NATIONAL EDUCATION POLICY-2020

Common Minimum Syllabus for all Uttarakhand State Universities and Colleges for Five Years of Higher Education

PROPOSED STRUCTURE OF
PG – BIOMEDICAL SCIENCES
SYLLABUS

2021

Curriculum Design Committee, Uttarakhand

Sr. No.	Name & Designation	
1.	Prof. N.K. Joshi Vice-Chancellor, Kumaun University Nainital	Chairman
2.	Prof. O.P.S. Negi Vice-Chancellor, Uttarakhand Open University	Member
3.	Prof. M . S.Rawat Vice-Chancellor, Sri Dev Suman Uttarakhand University	Member
4.	Prof. Jagat Singh Bisht Vice-Chancellor, Soban Singh Jeena University Almora	Member
5.	Prof. Surekha Dangwal Vice-Chancellor, Doon University, Dehradun	Member
6.	Prof. M.S.M. Rawat Advisor, Rashtriya Uchchatar Shiksha Abhiyan, Uttarakhand	Member
7.	Prof. K. D. Purohit Advisor, Rashtriya Uchchatar Shiksha Abhiyan, Uttarakhand	Member

Syllabus Expert Committee

S. No.	Name	Designation	Department	Affiliation
1.	Prof. N. Senthil Kumar	Professor	Department of Biotechnology	Mizoram University, Mizoram
2.	Prof. C.P Singh Bhaisora	Professor	Forensic Medicine	Government Medical College, Haldwani
3.	Prof. Rambir Singh	Professor	Department of Horticulture (Aromatic and Medicinal Plants)	Mizoram University, Mizoram
4.	Mr. Ashok Bansal	President	-	Kumaun and Garhwal Chamber of Commerce
5.	Prof. Dharmesh Silajiya	Dean and Professor	Forensic Medicine	National Forensic Science University, Gujarat
6.	Dr. Mahendra Rana	Associate Professor	Pharmaceutical Sciences	Sir J.C Bose Technical Campus, Kumaun University, Nainital

Syllabus Preparation Committee

S.N.	Name	Designation	Department	Affiliation
1.	Prof. S.P.S Bisht	Dean	Biomedical Sciences	D.S. B Campus, Kumaun University, Nainital
2.	Dr. Mahendra Rana	Associate Professor	Department of Pharmaceutical Sciences	S J.C Bose Technical Campus, Kumaun University, Nainital
3.	Dr. Rashi Miglani	Project Associate-I	Biomedical Sciences	D.S.B Campus, Kumaun University Nainital

YEAR	SEMESTER	PAPER CODE	PAPER TITLE	CREDITS TH+PR
Master in Faculty (Biomedical Sciences)				
1	I	PAPER- I	Biochemistry	4
		PAPER- II	Cell Biology and Human Genetics	4
		PAPER- III	Medical Biotechnology	4
		PAPER- IV	Techniques and Instrumentation	4
		LAB	Lab Course I	4
		Industrial Training/ Survey/Research Project	With reference to the Major Papers of Semester-I	4
			Total	**24**
	II	PAPER- I	Human Physiology-I	4
		PAPER- II	Medical Microbiology	4
		PAPER- III	Immunology	4
		PAPER- IV	Molecular Biology	4
		LAB	Lab Course II	4
		Industrial Training/Survey/ Research Project	With reference to Major Papers of Semester-II	4
	I or II	Minor Elective	Laboratory Safety Guidelines or Good Clinical and Laboratory Practices or Ethical Guidelines for medical research	4
			Total	**28**
			Credits I+II	**52**
2	III	PAPER- I	Human Physiology-II	4
		PAPER- II	Principles of Medicinal Chemistry	4
		PAPER- III	Pharmacology & Toxicology	4
		PAPER- IV	Bioinformatics, Computational Biology and Drug Design	4
		LAB	Lab Course III	4
		Industrial Training/Survey/ Research Project	With reference to Major Papers of Semester-III	4
			Total	**24**
	IV	PAPER- I	Human Physiology III	4
		PAPER- II	Bioprocess Engineering	4
		PAPER- III	Bioinstrumentation	4
		PAPER- IV	Research Methodology and Intellectual Property Rights (IPR)	4
		LAB	Lab Course IV	4
		Industrial Training/Survey/ Research Project	With reference to Major Papers of Semester-IV	4
			Total	**24**
			Credits III+IV	**48**
			Total Credits	**100**

Course Objective (CO):

1. To enhance career opportunities and develop knowledge and skills in life sciences focusing on human health, disease pathophysiology, emerging diagnostics, therapeutics and state-of the-art research.

2. To explore the contemporary understanding of disease pathophysiology, current and emerging diagnostic procedures and aspects of therapy.

3. To create an ideal progression route for graduates of the Biomedical Science BMC or other bioscience disciplines towards relevant industries and organizations.

4. Our consistent aim is to encourage students to become engaged, be active learners and promote medical research so that ultimately, they acquire knowledge, skills and understanding so as to provide well-qualified and trained professionals in Allied Health Sciences to improve the quality of life.

Outcomes of the course

1. Trained employable professionals forInstitutions of Biomedical Sciences

2. Enables Health and Care Professionals toincrease their opportunities for progression within pathology services.

3. Development in terms of conjunctionwith local health units and practitioner- based academic staff ensuring use of relevant current practices

SYLLABUS (CBCS) M.Sc. BIOMEDICAL SCIENCE

KUMAUN UNIVERSITY, NAINITAL, UTTARAKHAND.

1.	**Name of the Programme**	M.Sc. Biomedical Science
2.	**Type of Course (U.G/P. G)**	Post Graduate
3.	**Duration of Course**	4 Semester (2 Year course) CBCS
4.	**Objectives of Course**	➢ To enhance career opportunities and develop knowledge and skills of life sciences focusing on human health, disease pathophysiology, emerging diagnostics, therapeutics and state-of-the-art research. ➢ To explore contemporary understanding of disease pathophysiology, current and emerging diagnostic procedures and aspects of therapy. ➢ To create an ideal progression route for graduates of the Biomedical Science BMC or other bioscience disciplines towards relevant industries and organizations.
5.	**Outcome of Course**	4. Trained employable professionals for Institutions of Biomedical Sciences 5. Enables Health and Care Professionals to increase their opportunities for progression within pathology services. 6. Development in terms of conjunction with local health units and practitioner-based academic staff ensuring the use of relevant current practices.
	Number of Proposed seats (Intake)	20 (Twenty)

M. Sc. in Biomedical Science
FIRST SEMESTER (ODD SEMESTER)

Course Code	Course Type	COURSE (PAPER/SUBJECTS)	Credits	Maximum Marks		
				Internal	External	Total
BSC	CCC	Biochemistry	4	20	80	100
BSC	CCC	Cell Biology and Human Genetics	4	20	80	100
BSC	CCC	Medical Biotechnology	4	20	80	100
BSC	CCC	Techniques and Instrumentation	4	20	80	100
BSC	LAB	Lab (Lab Course 1)	4	20	80	100
Minimum credits in complete semester would be 20			**Total: 20**			

The M.Sc. program will be divided into four semesters each being of six months duration. Each semester comprises compulsory core courses (CCC) Lab course (LC) will be based on CCC. Each theoretical course will be divided into Internal Assessment of 20 marks and semester end examination of 80 marks.

Duration of Theoretical and Practical Examination Time: 03 Hours

M.Sc. BIOMEDICAL SCIENCE		I SEMESTER
COURSE CODE: BSC		COURSE TYPE: CCC
COURSE TITLE: BIOCHEMISTRY		
CREDIT: 04	TEACHING HOURS: 90	
MARKS: 100	THEORY EXAM: 80	CCA: 20

UNIT-I 18 Hours	**Amino Acids and Proteins** **Protein Structure:** Primary Structure, Secondary, tertiary and Quaternary structure of protein: α-helix, ß-pleated sheets, Ramachandran plot. Factors affecting secondary and tertiary structure(pH, ionic strength, solvents). Simple and conjugated protein: Fibrous and globular Proteins (Collagen, Elastin, Keratins, Hemoglobin, Myoglobin). Super secondary structures of Protein: Concept of Motiff, types of structural motifs in proteins. Domains, structural diversity of different domains and domain swapping, Intrinsically disordered proteins (IDP). **Protein Folding:** Molecular chaperones**,** Amyloids, Ubiquitin mediated protein degradation and N-end rule
UNIT-2 18 Hours	**Enzymes:** Introduction, Naming and Classification of enzymes, Catalytic strategies (Covalent catalysis, acid-base catalysis, Metal-ion catalysis and Enzyme Activity). Enzyme Kinetics: Substrate, active site, transition state, activation energy, equilibrium constant K_m, V_{max}, specificity, Michaelis-Menten equation. Reaction Mechanism: Acid-base catalysis and covalent catalysis. Enzyme Inhibition: Competitive inhibition, Non-competitive inhibition. Regulatory enzymes, Isozymes, Zymogens, Ribozymes.

