swiss PDB viewer, energy minimization. Molecular Visualization Packages: Rasmol - basic utilities and commands for protein visualization in 3-D. study of protein-DNA interactions, stereo mode, visualization of hetero atoms, HOH, metals, electron density maps, N and C terminals, disulfide bonds. Phases of drug development and drug design in genomic era.

Unit-III

Proteomics: Introduction, principle, technique, 2-D database. Gel analysis software, post gel analysis, MALDI-TOF, MS analysis. Significance and applications of proteomics in biology. Protein – Protein Interaction Network, Signalling Pathways, key metabolic pathways; network motifs, Systems Biology tools and standards. Study of Metabolomics.

Unit-IV

Genomics: Micro RNAs, NGS, Genome Projects: General introduction to genome projects. Human Genome Project (HGP) - Science behind HGP, facts at genome, chromosome and gene level. Benefits of HGP in medicine, agriculture, evolution, forensic science. Ethical Legal Social Implications (ELSI) of HGP- fairness in the use of genetic information, privacy and confidentiality, psychological impact and stigmatization. Genetic testing-standards, quality control and commercialization.

Expected Course Outcomes: On the successful completion of the course, students will be able to:

1. Gives an idea about Bioinformatics and its various disciplines (K1& K2).
2. Gives a clear understanding about Biological Data bases and sequence alignments. (K2 & K3).
3. Gives a clear Knowledge on Molecular modeling and drug designing. (K2 & K3).
4. A Clear Knowledge of proteomics and tools and techniques related to it. (K2 & K3).
5. Provides knowledge on metabolomics. (K2 & K3).
6. Acquires knowledge on genomics, HGP and its impact in different modes. (K2, K3 & K4).

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create

Practicals: Computational biology (Credit 1)

1. Extraction of DNA and Protein from various tissues
2. Isolation of Plasmid DNA
3. Quantification of DNA – Spectrophotometry.
4. Quantification of protein – Spectrophotometry.
5. Chromatography: Paper, Thin layer
6. Electrophoresis: AGE, PAGE, SDS-PAGE
7. Amplification of DNA - Polymerase Chain Reaction.
8. *In silico* Experiments: Genomics- orf finder, Gene finder,
9. Sequence alignment- pair-wise –Blast, Dot plot analysis
10. Multiple sequence alignment

Recommended books

1. Benson, G. (2003). Algorithms in Bioinformatics. Springer Berlin Heidelberg.
2. Rastogi, S. C., Mendiratta, N., & Rastogi, P. (2013). Bioinformatics: Methods and Applications-(Genomics, Proteomics and Drug Discovery). PHI Learning Pvt. Ltd.
3. Primrose SB. Principles of Genome Analysis: a guide to mapping and sequencing DNA from different organisms. 2nd Ed.
4. Genome Mapping: A practical approach. Dear P (Editor). 1st Ed. 1997. Oxford University Press: Oxford, New York.
5. Developing Bioinformatics Skills. Alfonso Valencia and Blaschke. L (2002) Oreille's Publication.
6. Bioinformatics sequence, structure and data banks ed. By Des Higgins Willie Taylor.

References on WEB

1. European Molecular Biology Laboratory (EMBL) <http://www2.ebi.ac.uk/Help/General/general.html>
2. UK Human Genome Mapping Project - Resource Center (HGMP-RC) <http://www.hgmp.mrc.ac.uk/>
3. SeqNet: UK Node of European Molecular Biology Network (EMBN) <http://www.seqnet.dl.ac.uk/About/SEQNET/>
4. GenBank <http://www.ncbi.nlm.nih.gov/Genbank/>
5. DNA Databank of Japan (DDBJ) <http://www.ddbj.nig.ac.jp>

IMT 303 Core Course 9(A): Applied and Molecular Immunology (Credits-3)

Course Objectives:

1. To acquaint them with the hybridoma technique and its clinical applications.
2. To impart knowledge on Immobilization of enzymes.
3. To make them understand the concept of Vaccines and Subunit vaccines.
4. To impart knowledge about intellectual property rights.

Unit I

Immunodiagnosics and preparation of tools: Hybridoma technique, monoclonal antibodies production, myeloma cell lines, fusion of myeloma cells, selection of hybridomas, Screening, purification and application (biochemical research, clinical diagnosis and treatment) of monoclonal antibodies

Unit II

Immobilization of enzymes, Examples and their industrial and clinical applications. Production of DNA antigens. Transgenic organisms and their uses, Patenting, General Agreement on Trade and Tariff {GATT} and Intellectual Property Rights

Unit III

Histamines, Serotonins, vasoactive peptides and ergot alkaloids, Immunomodulation therapy, infiltration of cells and their diseases,

Immunosuppressive drugs and antibodies, glucocorticoid drugs, malignancy therapy, role of TNF α , Immunoglobulin genes.