UNIT-3 18 Hours	DNA Replication - Prokaryotic and eukaryotic DNA replication, Molecular Mechanisms of DNA replication, Enzymes, and accessory Proteins involved in DNA replication. DNA Damage and Repair (Direct repair, Excision repair, Mismatch repair, Recombinational repair, Repair of double-strand DNA break, SOS response), Recombination, Homologous Recombination Holliday junction, gene targeting, gene disruption, FLP/FRT and Cre/Lox recombination, Rec-A proteins and other recombinases.
UNIT-4 18 Hours	**Transcription**- Prokaryotic and Eukaryotic transcription, RNA polymerase, General and specific transcription factors, transcription signals, promoter sites, rho and sigma factor, Regulatory elements and mechanisms of transcription regulation Transcription termination, Transcriptional and post-transcriptional modification: 5'-Cap formation, 3'-end processing and polyadenylation, Splicing; Ribonucleoproteins, RNA editing, nuclear export of mRNA and stability. **Translation**-Prokaryotic and eukaryotic translation, the translation machinery, Mechanisms of initiation, elongation and termination, Regulation of translation, co-and post-translational modifications of proteins. Genetic code: Properties, codon usage patterns and codon bias (Wobble Hypothesis).

SUGGESTED READINGS	
	1. *Proteins: Structure and Function; David Whitford; 1st Ed; Wiley, 2005.* 2. *Biochemistry by Donald Voet and Judith G. Voet; Ed. 4th; Wiley; 2010.* 3. *Lehninger principles of biochemistry by David L. Nelson and Michael M. Cox; Ed. 6th; W.H. Freeman, 2012.* 4. *Biochemistry by Christopher K. Mathews and Kensal E. van Holde and Kevin G. Ahern; Ed. 3rd; Prentice Hall, 1999.* 5. *Biochemistry by Jeremy M. Berg and John L. Tymoczko and Lubert-Stryer; Ed. 6th; W.H. Freeman, 2008.* 6. *Fundamentals of Protein structure and function, Buxbaum Engelberg; Springer, 2015.* 7. *Life Sciences, Fundamentals and Practice-I and II, Pathfinder Publication, New Delhi, India. 2021*

M.Sc. BIOMEDICAL SCIENCE		I SEMESTER
COURSE CODE: BSC		COURSE TYPE: CCC
COURSE TITLE: CELL BIOLOGY AND HUMAN GENETIC		
CREDIT: 04	TEACHING HOURS: 90	
MARKS: 100	THEORY EXAM: 80	CCA: 20

UNIT-1 18 Hours	**Cell Structure and Functions:** structure of eukaryotic cells; Plasma membrane; Transport across the plasma membrane, endocytosis, exocytosis. Cellular organelles; Ribosome, Mitochondria, ER, Golgi complex. Cytoskeleton: Cell motility and shape, protein sorting, Transport of proteins. Microfilaments and actin filaments, Cell-cell interaction, Cell junctions, Adhesion proteins, Cell matrix interaction, Integrins, Functional role of adhesion proteins. Molecular aspects of cell division; Cell cycle and its control - molecular events and model system, cell cycle regulation.
UNIT-2 18 Hours	Cellular communication: general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation. Cellular responses to environmental signals in bacteria and animals; cell signaling molecules, Receptors, GPCR and G protein, Ion channel linked receptor, Enzyme-linked receptor, Nitric oxide, Quorum sensing. Biology of cancer: Molecular basis of cancer, Proto-oncogenes, Tumor suppressor genes, Carcinogen, Retinoblastoma, Oncovirus or tumor virus, coronavirus Apoptosis and necrosis.

UNIT-3 18 Hours	**Classical Genetics:** Mendel's Principles (Mendel's law of Inheritance, Incomplete dominance and co-dominance, Multiple Alleles, Lethal Alleles, Penetrance and Expressivity, Probability), Chromosomal basis of inheritance. Genetic linkage and gene mapping (Gene mapping from two and three-point cross), Cytogenetics (Karyotyping, Chromosome banding, variation in chromosome number, chromosome aberrations)
UNIT-4 16 Hours	**Molecular Genetics:** Genome, Genome complexity-Repetitive Sequence, Highly Repetitive DNA Sequence, Mini and Microsatellites, Moderately Repetitive Sequence. Transposable Elements-Transposons, Bacterial Transposons, Eukaryotic Transposons, Viral Transposons. Gene, Introns, Acquisition of new genes, fate of duplicated genes, gene families (homologous gene, Pseudogenes), human nuclear genome, organelle genome, Yeast *S. cerevisiae* genome, *E.coli* genome.
SUGGESTED READINGS	1. *Molecular biology of the cell by Bruce, Alberts and Alexander Johnson and Julian Lewis, and Martin Raff; Ed. 5th; Garland Science; 2008.* 2. *Molecular biology of the cell: the problem book by John Wilson and Tim Hunt; Ed. 5th; Garland Science; 2008.* 3. *Molecular cell biology by Harvey Lodish and Arnold Berk, Chris A. Kaiser, and Monty Krieger; Ed. 6th; W H Freeman and Company; New York; 2008.* 4. *Cell: molecular approach by Geoffrey M. Cooper and Robert E. Hausman; Ed. 4th; ASM Press; 2007.* 5. *Cell biology by Thomas D. Pollard and William C. Earnshaw; Ed. 2nd; Saunders;2008. Topley and Wilson's Microbiology and Microbial Infections by Leslie Collier and Albert Balows and Max Sussman; Ed. 9th; 6-Volume Set; A Hodder Arnold Publication, 2000.* 6. *Human Molecular Genetics, Strachan T and Read AP – Garland Science* 7. *Life Sciences, Fundamentals and Practice-I and II, Pathfinder Publication, New Delhi, India. 2021*

7. *Genomes, Brown TA – Wiley Liss*

8. *Human Genetics and Genomics, Korf BR - Wiley*

9. *The Book of Genes and Genomes, Willard and Haga, - Springer*

10. *Modern Genetic Analysis, Griffiths AJF, Gelbart WM, Miller JH et al., - Freeman*

11. *An Introduction to Genetic Analysis, Griffiths AJF, Miller JH, Suzuki DT et al., - Freeman*

M.Sc. BIOMEDICAL SCIENCE		**I SEMESTER**
COURSE CODE: BSC		**COURSE TYPE: CCC**
COURSE TITLE: MEDICAL BIOTECHNOLOGY		
CREDIT: 04	**THEORY HOURS: 90**	
MARKS: 100	**THEORY EXAM: 80**	**CCA: 20**

UNIT-1 20 Hours	Recombinant DNA Technology: DNA Cloning (Cell-based DNA cloning, Cell-free DNA Cloning, Enzyme used in recombinant DNA Technology: Template-dependent DNA polymerase, Nucleases (Mung bean nucleases, S1 nucleases, RNase A, RNase H, Types of Restriction endonucleases & restriction maps, Restriction modification systems. End-modification enzymes: Terminal deoxynucleotidyl transferase, Alkaline phosphatases, T4 polynucleotide kinase. Ligases, Linkers and adaptors.
UNIT-2 20 Hours	Vectors: Cloning vectors and Expression vectors. Vector for *E. coli* (Cloning vector based on Plasmid DNA, viral DNA, M13 Phage DNA, Cosmids, Phagemid Vectors, PAC, YAC. Vectors for Animals, Expression Vectors. Selectable and Screenable marker (Positive and Negative marker gene), Recombinant screening (red-white selection), Expression system (Prokaryotes and Eukaryotes), DNA Library: Genomic and cDNA library.
UNIT-3 15 Hours	PCR: Application and principles of Polymerase Chain Reaction, RFLP, RT-PCR, RACE. DNA sequencing: Sanger Method, Maxam-Gilbert, Chain-termination method, Next-Generation sequencing. Genome Mapping: Genetic Markers, types of DNA markers (RFLPs, RAPD, AFLP, SSLPs and SNPs), Physical Mapping: Restriction, Fluorescence in situ hybridization and sequence tagged site mapping
UNIT-4 20 Hours	Animal Cell Culture: Primary cell culture, Cell line, Growth cycle, culture media (Natural, Artificial, Serum free media). Gene Therapy: Potential use of somatic gene therapy, Methods for inserting and expressing a gene in a target cell, gene delivery system, Viral (Retrovirus, Adenovirus, adeno-associated virus, retrovirus), non-viral mediated transduction methods (Liposome mediated, Biolistic)

SUGGESTED READINGS

1. *Principles of Gene manipulation (Primrose), 7th Edition*
2. *Molecular Cloning (A laboratory manual), Vol 1, Vol 2, Vol 3*
3. *Molecular Cell Biology (Lodish), 7th Edition*
4. *Review articles from: Nature Reviews (Journals)*
5. *Life Sciences, Fundamentals and Practice-I and II, Pathfinder Publication, New Delhi, India. 2021*

M.Sc. BIOMEDICAL SCIENCE		I SEMESTER
COURSE CODE: BSC		COURSE TYPE: CCC
COURSE TITLE: TECHNIQUES AND INSTRUMENTATION		
CREDIT: 04	TEACHING HOURS: 90	
MARKS: 100	THEORY EXAM: 80	CCA: 20

UNIT-1 15 Hours	Selecting an analytical method and developing a new Analytical Technique. Ultraviolet. Visible molecular absorption spectroscopy, Theoretical basis, transitions, Lambert's Beers Law, factors affecting Absorption, Fluorescence and Phosphorescence, Fluorescence quenching, Fluorescence resonance energy transfer (FRET) with examples from the Biomedical field. Biomolecular interactions using spectroscopic methods, Infrared–vibrational spectroscopy introduction, Functional group identification, Effects of various factors on IR frequencies and biomedical application. Concept of circularly polarized light and principles of Circular dichroism (CD), concepts of bandwidth, slit width, scan speed, and other factors in getting proper resolution of bands.
UNIT-2 15 Hours	Principles of chromatography, Types of Chromatography: Paper chromatography, Thin layer Chromatography, size exclusion, Ion exchange, Affinity chromatography, High-performance liquid chromatography (HPLC), Gas-liquid chromatography (GLC), Reverse Phase Chromatography, Mass Spectrometry, GC-MS and LC-MS.
UNIT-3 20 Hours	Introduction to mass Spectrometry. Forming charged particles: Electron impact (EI) and Chemical Ionization (CI), Fast Atom Bombardment (FAB), Field Desorption (FD), Electrospray Ionization, Matrix-Assisted Laser Desorption Ionization (MALDI). Mass Analyzers: Magnetic sector mass spectrometers, Double focusing mass spectrometers, Quadrupole pole mass spectrometers, ion cyclotron resonance, Time of Flight mass analyzers.

UNIT-4 20 Hours	Introduction to flow cytometer: Need and versatility of FACS. Fluidics and Optics in FACS. Filters and detectors in FACS: choosing the right fluorochromes, compensation of overlapping emissions. Plotting of data in various formats (Histograms/dot plots/ contour plots) Gating, Principles of cell Sorting by FACS and MACS.
SUGGESTED READINGS	1 *Spectrometric identification of organic compounds by Robert M. Silverstein and Francis X. Webster; Ed. 6th; John Wiley; 1997.* 2 *Principles of instrumental analysis by Douglas Skoog and F. James Holler andTimothy A. Nieman; Ed. 5th; Saunders; 1998.* 3 *Contemporary instrumental analysis by Kenneth A. Rubinson and Judith F. Rubinson; Prentice Hall 2000.* 4 *Organic spectroscopy by William Kemp; Ed. 3rd; Palgrave; 1991.* 5 *Basic one and two-dimensional NMR spectroscopy by Horst Friebolin; Ed.3rd; Wiley- VCH; 1998.* 6 *Principles of Fluorescence Spectroscopy by Lacowicz, 3rd Ed. 2006, Springer US.* 7 *NMR and its applications to living systems by David G. Gadian; Ed. 2nd; Oxford; 1995.* 8 *Structure determination of organic compounds: tables of spectral data by E. Pretsch and P. Buhlmann and C. Affolter; Springer; 2005.* 9 *MRI principles by Donald G. Mitchell; W S Saunders; 1999.* 10 *HPLC: a practical user's guide; Ed.2nd by Marvin C. McMaster; Wiley-Interscience; 2007.*

M.Sc. BIOMEDICAL SCIENCE	I SEMESTER
COURSE CODE: BSC	**COURSE TYPE: PRACTICAL**
COURSE TITLE: LAB (Lab Course 1)	
CREDIT: 04	**PRACTICAL HOURS: 90**
MARKS: 100	

LABORATORY WORK

1. Preparation of buffers and other solutions
2. Salting in and salting out of proteins.
3. Void Volume estimation
4. Desalting of proteins by dialysis
5. Desalting of proteins by Sephadex G-25
6. Protein estimation by Lowrys & Bradford methods.
7. Protein estimation by Lamberts & beer law
8. Ion-exchange chromatography.
9. Affinity chromatography for protein:

(i) protein induction & binding to affinity column

(ii) running gel & analysis

10. To check purity of protein & subunit structure by SDS page silver staining

(i) reducing Gel **(ii)** non reducing Gel

11. (i) Running Western blot of a specific protein:

(i) SDS, transfer & blocking and **(ii)** probing with antibodies & analysis of result

12. To run Native Gel of a protein/Far western blot.

13. Protein & Nucleic Acid blasts, Clustal W and sequence alignment etc.

14. Measurement of Enzyme activity parameters

15. Measurement of Enzyme inhibition mechanisms

16. Recrystallization and Melting Determination
17. Thin Layer Chromatography (mixture of 2 compounds)
18. Thin Layer Chromatography (mixture of 3 compounds)
19. Claisen Schmidt reactions
20. Infrared spectroscopy (instrumentation and spectra analysis)
21. Cannizarro reaction
22. Optical activity by polarimetry of known optically active compound of known concentration and hence to determine concentration of unknown sample
23. Column chromatography

24. Aldol condensation
25. Schotten Baumann reaction
26. Demonstration of sterilization techniques related to equipment and use of aseptic techniques for preparation of pure cultures.
27. Demonstration of differential staining techniques like Gram's staining, AFB staining, spores taining etc. Differentiation of flagellate vs non-flagellate bacteria.
28. Differential diagnosis of bacteria based on biochemical tests.
29. Spread plate technique and antibiotic sensitivity assay.
30. Identification of medically important fungi.

M. Sc. in Biomedical Science

SECOND SEMESTER (EVEN SEMESTER)

Course Code	Course Type	COURSE (PAPER/SUBJECTS)	Credits	Maximum Marks		
				Internal	External	Total
BSC	CCC	Human Physiology-I	4	20	80	100
BSC	CCC	Medical Microbiology	4	20	80	100
BSC	CCC	Immunology	4	20	80	100
BSC	CCC	Molecular Biology	4	20	80	100
BSC	LAB	Lab (Lab Course 2)	4	20	80	100
Minimum credits in complete semester it would be 20			**Total: 20**			

The M.Sc. program will be divided into four semesters each being of six months duration. Each semester comprises of compulsory core courses (CCC) Lab course (LC) will be based on CCC. Each theoretical course will be divided into Internal Assessment of 20 marks and semester end examination of 80 marks.

Duration of Theoretical and Practical Examination Time: 03 Hours

M.Sc. BIOMEDICAL SCIENCE		II SEMESTER
COURSE CODE: BSC		COURSE TYPE: CCC
COURSE TITLE: HUMAN PHYSIOLOGY-I		
CREDIT: 04	TEACHING HOURS: 90	
MARKS: 100	THEORY EXAM: 80	CCA: 20

UNIT-1 18 Hours	Tissues: Epithelial tissue (Covering and lining epithelium; Simple epithelium- stratified epithelium, glandular epithelium Endocrine and exocrine glands). Connective tissue (Embryonic connective tissue and Mature connective tissue-Loose connective tissue, Dense connective tissue, Cartilage, Bone tissue, Liquid connective tissue), Nervous tissue, Muscular tissue.
UNIT-2 18 Hours	Nervous system: Histology of Nervous tissue, Classification of neurons, Structural organization of Central Nervous system, blood-brain barrier, parts of the brain, Spinal cord. Peripheral nervous system (Cranial and Spinal nerve), Autonomic nervous system. Sensory organs. Resting membrane potential of nerves, Nerve action potential, neurotransmitters: synthesis, models of exocytosis of synaptic vesicles and its inhibitors, synapse: types, pre and post-synaptic regulation.
UNIT-3 18 Hours	Excretory system: Structure of the kidneys-Anatomy of Kidneys (Renal capsule, blood supply of the kidneys), Nephron and parts of nephron, Urine Formation-Glomerulus filtration (Glomerulus filtration rate, Glomerulus hydrostatic pressure, capsular hydrostatic pressure, blood colloid osmotic pressure), Regulation of glomerulus filtration rate (GFR)-Neural regulation of GFR, Renal autoregulation of GFR, Hormonal regulation of GFR. Tubular reabsorption and tubular secretion (in the proximal convoluted tubule, loop of Henle, distal convoluted tubule and collecting duct. Hormonal regulation of tubular reabsorption and tubular secretion- Angiotensin II, Antidiuretic hormone (ADH), Countercurrent exchange

UNIT-4 18 Hours	Reproductive System: Anatomical and functional aspects of human genital system, Sex Differentiation & Development, Aberrant Sexual Differentiation, Embryology of the Human Reproductive System, defects of reproductive system, Puberty: Precocious & Delayed Puberty, Menopause, Male: Gametogenesis, Development structure and function of testis with Ejaculation, Control of Testicular Function, Abnormalities of Testicular Function, Female: Gametogenesis Development structure and function of ovary The Menstrual Cycle, Control of Ovarian Function, Abnormalities of Ovarian Function, Pregnancy: conception, fetal development, placenta, parturition, Lactation, fertility and infertility, Physiological concepts for a planned family.