Unit IV

Vaccines and Subunit vaccines-against Herpes Simplex virus, Foot and Mouth disease, live recombinant vaccines-attenuated (Cholera, Salmonella), Vector vaccines directed against viruses and bacteria. Purified vaccines. DNA vaccines. Antifertility vaccines.

Recommended Books:

1. Harper's Review of Biochemistry.
2. Leninger's principles of Biochemistry
3. Biochemistry – Lubert Stryer.
4. Fermentation Technology (2nd Ed.) Standury (Pergman press)
5. Biotechnology: Textbook of Industrial microbiology 2nd Edit. By Wulf Crueger and Anneliese Crueger (2000).
6. Molecular biotechnology: Principles and Applications of Recombination DNA. (1996) Bernard R. Glick and Jack. J. Pasternak (Panima Publishing Corporation)
7. Principles of Gene manipulation: An Introduction to genetic Engineering (5th) R.V. Old and S. B. Primrose (Blackwell Scientific Publications).
8. Principles of Biotechnology (1985) Alen Weisman (Surrey University Press).
9. Concepts in Biotechnology (1996) Ed., D.Balasubramaian, K.Dharmalingam, J.Green and K. Jayaraman (University Press).
10. Industrial Microbiology, Miller and Litsowky, Mc Graw- Hill, 1976.
11. Industrial Microbiology, L.E.Casida, JR. New Age International. (1995).
12. Industrial Microbiology (Prescott & Dunn), Ed by G.Reed, CBS Publishers.
13. Immobilized enzymes (1978) by Ichiro Chibata, Halsted Press Book.
14. Basic and Clinical pharmacology by BT Katzung, 10th Edn, McGraw Hill Edn, Oxford, 2008

Course Outcomes:

1. Develop skill in production of monoclonal antibodies.
2. How better enzyme immobilization enhances its activity and their industrial and clinical applications.
3. Familiar with different types of vaccines and how they help in prevention of diseases.
4. Acquire the knowledge on IPR and procedures for patent filing.

Practicals: Applied and Molecular Immunology (Credit-1)

1. Raising of antibodies to soluble antigen in rabbits.
2. Single Radial Immunodiffusion.
3. Ouchterlony Double Immunodiffusion.
4. Rocket immune electrophoresis.
5. Cross over Immuno electrophoresis.
6. Graber and Williams Immuno electrophoresis.
7. Haemeagglutination tests for identification of human blood groups.

IMT 303 Core Course 9(B): Cancer Biology (Credits-3)

Course Objectives:

The objective of this course is:

1. To learn the principles of cancer biology and identify the main cellular and molecular mechanisms underlying the initiation and progression of neoplastic growth.
2. The focus of this course is on the difference between malignant cells and normal cells.
3. It explores the animal models of cancer study and the multi-step process of tumor progression leading to invasive metastatic growth.
4. The course will also examine the role of stem cells and their potential for differentiation in different types of malignancies and it includes recent advances in molecular diagnostics and therapy of cancer.

Unit-I

Introduction to Cancer Biology: Definition and classification; evolution of cancer cells; cellular oncogenes; oncogene, viral-oncogene, tumorigenicity, tumor suppressor genes; p53, Rb and PTEN. Cancer metastasis, migration & invasion, metastasis steps, epithelial to mesenchymal transition, angiogenesis.

Unit-II

Microenvironment of Tumor cells: Stroma interaction, adipose stromal cells, cancer associated fibroblast, tumor associated macrophages, mesenchymal stem cells, impact of tumor-stroma interaction on tumor development, tumor immunology; interferons, T cells, cancer stem cells; origin, isolation and culture of cancer stem cells, animal models of cancer study; xenograft and metastasis models.

Unit-III.

The difference between Normal cell versus Cancer cell. Cell immortalization and tumorigenesis, Oncogenes and tumor suppressor genes, Maintenance of Genomic integrity and development of cancer, Invasion and metastasis- Epithelial to Mesenchymal transition, Cancer stem cells-Basics and how to targeting cancer stem cells, Rationale treatment of cancer and Special emphasis on few imp cancers which are prevalent in India- Breast cancer, Oral cancer, etc

Unit-IV

Cancer growth and metastasis: Growth factor, receptors and cancer; in vitro testing of stemness property of cancer stem cells; detection and monitoring of metastasis process in animal models; osteoblastic & osteolytic metastasis.