SUGGESTED READINGS	

1. *Textbook of medical physiology by Arthur C. Guyton and John E. Hall; Ed.13th & 14th.*
2. *Review of medical physiology by William F. Ganong; Ed. 23nd; McGraw Hill; 2010.*
3. *Essential medical physiology by Leonard R. Johnson and Ed. 3rd; ELSEVIER; 2003.*
4. *Principles of anatomy and physiology by Gerard J. Tortora and Bryan Derrickson; Ed.15th; John Wiley; 2016.*
5. *Hole's Human Anatomy & Physiology, McGraw-Hill Education; 14th edition, 2015*
6. *Medical Physiology: A cellular and molecular approach by Walter F. Boron and Emile L. Boulpaep; Saunders; Ed. 3rd, 2017.*
7. *Physiology by Robert M. Berne and Matthew N. Levy; Mosby; ELSEVIER, Ed.7th 2018.*
8. *Essentials of Anatomy & Physiology Plus Mastering A&P with Pearson (7th Edition) 2016*
9. *Life Sciences, Fundamentals and Practice-I and II, Pathfinder Publication, New Delhi, India. 2021*

M.Sc. BIOMEDICAL SCIENCE		**II SEMESTER**
COURSE CODE: BSC		**COURSE TYPE: CCC**
COURSE TITLE: MEDICAL MICROBIOLOGY		
CREDIT: 04	**THEORY HOURS: 90**	
MARKS: 100	**THEORY EXAM: 80**	**CCA: 20**

UNIT-1 20 Hours	Bacterial morphology: detailed structural features of gram positive and gram-negative bacteria, Staining techniques for identification of bacteria. Detailed structure and functions of various bacterial organelles, cell wall, cell membrane, ribosomes, flagella, spores, capsules, storage components, Techniques to study morphology of bacteria, Nutrition and condition requirements of bacteria: Macro and micronutrients, growth of bacteria, temperature, moisture and desiccation, oxygen and carbon dioxide requirements of bacteria. Multiplication and bacterial growth and methods to study growth patterns in bacteria. Identification of bacteria using biochemical methods.
UNIT-2 20 Hours	Bacterial and Phage genetics: Bacterial genome- chromosome and plasmids (Nucleoid, types of plasmids: F-plasmid, R-plasmid, col plasmids), Properties of plasmids- Plasmid replication, Host range, copy number, plasmid incompatibility, partitioning, Function encoded by plasmids. Transformation, transduction, Conjugation, genetic map construction in *E. coli*. Phage genetics, fine structure of rII region, work of Seymour Benzer, highlighting the design of experiment and choice of the experimental model.
UNIT-3 15 Hours	GI tract infections: Salmonella, Shigella, *Staphylococcus*, *E. coli*, Helicobacter pylori. Microbial pathogenicity, virulence factors and their effect on pathogenesis. Chemotherapy: structure and mechanism of action of Cell wall inhibitors, antimetabolites. Antimicrobial chemotherapy, protein synthesis inhibitors, Nucleic acid inhibitors. Methods for estimation of antimicrobial activity. Mechanisms of Antibiotic resistance. Urinary tract infections and Infections of the respiratory system

UNIT-4 20 Hours	Classification of Fungi, Reproduction in fungi, Spore formation in fungi, Economic importance of fungi. Mycoses, Tenia Versicolor, White Piedra, Black Piedra. Dermatophytes, Dermatophytidis, Candidiasis, Cryptococcosis. Opportunistic Fungi, Ostomycosis. Fungal Contaminants. Medical parasitology overview and classification of medically important parasites. Shapes and structure of viruses, classification of viruses. Life cycle of various viruses as per Baltimore system of classification. Arboviruses, their genetics, pathogenesis, epidemiology, diagnosis and clinical features with emphasis on hepatitis, Dengue, Zika and Chikungunya viruses
SUGGESTED READINGS	1. *Medical Microbiology by Geo. Brooks and Karen C. Carroll and Janet Butel and Stephen Morse; Ed. 24th; McGraw-Hill Medical, 2007.* 2. *Microbiology by Lansing M. Prescott and John P. Harley and Donald Klein; Ed. 6th; McGraw-Hill Science, 2004.* 3. *Medical microbiology: a guide to microbial infections: pathogenesis, immunity, laboratory diagnosis and control by David Greenwood and Richard C. B. Slack and John F. Peuthere, ed. 17th Ed. Churchill Livingstone; 2007.* 4. *Fundamental Virology: Fields and Knipe, ed. Raven Press, 1991.* 5. *Strauss, E. G. and Strauss, J. H., "Viruses and Human Disease", Academic Press, 2002.* 6. *Flint, S.J., Enquest, L.W., Krug, R. M., Racaniello, V. R., and Skalka, A. M., "Principles of Virology: Molecular Biology, Pathogenesis and Control", ASM Press. 2000.*

M.Sc. BIOMEDICAL SCIENCE		II SEMESTER
COURSE CODE: BSC		COURSE TYPE: CCC
COURSE TITLE: IMMUNOLOGY		
CREDIT: 04	TEACHING HOURS: 90	
MARKS: 100	THEORY EXAM: 80	CCA: 20

UNIT-1 15 Hours	History and scope of Immunology: Introduction to Immune System, concepts of Innate and acquired Immune responses, Active and passive Immunity, Natural and artificial immunity, primary and secondary immune responses. Lymphoid system: Primary and Secondary Lymphoid organs. Bone marrow, spleen, various lymph nodes, MALT, GALT, NALT, ILT. Cells involved in the Immune Response: Structural and functional features of cells involved in immune responses and their relative significance. Lymphocytes (B&T lymphocytes), NK Cells. Mononuclear Phagocytes, Antigen-presenting cells, Polymorphonuclear cells, eosinophils, basophils and mast cells,
UNIT-2 15 Hours	Antigens: Requirements for immunogenicity (Foreignness, size, chemical complexity, dose and route of administration), Haptanes, Antigen-antibody interactions- affinity and avidity, cross-reactivity, Factors affecting antigen-antibody interactions, Adjuvant. Major Histocompatibility complex (MHC): Classes of MHC, Important aspects of MHC. Antigen processing and presentation: Processing and presentation of endogenous antigens by cytosolic pathway, Processing and presentation of exogenous antigens by Endocytic pathway
UNIT-3 20 Hours	Immunoglobulins: Structure and function, Basic structure of antibody molecule (Deduction of Ab structure, Immunoglobins domains), different classes of immunoglobin (IgG, IgM, IgA, IgE and IgD). Action of antibody (Opsonization, Toxin neutralization, activation of complement, Immune complex formation and Antibody-dependent cell-mediated cytotoxicity). Antigenic determinants on immunoglobins-Isotypes, allotypes, idiotypes.

UNIT-4 20 Hours	Hypersensitivity: Type I, II, III, IV Hypersensitivity. Autoimmune disease, transplantation-Isograft, allograft, Xenograft and Autograft. Immunodeficiency diseases: Primary and Secondary Immunodeficiency. Vaccines: Types of antigens used in vaccines, whole organism vaccines-Live but attenuated vaccines, inactivated (killed) vaccines, purified antigen vaccines, DNA Vaccines, Recombinant vector vaccines
SUGGESTED READINGS	1. *Fundamental Immunology William Paul (Ed) 2017. Lippincott Williams & Wilkins.* 2. *Kuby Immunology by Thomas Kindt and Richard A. Goldsby and Barbara A. th Osborne; Ed. 6 edition. W.H. Freeman and Company, New York; 2007* 3. *Cellular and molecular immunology by Abul K. Abbas and Andrew H. Lichtman and Shiv Pillai; Ed. 6th; Saunders, 2007.* 4. *Immunology; Ed.7th by David Male and Jonathan Brastoff and David B. Both and Ivan Roitt; Mosby Elsevier; 2006.* 5. *Immunobiology: the immune system in health and disease by Charles A. Janeway and Paul Travers and Mark Walport and Mark J. Shlomchik; 7th Ed; Garland Science; 2008.* 6. *Immunology of infection diseases by Stefan H.E. Kaufmann and Alan Sher and Rafi Ahmed; ASM Press, Washington; 2002.* 7. *Essentials of immunology & serology by Jacqueline H. Stanley; DELMAR; Australia; 2002.*

M.Sc. BIOMEDICAL SCIENCE		**II SEMESTER**
COURSE CODE: BSC		**COURSE TYPE: CCC**
COURSE TITLE: MOLECULAR BIOLOGY		
CREDIT: 04	**TEACHING HOURS: 90**	
MARKS: 100	**THEORY EXAM: 80**	**CCA: 20**

UNIT-1 15 Hours	Molecules and macromolecules in BIOMEDICAL systems, Amino acids, peptides and proteins, Structure and Functions of proteins Formation of peptide bonds, Protecting groups and peptide bond formation, protein degradation and sequencing of amino acids, DNA and RNA bases, nucleosides and nucleotides, phosphodiesters, formation of N- and C- glycosides, conformation and configuration of 5 carbon and 6-carbon sugars, maltose, sucrose and lactose, Synthetic macromolecules and polymers in biology, Building of macromolecules and molecular frameworks and their biomedical applications.
UNIT-2 15 Hours	Regulation of gene expression in Prokaryotes Coordinated control of clustered genes-operon model, with example of inducible systems like Lac– Operon. Arabinose operon and repressible systems like Trp operon. Role of cyclic AMP. Role of repressors and activators of transcription in regulation of phage-lytic and lysogeic pathways, lambda repressor. Regulation of Gene expression in Eukaryotes Introduction-Organization of genes in eukaryotic DNA; Repetitive DNA sequences, Activators, enhancers. Modular structure of trans activators, repressor complexes, mechanism of their function in gene regulation. Post transcriptional regulation of transcription regulators by methylation, acetylation, hormones and protein-protein interactions.
UNIT-3 20 Hours	Chromatin remodeling: Introduction to chromatin remodeling concepts and factors involved. Role of various remodeling proteins such as NURF, ACF**,** Role of DNA and histone methylation and histone acetylation in chromatin remodeling and gene regulation. Concept of insulators, nuclear matrix in gene regulation, Methods to understand chromatin remodeling.