Success and failure of chemotherapy, targeted specific therapy, monoclonal antibody for cancer treatment, micro-RNA mediated cancer treatment and targeted drug delivery, drug resistance, molecular diagnosis and stem cell therapy.

Expected Course Outcomes:

Upon successful completion of this course students should be able to:

1. Identify the main cellular mechanisms leading to initiation and progression of cancer growth. Describe the characteristics of cancer cells that explain high mortality rate.
2. Define the role of oncogenes and mutations in cancer and explain why several types of cancer have heritable traits and family history.
3. Define the main factors contributing to metastatic growth. Identify the role of stem-like cells, their properties and contribution to tumor progression. List and describe the main factors controlling the evolution of cancer cell populations.
4. Develop a solid understanding of the main methods used in the modern studies of cellular and molecular mechanisms of cancer.
5. Demonstrate core knowledge of the cellular targets and molecular mechanisms of traditional and novel cancer therapies.

Practicals: Cancer biology (Credit-1)

1. Preparation of culture media.
2. Establishment of primary cell culture: mouse splenocyte culture.
3. Handling mammalian cell lines: thawing, culture maintenance and cryopreservation.
4. Cell counting using hemocytometer.
5. Cell viability and proliferation assays: i. Trypan blue exclusion test, ii. MTT assay, iii. Propidium Iodide staining, iv. CFSC labeling.
6. Mammalian cell transfection (transient).
7. Immuno fluorescence detection to check transfection efficiency (using fluorescence and confocal microscopes).

Recommended books:

1. Biology of Cancer by Robert Weinberg
2. Principles Of Cancer Biology - Lewis J Kleinsmith
2. Oxford Textbook of Cancer Biology. Edited by Francesco Pezzella, Mahvash Tavassoli and David Kerr.
3. Cancer Biology by Raymond Ruddon.

IMT 305 Skill Oriented Course 5(A): Technical writing, Biostatistics, Bioinformatics and Omics

Course Objectives: The main objectives of this course are to:

1. Know the nuances of technical writing of scientific documents like thesis, project proposals and journal articles.
2. Understand the statistical tools commonly used in biological research.
3. Know the aspects fundamental to research and to understand the methods of research
4. Assimilate the concepts of hypothesis testing and its importance in research
5. Improve computer based skills for analyzing biological data.

Unit I

Technical Writing: Sentence writing, paragraph writing, story writing, review writing, various types of letters writing.

Preparation of a research project proposal: Selection of appropriate funding agency, Informal proposal, formal proposal, submission of technical report (format: title page, introduction, aims of the proposal/research, methodology, results, interpretation of results, references, acknowledgments, budgetary allocations), execution of results, submission of progress report (year wise), scientific communications (Articles, papers, reviews etc.,) and critical comments writing.

Unit II

Scope of statistical methods in life sciences. Variables, Measure of central tendency: Mean, median and mode, Measuring Dispersion:

Standard deviation, co-efficient of variation, probability, probability distributions, test of significance and estimation, Linear regression and correlation, the chi-square test, ANOVA, t-Test and F-Test.

Unit III

Bioinformatics: Branches of Bioinformatics, scope of bioinformatics, useful sites on the internet: Data bases and search tools: NCBI (<http://www.ncbi.nlm.nih.gov/>), EMBL serve: (<http://www2.ebi.ac.uk/services.html>), sequence alignment: gene bee multiple sequence alignment (<http://www.genebee.msu.su/>), Tree view (<http://taxonomy.zoology.gla.ac.uk/rod/treeview.html>), Gene doc (<http://www.cris.com/ketchup/genedoc.shtml>). Sequence analysis, repetitive elements, Image analysis, office applications, logic development. Introduction to Proteomics and genomics.

Unit IV

Genomics, Transcriptomics, proteomics, metabolomics and omic data bases. Sequencing by conventional, automated and next generation sequencing approaches-advantages and limitations. ARDRA, RISA, DGGE/TGGE, Multiple Displacement Amplification (MDA). Whole genome analysis. Advantages and limitation of Metagenomics approach. Culturomics. Proteome, Functional proteomics, metaproteome. Proteome tools – 2-DE Mass spectrometry analysis. Identification of post-translational modifications: Phosphorylation, Glycosylation, Acetylation. Sequence based protein prediction: Homology or comparative modeling, Remote homology (Threading), Protein function prediction. Application of omic technologies in Bioprospecting. Integration of omic platforms, interactomics, Systems biology.

Recommended Books:

- 1) Bio-statistics, A foundation for analysis in the Health (7th Ed. 1999) by WWW Daniel and Sons Inc., New York.
- 2) Introduction to Bio-statistics and Research Methods by P.S.S. Sundar Rao and Richard.
- 3) Bio-statistics by Sokal and Rolf.
- 4) Bioinformatics, Sequence, Structure and Databanks by Des Higgins Willie Taylor (2000).
- 5) Introduction to Bioinformatics by T.K. Altwood and D.J Parry- Smith (Oearson Education Asia 1999).
- 6) UGC-MRP guidelines and format, DST and DBT guidelines and formats for project praposals.
- 7) Authour guidelines of any UGC recognized journals.
- 8) English grammar books for formal and informal letter writing.

Expected Course Outcomes: On the successful completion of the course, students will be able to:

7. Gives an idea about thesis writing, funding agencies and patenting (K3 & K4).
8. Helps to collect data and organize the data (K1 & K2).
9. Gives a clear understanding about the basic statistical analysis (K1 & K2).
10. A Clear Knowledge of probability and its application (K2 & K3).
11. Provides the sampling distribution techniques and its analysis (K2 & K3).
12. Expertise in computer based analysis of biological data (bioinformatics) (K4, K5 & K6).

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create

Practicals: Technical writing, Biostatistics, Bioinformatics and Omics (Credits 1)

1. Article writing
2. Standard Deviation
3. Mean, Median and Mode
4. ANOVA
5. Survey of some genome, metagenome, proteome data bases.
6. nBLAST, pBLAST, Multiple Sequence Analysis
7. Gene Annotation of genome sequences (ORF finding)
8. Amplification of 16S DNA
9. Phylogenetic analysis using 16S rDNA typing
10. Native gel, SDS PAGE and 2D gel Electrophoresis.

IMT 305 Skill Oriented Course 5(B): Research methodology tools techniques, Research Publication and Ethics

Course Objectives:

1. The primary objective of this course is to enable the students, irrespective of their disciplines, in developing the most appropriate methodology for their research studies; and
2. To make them familiar with the art of exploiting different research methods and techniques.
3. Students should obtain a guideline on how to write, publish, present, and review scientific papers.
4. The course aims to guide the students regarding the publication ethics and misconducts. It is expected that the course will assist in the accomplishment of exploratory as well as result-oriented research studies.

Unit I

Research Methodology- Definition and significance- Types of research - Exploratory research, Conclusive research, Modeling research, Algorithmic research, Casual research, Theoretical and Empirical research, Cross-Sectional research and Time Series research, Research process-, Research problem- Objectives, Characteristics, Hypothesis and research in evolutionary perspective. Research Design- Definition, Types- Descriptive and Experimental Questionnaire preparation- prerequisites of a good questionnaire, Data Collection methods in research -Primary data and Secondary data.

An overview and implications of translational research. Rationale and implications of Intellectual property rights (IPR) and Patenting. Fundamentals of IPR; Basics understanding about Patentability. Innovation & Knowledge management; Translating Ideas to Entrepreneurship and Startups

Unit II

Validity and Reliability-Definition, importance, types of validity, types of reliability-- Construction and Validation of questionnaire, Cronbach alpha test, Measurement – definition- significance – types Nominal, Ordinal, Interval and Ratio ,Scaling- Importance, Scaling techniques. Sampling methods- Probability sampling methods and Non - Probability sampling methods, Report writing – importance , guideline to write an academic report, Basics of report presentation- Content of an Academic Research report, Content on a Research Article, Steps to publish an article, Research Metrics: Significance of Journal Impact Factor, SNIP, SJR, IPP, Cite Score, Metrics: h-index, g index, i10 index.

Unit III

Non parametric tests- One sample tests- one sample sign test. Kolmogorov- Smirnov test, Run test for randomness, two sample tests- two sample sign test, Mann-Whitney U test, K sample test- Kruskal Wallis test (H- test). Hypothesis testing – Testing of hypothesis concerning means (one mean and difference between two means – one tailed and two tailed tests), Concerning Variance – One tailed Chi square test, Analysis of Variance (anova). Introduction to Discriminant.

Unit IV

Introduction to philosophy: definition, nature and scope, concept, branches, Ethics: definition, moral philosophy, nature of moral judgments and reactions', Ethics with respect to science and research, Intellectual honest and research integrity, Scientific misconduct: falsification, fabrication, and plagiarism, Redundant publications: duplicate and overlapping publications, salami slicing, Selective reporting and misrepresentation of data.