UNIT-4 20 Hours	The Cancer Problem Epidemiology, Environmental carcinogens and risk factors. Mechanisms of Carcinogenesis: Initiation, Promotion and Progression. Role of DNA damage, repair and mutations by physicochemical agents and viruses, interaction of various agents. Tumor types and leukemia Benign and malignant tumors, localized and metastatic disease, degree of malignancy. Angiogenesis, Neoarrgiogenesis, Stem Cell Differentiation, Morphogens Experimental Model Systems in Cancer Research Microbial Models, Primary Cell Cultures, Established Cell Lines, Organ Cell Cultures, Spheroids. Tumor suppressor genes and Viral oncogenes. Mechanisms of P53, Rb, Ras action in normal and transformed cells and viral oncogenes, Role of oncogenes in gene regulation using examples erb, rel, jun-fos, large Tantigen etc. Growth factor-signalling pathways in cancer Relationship between oncogene products and growth factors, using example of Src, Wnt, Abl, GAP and growth factors. Effect of viral infection on signal transduction. Cancer genetics, familial cancers. Emerging Cancer Therapy Cellular, tissue and molecular markers, potential targets for Cancer Therapy, Drug Discovery Strategy.

SUGGESTED READINGS	
	1. *Biomedical Chemistry: Applying Chemical Principles to the Understanding and Treatment of Disease edited by Paul F. Torrence.* 2. *Molecular Biology of Gene, Watson James D., Baker Tania A., Bell Stephen P., Gann Alexander, Levine Michael, Losick Richard.* 3. *Karp's Cell and Molecular Biology: Concepts and Experiments, Binder Ready Version, 8th Edition.* 4. *Molecular cell biology by Harvey Lodish and Arnold Berk, Chris A. Kaiser, and Monty Krieger; Ed. 6th; W H Freeman and Company; New York; 2008.* 5. *Principles of molecular oncology by Miguel H. Bronchud and Others; Humana Press; 2000.*

M.Sc. BIOMEDICAL SCIENCE	II SEMESTER
COURSE CODE: BSC	**COURSE TYPE: PRACTICAL**
COURSE TITLE: Lab Course II	
CREDIT: 04	**PRACTICAL HOURS: 90**
MARKS: 100	

LABORATORY WORK

1. Primer designing for gene amplification using PCR, and other types of primers forreal-time PCR based detection or analysis
2. Preparation of Various solutions and Buffers, cell culture LB (Luria-Bertani) media preparation, LB-Agar Plates, Ampicillin Antibiotics preparation, autoclaving,sterilized surface, laminar flow operation.
3. Adopting calcium chloride methodology for Competent cells preparation
4. Polymerase Chain Reaction based gene amplification and recombinant formation using cloning vector
5. Recombinant plasmid isolation and preparation
6. Recombinant restriction digestion of DNA and excision of DNA from Agarose gel Heat shock methodology based recombinant transformation, competent efficiencycalculation and Blue white colony screening
7. Application of Polymerase Chain Reaction based infectious or non-infectious diseasediagnosis

M. Sc. in Biomedical Science

THIRD SEMESTER (ODD SEMESTER)

Course Code	Course Type	COURSE (PAPER/SUBJECTS)	Credits	Maximum Marks		
				Internal	External	Total
BSC	CCC	Human Physiology II	4	20	80	100
BSC	CCC	Principles of Medicinal Chemistry	4	20	80	100
BSC	CCC	Pharmacology & Toxicology	4	20	80	100
BSC	CCC	Bio informatics, Computational Biology and Drug Design	4	20	80	100
BSC	LAB	Lab (Lab Course 3)	4	20	80	100
Minimum credits in complete semester it would be 20			**Total: 20**			

The M.Sc. program will be divided into four semesters each being of six months duration. Each semester comprises of compulsory core courses (CCC) Lab course (LC) will be based on CCC. Each theoretical course will be divided into Internal Assessment of 20 marks and semester end examination of 80 marks.

Duration of Theoretical and Practical Examination Time: 03 Hours

M.Sc. BIOMEDICAL SCIENCE		III SEMESTER
COURSE CODE: BSC		COURSE TYPE: CCC
COURSE TITLE: HUMAN PHYSIOLOGY II		
CREDIT: 04	TEACHING HOURS: 90	
MARKS: 100	THEORY EXAM: 80	CCA: 20

UNIT-1 18 Hours	**Cardiovascular system:** Blood-Function of blood, components of blood, formed elements, Blood clotting. Heart: Anatomy of Heart, Heart valves and circulation of blood. Cardiac conduction system, Heartbeat, electrocardiogram, Characteristics of normal electrocardiogram, analysis of ECG for various myopathies, Cardiac arrhythmias, Physical characteristics and basic theory of circulation. Cardiac Cycle Control and Regulation of excitation, contraction and conduction of heart pumping, Heart sounds, Cardiac output. Blood and circulation: blood corpuscles, haematopoiesis and formed elements, plasma function, Hemostasis and blood coagulation, Blood banking, blood groups, Transfusion, cardiovascular disorders-coronary artery disease, heart failure etc.
UNIT-2 18 Hours	**Digestive System:** Gastro-intestinal tract, Layers of gastrointestinal tract (Mucosa, Submucosa, Muscularis propria, Serosa), Exocrine Cells-Mucus neck cells, chief cells and parietal cells. Enteroendocrine cells- G and D Cells, Enterochromaffin cells. Phases of gastric secretion-Cephalic phase, Gastric phase and intestinal phase. Accessory digestive organs- Salivary glands, liver, gallbladder and Pancreas. Digestion and absorption of food, Regulation of digestive function, Characteristic of major digestive enzymes.

UNIT-3 18 Hours	**Reproductive System:** Reproductive Anatomy Male reproductive system (gross anatomy, neuroendovascular supply) Female reproductive system (gross anatomy, neuroendovascular supply). Male reproductive system- Spermatogenesis, Female reproductive system-Oogenesis, Female reproductive cycle (Ovarian and Uterine cycles). Fertilization, Implantation, Bilaminar germ disc, Trilaminar germ disc, The embryonic period (overview), The fetus, The fetal membranes and placenta Birth defects and prenatal diagnosis.
UNIT-4 18 Hours	**Endocrine System:** Major hormones producing endocrine glands- Hypothalamus, Pituitary gland, Pineal gland, thyroid gland, parathyroid gland, thymus gland, pancreas, adrenal gland, gonadal hormone, Hormones from kidney, heart, placenta and gastrointestinal tract. General Mechanism of hormone action- action of lipid and water-soluble hormone. Hormone and disease-Pituitary gland disorder, pancreatic islet disorders, thyroid gland disorders, parathyroid gland disorder, adrenal gland disorder.

SUGGESTED READINGS	
	1. *Textbook of medical physiology by Arthur C. Guyton and John E. Hall; Ed.13th & 14th.* 2. *Review of medical physiology by William F. Ganong; Ed. 23nd; McGraw Hill; 2010.* 3. *Essential medical physiology by Leonard R. Johnson and Ed. 3rd; ELSEVIER; 2003.* 4. *Principles of anatomy and physiology by Gerard J. Tortora and Bryan Derrickson; Ed.15th; John Wiley; 2016.* 5. *Hole's Human Anatomy & Physiology, McGraw-Hill Education; 14 edition, 2015* 6. *Medical Physiology: A cellular and molecular approach by Walter F. Boron and Emile L. Boulpaep; Saunders; Ed. 3rd, 2017.* 7. *Physiology by Robert M. Berne and Matthew N. Levy; Mosby; ELSEVIER, Ed.7th 2018.* 8. *Principles of Neural Science, (Kandel) 5th Edition, 2013.* 9. *Fundamental Neuroscience, ELSEVIER 4th Edition, 2012* 10. *Neuroscience Online,an Open-Access Neuroscience Electronic Textbook https://nba.uth.tmc.edu/neuroscience/*

M.Sc. BIOMEDICAL SCIENCE		III SEMESTER
COURSE CODE: BSC		COURSE TYPE: CCC
COURSE TITLE: PRINCIPLES OF MEDICINAL CHEMISTRY		
CREDIT: 04	TEACHING HOURS: 90	
MARKS: 100	THEORY EXAM: 80	CCA: 20

UNIT-1 18 Hours	**Role of Medicinal Chemistry in discovery of drugs:** Introduction to medicinal chemistry as a strategy for the design of new drug candidates for human pathologies, Discovery of lead compound- Serendipous, Random and Non-random screening, drug metabolism studies, clinical observations, Rational approaches to lead discovery- Homologation, chain branching, ring-chain transformations, bioisosterism. Lead modifications: Conventional drug screening and structural modifications, concept of isosteres and bioisosteres, structure activity relationship. Introduction to molecular modeling and molecular graphics, pharmacophore descriptors: The classical mechanics model (e.g., MM1, MM2), Quantum chemical methods semi-empirical and ab initio methods, Molecular graphics.
UNIT-2 18 Hours	**Receptors:** Chemical nature of receptors-Covalent, ion-ion, ion-dipole, Hydrogen bonding, C-H bonding, dihydrogen bonding, Van der Waals interactions and the associated energies, Chirality and receptor binding. Drug receptor interactions-Occupancy Theory, Rate Theory, Induced Fit Theory, Macromolecular perturbation theory, Activation-Aggregation theory. Classification of receptors and receptor subtypes, Neurotransmitters and their receptors, Receptor modulation and mimics receptor sites. Chirality and receptor binding, Signal transduction and second messenger systems. Active transport, affinity and efficacy, antagonism, partial antagonism, inverse agonism, allosteric binding sites.