Publication ethics: definition, introduction and importance, Best practices/standards setting initiatives and guidelines: COPE, WAME, etc. Conflicts of interest, Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types, Violation of publication ethics, authorship and contributor ship, Identification of publication misconduct, complaints and appeals, Predatory publishers and journals.

Expected Course Outcomes: On the successful completion of the course, students will be able to:

1. Learn about research methodology, statistical methods, research plan and implementation.
2. The knowledge will be utilized for improving the quality of research practice and education.

Practicals: Research methodology tools techniques, Research Publication and Ethics

1. Open access publishing and initiatives, SHERPA/RoMEO online resource to check publisher copyright and self-archiving policies.
2. Software tool to identify predatory publications developed by SPPU, Journal finder/ journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.,
3. Publication misconduct (Group Discussion): Subject specific ethical issues, FFP, authorship, Conflicts of interest, Complaints and appeals: examples and fraud from India and abroad.
4. Software tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools.
5. Databases: Indexing databases, Citation databases: Web of Science, Scopus, etc.
6. Research Metrics: Impact Factor of journal as per journal citation report, SNIP, SJR, IPP, Cite Score, Metrics: h-index, g index, i10 index, altmetrics.

Recommended Books:

1. Ana smith Iltis," Research Ethics", Publisher: Routledge, ISBN: 0415701589, 2016 by HAN LUO - 2012
2. Dr.Tripathi, P.C, Research Methodology, 1st Edition, Prentice Hall Inc., 2009.
3. Garg, B.L.Karadia, R.Agarwal, &F.Agarwal, U.K 2002. An introduction to research methodology, RBSA Publishers
4. Introducing Research Methodology: A Beginner's Guide to Doing a Research Project by FLICK, UWE. HAN LUO. Northwestern University.
5. Kothari, K.C. and Gaurav Garg Research Methodology: Methods and Techniques (Multi Colour Edition, 6. Mr.Suber Peter, Open Access (MIT Press Essential Knowledge series), New age international publishers, 2019
7. Oliver Paul, "The Student's guide to research ethics", McGraw-Hill Education (UK), Second edition 2010
8. The Ethics of Online Research (Advances in Research Ethics and Integrity Book 2) Kindle Edition by Kandy Woodfield (Editor), 2017.
9. William G.Zikmund, Business Research Methods, 7th Edition, Tata Mc Graw Hill, 2009.

IMT 306 Skill Oriented Course 6(A): Clinical Immunology (Credits 3)

Course Objectives: The main objectives of this course are to:

1. To inculcate the etiquette to be maintained in Immunology lab.
2. To impart knowledge about different types of immuno deficiencies and autoimmune diseases.
3. To equip with the knowledge on transplantation and immunosuppression.
4. To understand the fundamentals of cancer biology, the Principles of carcinogenesis and immunotherapy.

Unit I

Introduction to Clinical Immunology: Introduction and maintenance of clinical Immunology/ biochemistry laboratory; hazards in clinical laboratory; units; 'normal range', reference values. Factors affecting reference values quality control in laboratory – use of external and internal standards; use of WHO standards. Selection of analytical methods. Automation in clinical laboratory. Collection and preservation of specimens.

Natural Immunity a. First Line of Defense innate / nonspecific immunity b. Adaptive / specific immunity, c. Factors associated with immunologic disease, Components of the Immune System. Immune response to various infectious diseases

Unit II

Primary immune deficiencies, AIDS and other acquired or Secondary immune deficiencies, Auto immune diseases, Animal model for autoimmune diseases. Proposed mechanism for induction of autoimmunity. Treatment of autoimmune diseases.

Unit III

Transplantation, Types of grafts, Graft acceptance and rejection, Clinical manifestation of graft rejection. General immunosuppressive therapy, immune tolerance to allografts, clinical transplantation.

Unit IV

Cancer origin and terminology, malignant transformation of cells, oncogenes and cancer induction, tumors of the immune systems, tumor antigens, tumor evasion of the immune system and cancer immunotherapy. Psycho immunology: Psychoneuroimmunology, Immuno mediators, Immune system neuro anatomy, Neuroimmuno modulation.

Recommended books

1. Turgons "Immunology and serology" by Mosby Latest Edition 2007
2. Immunology by Irwin Roitt Latest edition.
3. Immunology by Kubay.
4. Varley's Practical clinical Biochemistry – Ed. Alan W.Gowenlock (Heinemann medical).
5. Clinical diagnosis and management by Laboratory methods (John Bernard Henry, W.B. Salunders Company, 1984).
6. Hand Book of Human stress and immunity by Glaser R and Glaser K (1994)
7. Psychoimmunology by Schedlowski M (2000).