UNIT-3 18 Hours	Drugs Targeting and Interaction: Introduction of various classes of drugs based on their interaction with target site. Drugs interacting with Receptors-Rational design of agonist/antagonist Enzymes, Mechanisms of enzyme catalysis, Electrostatic catalysis and desolvation. Covalent catalysis, Acid-base catalysis, Strain / distortion in enzyme catalysis. Coenzyme catalysis. Enzyme Inhibition-Reversible and irreversible, rational design of various enzyme inhibitors, Adverse drug reactions, Drugs acting on cell wall, Fungal membrane and nuclear membrane, Drugs inhibiting protein synthesis. DNA- NA as targets for drug action. NA-interactive agents. Classes of drugs that interact with nucleic acids. Intercalation, NA-alkylation, NA-strand breaking and their importance in drug action, Carbohydrates- development of glyco-conjugates in cancer models
UNIT-4 16 Hours	Drug Metabolism: Structure-activity relationship illustrated with examples from, Sulphonamides, b-lactams, Quinolones, Nucleosides and Alkaloids. Bio-transformations and their Mechanisms, Phase I and Phase II metabolism, Oxidation, Reduction, Hydrolysis, Deamination and Conjugation (GSH, Sulfate, Glucuronide and Amino acids), Role of non-specific enzymes: Oxidases, Mono-oxygenases, Di-oxygenases and Peroxidases.
SUGGESTED READINGS	*1.Organic chemistry of drug design and drug action by Richard B. Silverman; Ed. 2nd; ELSEVIER; 2004.* *2.Foye's Principles of Medicinal Chemistry by Thomas L Lemke and David A Williams; Ed. 6th; Lippincott Williams & Wilkins; 2007.* *3.Medicinal chemistry: principles and practice by Frank D. King; Ed. 2nd; The Royal Society of Chemistry; 2002.* *4. Introduction to Medicinal chemistry by Graham L. Patrick; Ed. 3rd; Oxford; 2006.*

M.Sc. BIOMEDICAL SCIENCE		III SEMESTER
COURSE CODE: BSC		COURSE TYPE: CCC
COURSE TITLE: PHARMACOLOGY & TOXICOLOGY		
CREDIT: 04	TEACHING HOURS: 90	
MARKS: 100	THEORY EXAM: 80	CCA: 20

UNIT-1 19 Hours	Introduction to pharmacology: Historical background and limitations. Pharmacokinetics: Absorption, Routes of administration of drugs, their advantages and disadvantages. Various processes of absorption of drugs and the factors affecting them. Metabolism (Biotransformation): Microsomal and non-microsomal mechanisms, Metabolizing Enzymes, Phase-I and II, Factors affecting drug metabolism. Enzymes kinetics-zero order, first order and steady state kinetics and half-life of drugs. Pharmacodynamics: General mechanism of drug action and the factors, which modify drug action: Dose response relationship curves and different types of antagonisms.
UNIT-2 18 Hours	Pharmacodynamics: Principles, site and mechanism of drug action (Nervous system, Histamines and Antihistamines, Cardiovascular Drugs), Drug Receptor, Classification of receptors, Drug-Receptor interactions, Theories of Drug receptor interactions. Determination of B-max and Kd by transforming data with hill plot and Scatchard plot, above concepts with special reference to opioid, adrenergic and GABA energic receptors, GPCRS receptors. Principles of Toxicology: Definition, scope and different branches of toxicology. A brief review of toxic substances: Synthetic organic compounds: Chemical additives in food, Chemicals in the work place, Solvents, Pesticides, Cosmetics, Drugs of abuse. Inorganic chemicals: Industrial and chemical environmental inorganic toxicantspolluting air/ water/ food. Naturally occurring poisons: Mycotoxins, Bacterial toxins, Plant toxins and Animal toxins.

UNIT-3 18 Hours	Types of toxicity and its measurement: Acute, Sub-acute or Chronic and its manifestations. Acute toxicity: Mode of application/ administration/ exposure, in-vitro tests, Dose response relationship, Measurement of TD_{50}/TC_{50} and LD_{50}/LC_{50}. Sub-acute and chronic toxicity. Risk and safety analysis: Margin of safety, Therapeutic index, Ideal therapeutic index. Inter-species extrapolation of dose-response data, NOEL, ADI, TLV, WHO standards. Special toxicity studies: Carcinogenicity, teratogenicity, in-vitro mutagenicity tests.
UNIT-4 16 Hours	Pharmacokinetic aspects of toxicants: Site of metabolism, Metabolizing enzymes of liver, kidney, lung, GI tract, skin and their role in activation and detoxification of drugs and chemicals. Physiological (route of exposure, species, sex and age), Nutritional and environmental (temperature, altitude and circadian rhythms related) factors affecting metabolism, detoxification and toxic responses of drugs and chemicals. Organ toxicities: Hepatotoxicity: A brief description of morphological and functionalaspects of liver with special reference to hepatotoxicity, various hepatotoxic agents, types of liver injuries. Nephrotoxicity: A brief description of morphological and functional aspects of kidney in relation of nephrotoxicity, nephrotoxic agents, detailed mechanisms of chemical induced nephrotoxicity. Neurotoxicity: A brief description neurotoxic agents and types of neurotoxic effects- Axanopathy, Neropathy, Neuronopathy, Mylenopathy. Broncho-pulmonary (inhalation) toxicity, Gastro-intestinal toxicity, Skin toxicity/ photosensitivity.

SUGGESTED READINGS	
	1. *Essential of medical pharmacology; 6th Ed. By K.D. Tripathi; Jaypee Brothers; New Delhi; 2008.* 2. *Goodman & Gilman's the pharmacological basis of therapeutics by Laurence Brunton and John Lazo and Keith Parker; Ed. 11th; McGraw-Hill Professional; 2005.* 3. *Pharmacology H. P. Rang and M.M. Dale and J.M. Ritter and P.K. Moore; Ed. 5th; Churchill Livingstone, 2003.* 4. *Integrated Pharmacology: With Student Consult Access by Clive P. Page and* *M.J. Curtis and M.C. Sutter and M.J. Walker and B.B. Hoffman; Ed. 3rd; Mosby; 2006.* 5. *Principles of toxicology by Karen E. Stine and Thomas M. Brown; Ed. 2nd; CRC Press; 2006.* 6. *Lu's basic toxicology: fundamentals, target organs and risk assessment by Frank C. Lu and Sam Kacew; Ed. 5th; Informa Healthcare; 2009.* 7. *Casarett and Dull's toxicology: the basic science of poisons by Curties D. Klaassen; Ed. 7th; McGraw Hill; New York; 2007.* 8. *Toxicology by Hans Marquradt and S.G. Schafer and R.D. McClellah and Academic Press; 1999.* 9. *Principles and practice of toxicology in public health by Ira R. Richards; Jones and Bartlett Publishers; 2007.* 10. *Handbook of human toxicology by E.J. Massaro; CRC Press; 1997.*

M.Sc. BIOMEDICAL SCIENCE	**III SEMESTER**
COURSE CODE: BSC	**COURSE TYPE: CCC**
COURSE TITLE: BIO INFORMATICS, COMPUTATIONAL BIOLOGY AND DRUG DESIGN	
CREDIT: 04	**TEACHING HOURS: 90**
MARKS: 100	**THEORY EXAM: 80** **CCA: 20**

UNIT-1 18 Hours	Basics of Bioinformatics, Basic commands of Windows, Unix and Linux operating systems, Sequence Analysis: Biological background for sequence analysis; Sequence alignment: Global, Local, Pairwise and Multiple sequence analysis; Algorithm for alignments Database Searching; Tools for Sequence alignment. Biological Databases, Introduction to Data types and source; Protein Sequence and Structural Databases; Nucleic acid databases; Genome databases; Specialized Databases; Carbohydrate Databases; Clinically relevant drug-drug interactions databases; Information retrieval from Biological databases: Entrez system, TCGA data bases, Bioportal Cheminformatics: Introduction; Cheminformatics tools; Chemical structure representation (SMILES and SMARTS); Chemical Databases: CSD, ACD, WDI, Chembank, PUBCHEM, Chemical Structure file formats; Structural Isomers; Structure visualization
UNIT-2 18 Hours	Biosimilars: Introduction to biosimilars, Definition, Examples of Biosimilars Genetically engineered products of biosimilars, Molecular Complexity of biosimilars. Critical manufacturing parameters of biosimilars and Challenges-Modifications linked to the process, conversion and formulation. Concept of expression cassette and vector, Host cell and expression system. Non-Clinical and Clinical Aspects of Biosimilars Preclinical approach and Clinical approach. Introduction to Computational Biology: Nature and scope of Computational Biology, Alignment definition, pairwise sequence alignment, biological interpretation of the alignment problem, scoring alignment
UNIT-3 18 Hours	Global alignment, local alignment, overlap alignment, banded alignment, normalized local alignment, maximizing Vs minimizing score, similarity and distance measures, PAM matrices, BLOSUM matrices, comparison between PAM and BLOSUM matrices, Application of substitution matrices. Pairwise sequence matching analysis: Sequence

	matching method- Dot plot visualization method, Dynamic programming method, Word method, Bayesian method, progressive method, Markov chain model, Hidden Markov Models and Kernal methods Advances of Computational Biology: Synthetic biology- Ethical issues of Synthetic Biology, Computational Synthetic biology, Codon optimization, AND gate and OR gate in biology, Operons, Switches and clocks, Re-pressilator. Computational Quantum Mechanics- One electron atoms, Polyelectron atoms and molecules, Molecular orbitals, Hartree-Fock Equations, Molecular Properties using ab initio methods, Semi-empirical methods, Huckel Theory
UNIT-4 18 Hours	Molecular Docking and Molecular Dynamics Simulations: Different types of molecular docking; Rigid docking; flexible docking; Protein docking. Induced fit docking with case studies. QM/MM docking; Constraints and restraints in Molecular Docking. Significance of partial charges in molecular docking. Molecular Dynamics using simple models; Molecular Dynamics with continuous potentials and at constant temperature and pressure; Solvent effects in Molecular Dynamics; Conformational changes in Molecular Dynamics. Biomolecular Simulations; Free energy Calculations; Restraint Potentials, Importance of Force Field in Dynamics, Conformational Sampling: Energy Minimization, Monte Carlo Simulations, Membrane Simulation, Metadynamics

SUGGESTED READINGS

1. *Alberts, B., Bray, D., Lews, J., Raff, M., Roberts, K.& Watson, JD. (1991). Molecular Biology of the cell. Oxford (3rd ed.). Garland publishers.*
2. *De Robertis, E. D., & De Robertis, E. M. (1987). Cell and molecular biology. Lea & Febiger.*
3. *Lehninger, A. L., Nelson, D. L., & Cox, M. M. (2004). Overhead Transparency Set for Lehninger Principles of Biochemistry (4th ed.). WH Freeman.*
4. *Aluru, S. (2005). Handbook of computational molecular biology. Chapman and Hall/CRC.*
5. *Gutka, H. J., Yang, H., & Kakar, S. (Eds.). (2018). Biosimilars: Regulatory, Clinical, and Biopharmaceutical Development (Vol. 34). Springer.*
6. *Haubold, B., & Wiehe, T. (2006). Introduction to computational biology: an evolutionary approach. Springer Science & Business Media*
7. *Najarian, K., Najarian, S., Gharibzadeh, S., & Eichelberger, C. N. (2009). Systems biology and bioinformatics: a computational approach. CRC Press.*
8. *Prugnaud, J. L., & Trouvin, J. H. (Eds.). (2012). Biosimilars: A New Generation of Biologics. Springer Science &Business Media.*
9. *Ramachandran, K. I., Deepa, G., & Namboori, K. (2008). Computational chemistry and molecular modeling: principles and applications. Springer Science & Business Media.*
10. *Cavasotto, C. N. (Ed.). (2015). In silico drug discovery and design: theory, methods, challenges, and applications. CRC Press.*
11. *Gore, M., & Jagtap, U. B. (Eds.). (2018). Computational drug discovery and design. Humana Press. Grover, A. (2017). Drug Design: Principles and Applications. Singapore: Springer Nature Singapore Pte Ltd.*
12. *Marx, D., & Hutter, J. (2012). Ab initio molecular dynamics: basic theory and advanced methods. Cambridge University Press.*

M.Sc. BIOMEDICAL SCIENCE		II SEMESTER
COURSE CODE: BSC	**COURSE TYPE: PRACTICAL**	
COURSE TITLE: Lab Course III		
CREDIT: 04	**PRACTICAL HOURS: 90**	
MARKS: 100		
LABORATORY WORK	1. Loop-mediated isothermal amplification assayConcept of cell culture (Demonstration) 2. To demonstrate that activation of peritoneal macrophages/ myeloid lineage cells by lipopolysaccharides results in reactive oxygen production (RNS) and reactive nitrogen species production. The estimation will be done by flowcytometry, Colorimetry and microscopy assays. 3. The antigen antibody interaction mechanisms will be demonstrated by precipitation and agglutination assays (octerlony, mancini methods and indirect agglutination tests) 4. The T cell and B cell separation and their proliferation will be done using MACS and FACS 5. Pro-inflammatory cytokine expression will be demonstrated in activated cells by ELISA or immunofluorescence.	

M. Sc. in Biomedical Sciences
FOURTH SEMESTER
(EVEN SEMESTER)

Course Code	Course Type	COURSE (PAPER/SUBJECTS)	Credits	Maximum Marks		
				Internal	External	Total
BSC	Theory	Human Physiology-III	4	20	80	100
BSC	Theory	Bioprocess Engineering	4	20	80	100
BSC	Theory	Bioinstrumentation	4	20	80	100
BSC	Theory	Research Methodology and Intellectual Property Rights (IPR)	4	20	80	100
BSC	LAB	Lab Course IV				
Minimum credits in complete semester it would be 20			**Total: 20**			

The M.Sc. program will be divided into four semesters each being of six months duration. Each semester comprises of compulsory core courses (CCC) Lab course (LC) will be based on CCC. Each theoretical course will be divided into Internal Assessment of 20 marks and semester end examination of 80 marks. Duration of Theoretical and Practical Examination Time: 03 Hours.

The Dissertation will be of 16 credits and a total of 400 marks. The students would be assessed externally as per the following criteria.

i) Presentation and Viva-voce: 100 Marks
ii) Dissertation Report/Thesis: 100 Marks

*Internal marks for dissertation work would be assessed as per following criteria

i) Regularity and attendance: 50 Marks
ii) Research concept and hypothesis: 50 Marks
iii) Field and Lab work: 100 Marks

M.Sc. BIOMEDICAL SCIENCE		IV SEMESTER
COURSE CODE: BSC		**COURSE TYPE: CCC**
COURSE TITLE: HUMAN PHYSIOLOGY-III		
CREDIT: 04	**TEACHING HOURS: 90**	
MARKS: 100	**THEORY EXAM: 80**	**CCA: 20**

UNIT-1 18 Hours	Sensory Physiology: Neuronal circuits for processing information, "Coding" of Sensory Information, Electrical & Ionic Events in Receptors. Somatic sensations: Tactile and position senses, Sensory pathways for transmission of somatic signals into the central nervous system, Sensory receptors, Transmission in dorsal column – medial lemniscal system. Pain and thermal sensations: Pain receptors and their stimulation, Dual transmission of pain signals into the central nervous system, Types of pain.
UNIT-2 18 Hours	Special Senses: Eye: The Image-Forming Mechanism (accommodation and visual acuity), Receptor and Photochemistry of vision, Neural function of retina. Visual Pathways and effects of lesions of these pathways. Hearing and equilibrium: Tympanic membrane and ossicular system, Cochlea, Central auditory mechanisms, directionality of sound, Vestibular sensations and maintenance of equilibrium, auditory and vestibular reflexes, oculo-vestibular system. Taste and smell: Anatomical aspects of olfaction and gustation, Receptors and sensory transduction of olfaction and gustation & Neuronal Pathways of olfaction and gestation
UNIT-3 20 Hours	Carbohydrates: Metabolism, Glycolysis, TCA, HMP, Glycogen synthesis and degradation, Blood glucose regulation). Lipids: Metabolism, Intestinal uptake, Fat transport, Utilization of stored fat, Activation of fatty acids, Beta oxidation and synthesis of fatty acids). Proteins: Metabolism, Digestion of protein, Transamination, Deamination, Fate of Ammonia, Urea cycle, end products of each amino acid and their entry into TCA cycle).
UNIT-4 20 Hours	Vitamins and Minerals: Water Soluble-Thiamine (Vitamin B1), Riboflavin (Vitamin B2), Niacin, biotin, Pantothenic acid, folic acid, cobalamin (Vitamin B12), pyridoxine, ascorbic acid (Vitamin C). Fat Soluble- Retinol (Vitamin A, Vitamin D, Vitamin K, Vitamin E). Minerals (Daily requirements, Dietary sources, Disorders and physiological role)

SUGGESTED READINGS

1. *Review of medical physiology by William F. Ganong; Ed. 23nd; McGraw Hill; 2010.*
2. *Essential medical physiology by Leonard R. Johnson and Ed. 3rd; ELSEVIER;2003.*
3. *Principles of Anatomy and Physiology by Gerard J. Tortora and Bryan Derrickson;Ed.15th; John Wiley; 2016.*
4. *Hole's Human Anatomy & Physiology, McGraw-Hill Education; 14th edition, 2015*
5. *Medical Physiology: A cellular and molecular approach by Walter F. Boron andEmile L. Boulpaep; Saunders; Ed. 3rd, 2017.*

M.Sc. BIOMEDICAL SCIENCE		IV SEMESTER
COURSE CODE: BSC		COURSE TYPE: CCC
COURSE TITLE: BIOPROCESS ENGINEERING		
CREDIT: 04	TEACHING HOURS: 90	
MARKS: 100	THEORY EXAM: 80	CCA: 20