Expected Course Outcomes: On the successful completion of the course, students will be able to:

Maintain the Clinical Immunology lab with all required standards.

Gain knowledge on different types of immunodeficiencies, their treatment and about autoimmune disorders.

Familiar with Clinical manifestation in graft acceptance or rejection and how immunosuppressive therapy is useful.

To understand cancers, the mechanisms involved from theory concept, experimental, research, cancer immunotherapy and human health-care perspectives and Psycho immunology.

Practical: Clinical Immunology (Credits 1)

1. Estimation of C-Reactive protein
2. Diagnosis of SLE
3. Diagnosis of Rheumatoid Arthritis
4. Widal test
5. VDRL test
6. *Detection of HCG by latex agglutination inhibition test*

IMT 306 Skill Oriented Course 6(B): *In Silico* Drug Design and Discovery

Course Objectives: The main objectives of this course are to:

1. Provide basic principle of pharmacology and Molecular interactions with drugs
2. Theories of receptors and enzyme inhibition
3. Biotransformation of drugs

Unit-I

Introduction to Pharmacology: Basic principles of pharmacology, including receptor mechanisms, drug distribution and metabolism, and pharmacokinetics. Interactions Inter- and intramolecular interactions. Weak interactions in drug molecules. Chirality and drug action. Covalent, ion-ion, ion-dipole, Hydrogen bonding, C-H hydrogen bonding, dihydrogen bonding, Van der Waals interactions and the associated energies.

Unit-II

Receptorology Drug-receptor interactions, Receptor theories and drug action: Occupancy Theory, Rate Theory, Induced Fit Theory, Macromolecular perturbation theory, Activation-Aggregation theory. Topological and stereochemical consideration.

Unit-III

Enzyme Inhibition Drug action through enzyme inhibition. Examples based on PDE4, GSK3, etc. Theories of enzyme inhibition and inactivation. Enzyme activation of drugs prodrugs.

Unit-IV

Drug likeness Drug like molecules and theories associated with the recognition of drug like properties. Physical organic chemistry of Drug metabolism, drug deactivation and elimination.

Drug action after Metabolism: Phase I and Phase II transformations. Concept of hard and soft drugs. Chemistry of ADME and Toxicity properties of drugs.

Expected Course Outcomes: On the successful completion of the course, students will be able to:

1. Gain knowledge about principles of pharmacology and interaction of drug and receptor.
2. Develop skills relevant for the medical and pharmaceutical industries.

Practical: *In Silico* Drug Design and Discovery (Credits 1)

In silico prediction: signal peptide, transmembrane domains.

Recommended Books

- 1) The Organic Chemistry of Drug Design and Drug Action by R.B. Silverman
- 2) C.J. Coulson, Molecular Mechanism of Drug Action by C.J. Coulson
- 3) A primer of Drug Action by R.M. Julien
- 4) Drug-Receptor Thermodynamics by R.B. Raffa
- 5) Principles of Drug Action by W.B. Pratt, P. Taylor
- 6) Medicinal Chemistry How Drugs Act and Why by A. Gringauz
- 7) Principles of Molecular recognition by A.D. Buckingham
- 8) Quantitative molecular pharmacology and Informatics by M. Lutz
- 9) Physical Biochemistry by K.E.V. Holde
- 10) Free energy calculations in rational drug design by M. Rami Reddy.

IMT 308 OPEN ONLINE TRANS DISCIPLINARY COURSE – 2 (Or)

BCH 308 Open Elective: Endocrine Biochemistry (Offered to other Departments)

Course Objectives: The main objectives of this course are to:

1. This course presents an introduction and provides a comprehensive, balanced introduction to Endocrine glands, their secretions and functions.
2. To enable the students to learn or to know the biological, physiological activities along with the mechanism of action of various hormones.

Unit I

Endocrine system – organization of the endocrine system. General features and classification of hormones, mechanism of action of hormones, hypothalamic hormones, chemistry, biosynthesis, Secretion, physiological functions, regulation and disorders of anterior and posterior pituitary hormones, LH, FSH, Growth hormone, prolactin, oxytocin, Vasopressin. Hormones of the pineal gland – Serotonin and melatonin.

Unit II

Thyroid hormones – chemistry, biosynthesis, secretion, physiological function, regulation and disorders, hypo and hyperthyroidism, tests for thyroid function. Antithyroid drugs and calcitonin.

Parathyroid gland – Parathormone and disorders of Parathormone. Role of calcitonin in calcium and phosphate homeostasis in blood.