UNIT-1 18 Hours	Basic Chemical Engineering calculations. Material balance. Material balance with reactions. Material balance with recycle and purge. Energy balance. Enthalpy, specific heat, mean specific heat. Heat Balance. Heat of reaction and heat of solution. Material and Energy balance together. Fluid statics: Classification of fluids, concept of Reynold's number, Rheological properties of fermentation process (Viscosity, cell concentration, product concentration etc), Fluid mechanics. Potential flow.
UNIT-2 18 Hours	Fermenters: Ideal Properties of Bioreactor, Components of the fermenters & their specifications: Body Construction, Agitator, Impeller, Baffles etc. Types of Bioreactors: (Packed-bed reactor, Air – lift, Trickle bed Photo bioreactors, Rotating Biological Reactors pneumatic). Downstream processing: Strategy for recovery, Harvesting of Biomass and Product, Removal of microbial cells and solid matter, foam separation, filtration, centrifugation, cell disruption, Liquid liquid extraction Ext, chromatography and membrane processes, Drying and crystallization,
UNIT-3 20 Hours	Air & Media sterilization: Air Sterilization Principles, Mechanisms of capture of particles in Air, Depth & Screen Filters, Sizing, Testing & validation of filters for air sterilization, Principle of Media Sterilization, Decimal reduction, Design of sterilization cycle using kinetics of thermal depth of microbes and Equipment's used in sterilization: Batch & Continuous Quality Control, Quality assurance, Standard Operating Procedures (SOP) & Good Manufacturing Practices (GMP)
UNIT-4 20 Hours	Measurement & Control of Bioprocesses Parameters: Cell growth. pH, temperature, Substrate consumption, product formation, Measurement of O2/CO2 uptake, evolution. Specific rates of consumption substrate & formation of product. Strategies for fermentation control. Computer controlled fermentations., Foam & its control. Scale up in Bioprocesses fermentations, Factors used in scale up. Bioprocess Economics, Choice of process, process analysis, fixes & variable cost, Depreciation, Amortized costs, Selection of Pricing, Profitability, Scales of operations etc.
SUGGESTED READINGS	*1.Principles of Fermentation Technology - Whittaker & Stan bury, Pergamon Press* *2. Bioprocess Engineering Principles - Pauline Doran, Academic Press 1995* *3. Operational Modes of Bioreactors, BIOTOL series - Butter worth, Heinemann 1992* *4. Bioreactor Design & Product Yield, BIOTOL series - Butter worth Heinemann 1992* *5. Bioprocess Engineering: Systems, Equipment & Facilities - Ed. B. Lydersen, N.A. Delia & K.M.*

Nelson, John Wiley & Sons Inc,1993

6. Bioseparation & Bioprocessing - Ed. G. Subramaniam, Wiley –VCH,1998

7. Product Recovery in Bioprocess Technology, 'BIOTOL series, Butter worth Heinemann 1992

8. Bioseparation: Downstraem Processing for Biotechnology - Paul A. Belter, E.L Cussler, Wei-Shou Hu, Academic Press

M.Sc. BIOMEDICAL SCIENCE		IV SEMESTER
COURSE CODE: BSC		COURSE TYPE: CCC
COURSE TITLE: BIOINSTRUMENTATION		
CREDIT: 04	TEACHING HOURS: 90	
MARKS: 100	THEORY EXAM: 80	CCA: 20

UNIT-1 18 Hours	Theory of NMR: Quantum description, Classical description – Processional motion, Larmour frequency, Relaxation processes, T1 and T2 and their measurement. Fourier Transform NMR: Pulsed excitation, FID, Types of NMR Spectra – Wild line and high. - resolution spectra. NMR Spectrometers: Instrumentation. Introduction to 13C NMR: Proton decoupling: Broad band, off-resonance, Pulsed decoupling, NOE, application to structure determination. The concept of MRI, BOLD imaging, fMRI, Application in Muscle Physiology, functional mapping of brain. Other nuclei: 31P, 19F, 23Na, 15N, metabolomics studies using NMR
UNIT-2 18 Hours	The nature of radioactivity, detection and measurement of radioactivity: detection based on gas ionization- Geiger Muller counter- principles and applications. Detection based on excitation- Liquid Scintillation counter-principle and applications. Supply, storage and purity of radiolabeled compounds, specific activity, inherent advantages and restrictions of radiotracer experiments, safety aspects, applications- of radio isotopes in biological sciences. Flow cytometry, ELISA, Immunoblotting
UNIT-3 20 Hours	Structure and operation of light microscope, phase, dark field and differential interference contrast microscopes, confocal microscope, fluorescence microscope, transmission electron microscope (TEM), scanning electron microscope (SEM), specimen collection, fixation, sectioning, basic staining and immunocytochemical methods for microscopic examination, photography and interpretation of the results, laboratory rules and regulations.
UNIT-4 20 Hours	Centrifugation: Principle of centrifugation, small bench top centrifuges, large capacity refrigerated centrifuges, High speed refrigerated centrifuges, preparative and analytical ultra centrifuge. Electrochemical techniques: Principles of electrochemical techniques, redox reactions, the pH electrode, ion-sensitive and gas-sensitive electrodes, The Clark oxygen electrode, Biosensors.

SUGGESTED READINGS

1. *Keith Wilson and John Walker. Practical Biochemistry- principles and techniques; Cambridge University press, London, UK. (Fifth edition).*
2. *Biophysical chemistry: Principles and Techniques; Himalaya Publishing House, Upadhyay, Upadhyay and Nath.*
3. *David T Plummer, Tata McGraw- Hill publishing company limited; McGraw office, New Delhi.*
4. *A Biologist's guide to principle and techniques of practical biochemistry-Brigan L. Williams.*
5. *Handbook of Biomedical Instrumentation-R.S. Khandpur, Tata McGraw Hill*
6. *Biophysics-Cotrell (Eastern Economy Edition) Clinical Biophysics –Principles and Techniques-P. Narayanan (BhalaniPub, Mumbai)*
7. *Biophysics-Pattabhi and Gautham (Narosa Publishing House)*
8. *Instrumentation measurements and analysis-Nakara, Choudhari (Tata Mc Graw Hill).*
9. *Handbook of analytical instruments-R.S. Khandpur (Tata Mc Graw Hill)*

M.Sc. BIOMEDICAL SCIENCE		IV SEMESTER
COURSE CODE:	**BSC**	**COURSE TYPE: CCC**
COURSE TITLE: RESEARCH METHODOLOGY AND INTELLECTUAL PROPERTY RIGHTS (IPR)		
CREDIT: 04		**THEORY HOURS: 90**
MARKS: 100	**THEORY EXAM: 80**	**CCA: 20**

UNIT-1 20 Hours	Understanding the language of research – Concept, Construct, Definition, Variable. Research Process, Problem Identification & Formulation – Research Question, Qualitative and Quantitative Research, Interpretation of Data and Academic Writing, Use of tools / techniques for Research: methods to search required information effectively, Reference Management Software like Zotero/Mendeley, Software for paper formatting like LaTeX/MS Office, Software for detection of Plagiarism
UNIT-2 20 Hours	Hypothesis – Qualities of a good Hypothesis –Null Hypothesis & Alternative Hypothesis. Hypothesis Testing – Logic & Importance, Research Design: Exploratory Research Design, Descriptive Research Designs and Experimental Design. Concepts of Statistical Population, Sample, Sampling Frame, Sampling Error, Sample Size, Sample types, Concept of Independent & Dependent variables, Levels of measurement – Nominal, Ordinal, Interval and Ratio. Data Analysis, Bivariate analysis – Cross tabulations and Chi-square test including testing hypothesis of association.
UNIT-3 15 Hours	Intellectual property rights and its types-Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of new GMOs, Basics of patents (Types, patent application and Specifications), concept of Prior Art and patent filling procedures, Process patent vs product patent.
UNIT-4 20 Hours	Introduction to General Agreement on Tariffs and Trade (GATT), World Trade Organization (WTO), World Intellectual Property Organization (WIPO) and Trade Related Intellectual, Property Rights (TRIPS), Indian Patent Act.

SUGGESTED READINGS	
	1. Business Research Methods – Donald Cooper & Pamela Schindler, TMGH, 9th edition *2. Business Research Methods – Alan Bryman & Emma Bell, Oxford University Press.* *3. Research Methodology – C.R. Kothari* *4. Intellectual Property Rights in India (2015) 2nd edition, V.K Ahuja.* *5. Intellectual Property Rights (2014), Neeraj Pandey and Dharni Khush deep, PHI Learning Pvt Ltd.*

M.Sc. BIOMEDICAL SCIENCE	IV SEMESTER
COURSE CODE: BSC	**COURSE TYPE: PRACTICAL**
COURSE TITLE: Lab Course IV	
CREDIT: 04	**PRACTICAL HOURS: 90**
MARKS: 100	

LABORATORY WORK

1. Media formulation and optimization.
2. Study of Growth Kinetics of Bacteria and Yeast by turbidometry& SCP
3. Screening and maintenance of Industrially important microorganism- Acids, Antibiotics, Enzymes.
4. Study of scale up of fermentation
5. Study of design of bioreactor
6. Determination of TDP
7. Determination of TDT and design of sterilizer
8. Study of types of fermentation process (Surface and submerged)
9. Downstream process of industrial products (Intra & Extra cellular)