Unit III

Pancreatic and gastrointestinal hormones – Biosynthesis, secretion, physiological functions and regulation of insulin and glucagon. Role of insulin and glucagon in carbohydrate, lipid and protein metabolism. Disorders of pancreas gastrointestinal hormones-. Gastrin, secretin, Cholecystokinin.

Unit IV

Adrenal hormones – Chemistry, biosynthesis and functions of adrenal medullary and adrenal cortical hormones. Cortisol, corticosterone, aldosterone, adrenaline, nor-adrenaline, Disorders of adrenal hormones.

Hormones of reproduction – Gonadal hormones (testosterone), chemistry, biosynthesis and physiological functions of androgens, estrogens and progesterone, inhibin.

Hormonal regulation of menstrual cycle, placental hormones, contraception, reproductive disorders.

Recommended Books:

1. Text book of Biochemistry and Human Biology by Talwar G.P., Prentice Hall India.
2. Human Physiology and Mechanism of distance. Guyton 3rd Ed. Igkushoen/Seunders.
3. Clinical Biochemistry, Vol. 1 and 2, Williams *et al.*, Heinemann Medical, 1978.
4. Lynchs Medical Laboratory Technology by Raphael, S. S., 4th Ed. Igkushoen/Seunders.
5. Text Book of Endocrinology, William.
6. General Endocrinology – Turner.
7. Biochemical Endocrinology of the Vertebrates – E. Fruden and H. Lines.
8. Metabolic and Endocrine Physiology – Jay Teppermann.
9. Metabolic Pathways – Green Berg.
10. Intermediary Metabolism and its regulation – Larner
11. Principles of Biochemistry – White A., Handler P and Smith.
12. Receptors and Hormone action. Receptors and Recognition series. Medical physiology by A.C. Guytom.

Expected Course Outcomes: On the successful completion of the course, student will be able to:

Obtain a deep knowledge regarding Endocrine glands and their secretions (K1 & K2).

Gives an idea about structure and functions of endocrine glands (K1 & K2)

Provides knowledge about Hormone and its regulation (K2, K3 & K4)

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create

SEMESTER: IV

➤ Type of Course: Open Online Skill Development Course's MOOCS / SWAYAM; Course No: **OOSDC IMT401**

IMT (CORE)401(A): Immunotechniques

Unit I

Methods used in immunology: Preparation of antigens and antibodies, purification of antibodies, analysis of antibodies and antigens, preparation and uses of various types of vaccines.

Unit II:

Techniques used in immunology: Types of immunodiffusion methods, ELISA, RIA, Western blot analysis, Electrophoresis and Hybridization techniques, immunohistochemistry, Immunoflow cytometry, Immunofluorescence.

Unit III:

Applications of antisera in the detection of various diseases. Examples: syphilis and lyme, typhoid, streptococci infections, HIV, various types of Hepatitis

Unit IV:

Antibody engineering, Catalytic antibodies, antibody immunotherapy, productions of drugs to allergies.

Recommended Books:

1. Harper's Biochemistry (Latest edition)
2. Immunology by Carpenter (Latest edition)
3. Kubay's Immunology (Latest edition)
4. Biotechnology by RC Dubay (2001) S Chand and Company, New Delhi.

IMT 401(b): Immunological Diseases and Therapeutics

Unit I

Introduction to Clinical Immunology: Introduction and maintenance of clinical Immunology laboratory; hazards in clinical laboratory; units; 'normal range', reference values. Factors affecting reference values quality control in laboratory – use of external and internal standards; use of WHO standards. Collection and preservation of biological samples.

Unit II Natural Immunity (a) First Line of Defense innate / nonspecific immunity (b) Adaptive / specific immunity, (c) Factors associated with immunologic disease, Components of the Immune System. Immune response to various infectious diseases

Unit III Primary immunodeficiencies, AIDS and other acquired or Secondary immunodeficiencies, Auto immune diseases, Animal model for autoimmune diseases. Proposed mechanism for induction of autoimmunity. Rheumatoid Arthritis, Scleroderma, Vitiligo, Systemic Lupus Erythematosus, Graves' disease, Myasthenia gravis, Multiple sclerosis, Diabetes (type 1) Psoriasis, Treatment of autoimmune diseases.

Unit IV Transplantation, Types of grafts, Graft acceptance and rejection, Clinical manifestation of graft rejection, general immunosuppressive therapy, immune tolerance to allografts, clinical transplantation. Tumors of the immune systems, tumor antigens, tumor evasion of the immune system and cancer immunotherapy.

Recommended Books:

1. Varley's Practical clinical Biochemistry – Ed. Alan W. Gowenlock (Heinemann Medical Books).
2. Clinical diagnosis and management by Lab methods (John Bernard Henry, W.B. Saunders Company).
3. Clinical Biochemistry – S.Ramakrishnan and Rajiswami.
4. Chemical Biochemistry (Metabolic and clinical aspects) by W.J.Marshall & S.K.Bangert.
5. Text book of clinical Biochemistry by Tietz et al.
6. Turgons "Immunology and serology" by Mosby Latest Edition 2007 Immunology by Irwin Roitt Latest
7. Immunology by Kubay.
8. Hand Book of Human stress and immunity by Glaser R and Glaser K (1994)

IMT 401(C): Immunopharmacology

Unit I

Drugs, Drug receptors, pharmacodynamics, pharmacokinetics, drug biotransformation, development and regulation of drug, Cholino and adreno receptor drugs.

Unit II

Histamines, Serotonins, vasoactive peptides and ergot alkaloids, Immunomodulation therapy, infiltration of cells and their diseases, Immunosuppressive drugs and antibodies, glucocorticoid drugs, malignancy therapy, role of TNF α , Immunoglobulin genes.

Unit III

The Eicosanoids, Prostaglandins, thromboxanes, leukotrienes and related compounds, and inhibitors of these molecules formation.

Unit IV

Nitric oxide and its immunological effects, Drugs used in asthma.

Reference Books:

Basic and Clinical pharmacology by BT Katzung, 10th Edn, McGraw Hill Edn, Oxford, 2008

- M.Sc. Biochemistry(Immunology) Project: Multi-Disciplinary Project Course No.: **IMT PW402**.
- Project work under the supervision of respective faculty.
- Dissertation – Thesis Submission, Project Evaluation and *Viva-voce*
- Project work carries **300 Marks** (Dissertation -200 marks, Seminar- 50 marks, *Viva voice* – 50 marks).

*Conducting classes for competitive exams, communication skills, UGC/ CSIR/ NET/ SLET examinations.

S.V.U .College of Sciences, M.Sc Biochemistry
M.Sc Biochemistry (Immunology): Model Question papers
Semester- III

CORE IMT 301 and IMTOE 308 Papers

Time 3 Hrs

Max marks 70

PART A (5 X 4 = 20 marks) Answer any Five (05) of the following questions?

1. Unit 1
2. Unit 1
3. Unit 2
4. Unit 2
5. Unit 3
6. Unit 3
7. Unit 4
8. Unit 4

PART B (4 X 12.5 = 50 marks) Answer any ALL of the following questions?

9. Unit 1 A or B
10. Unit 2 A or B
11. Unit 3 A or B
12. Unit 4 A or B

S.V.U. College of Sciences M.Sc Biochemistry (Immunology):
Model Question paper; Semester- IV
CORE IMT 401 paper

Time 3 Hrs

Max marks 70

PART A (5 X 4 = 20 marks) Answer any Five (05) of the following questions?

1. Unit 1
2. Unit 1
3. Unit 2
4. Unit 2
5. Unit 3
6. Unit 3
7. Unit 4
8. Unit 4

PART B (4 X 12.5 = 50 marks) Answer any ALL of the following questions?

9. Unit 1 A or B
10. Unit 2 A or B
11. Unit 3 A or B
12. Unit 4 A or B

M.Sc Biochemistry (Immunology):

Model Question paper Semester I/II/III CORE 1/ 4/ 7 Paper

Time 3 Hrs

Max marks 70

Attempt any **five** from Part A (5 x 4 =20 marks) and **all** from Part B (4 x12.5 =50 marks)

PART A (5 x 4=20 marks)

1. Unit 1
2. Unit 1
3. Unit 2
4. Unit 2
5. Unit 3
6. Unit 3
7. Unit 4
8. Unit 4

PART B (4 x12.5 =50 marks)

9. Unit 1 A or B
10. Unit 2 A or B
11. Unit 3 A or B
12. Unit 4 A or B

M.Sc Biochemistry (Immunology)::

Model Question paper Semester I/II/III CORE- 2 to 9/ SOC Papers 1/ 2/ 3/ 5/ 6

Time 2 Hrs

Max marks: 50

Attempt any **five** from Part A (5 x 2 =10 marks) and **all** from Part B (4x 10 =40 marks)

PART A (5x 2=10 marks)

1. Unit 1
2. Unit 1
3. Unit 2
4. Unit 2
5. Unit 3
6. Unit 3
7. Unit 4
8. Unit 4

PART B (4x10=40 marks)

9. Unit 1 A or B
10. Unit 2 A or B
11. Unit 3 A or B
12. Unit 4 A or B