

**Amrita Center For Nanosciences and Molecular Medicine**

**Program in the  
Bachelor of Science (B.Sc.)  
Molecular Medicine**

**2020**

**Amrita Vishwa Vidyapeetham**

## B.Sc-Molecular Medicine

### Curriculum

Course Code	Course Title	L T P	Cr	ES	Course Code	Course Title	L T P	Cr	ES
	<b>SEMESTER 1</b>					<b>SEMESTER 2</b>			
20ENG102	English I	3 0 0	3		20ENG112	English II	3 0 0	3	
20CHE102	Chemistry-1	3 0 0	3		20BIC111	Metabolism of Carbohydrates & Lipids	3 0 0	3	
20MAT102	Biostatistics	3 0 0	3		20MMD111	Cell biology 2	2 0 0	2	
20BIC102	Bio Physics and Bio Energetics	3 0 0	3		20CHE111	Chemistry-2	3 0 0	3	
20MMD102	Cell biology 1	2 0 0	2		20MMD112	Immunology	3 0 0	3	
20MMD101	Biochemistry-1	2 0 0	2		20BIC184	Biochemistry lab-2	0 0 6	2	
20CSA103	Computational Skills	2 0 0	2		20MMD184	Cell biology Practicals	0 0 6	2	
20BIC181	BioPhysics Practicals	0 0 6	2		20MMD182	Chemistry lab-2	0 0 6	2	
20MMD181	Chemistry lab-1	0 0 6	2		20MMD183	Immunology Practicals	0 0 6	2	
20CSA185	Computational Skills Practicals	0 0 3	1						
	<b>Total</b>	<b>23</b>				<b>Total</b>	<b>22</b>		
	<b>SEMESTER 3</b>					<b>SEMESTER 4</b>			
20BIC201	Protein structure and function	3 0 0	3		20BIC211	Bioinformatics	3 0 0	3	
20BIC203	Biotechniques	3 0 0	3		20MMD211	MolecularBiology and GeneticEngineering	3 0 0	3	
20MMD201	Microbiology	4 0 0	4		20MMD212	Genetics	3 0 0	3	
20MMD202	Developmental biology	2 0 0	2		20BIC212	Biosafety and bioethics	2 0 0	2	
20BIC281	Biotechniques Practicals	0 0 6	2		20MMD213	Proteome and Proteomics	2 0 0	2	
20MMD281	Microbiology Practicals	0 0 9	3		20BIC282	Bioinformatics Practicals	0 0 6	2	
20MMD282	Developmental Biology Lab	0 0 6	2		20MMD283	Molecular biology Practicals	0 0 6	2	
20IPR201	IPR	1 0 0	1		20CUL201	Cultural education	1 0 0	1	
	<b>Total</b>	<b>20</b>				<b>Total</b>	<b>18</b>		
	<b>SEMESTER 5</b>					<b>SEMESTER 6</b>			
20MMD301	Stem cell Biology	2 0 0	2		20BIC311	Antimicrobial agents	2 0 0	2	
20MMD305	Regenerative medicine	3 0 0	3		20MMD312	Microbial diseases and vaccine technology	3 0 0	3	
20MMD302	Biopolymers and its medical applications	3 0 0	3		20MMD311	Cancer Biology	2 0 0	2	
20BIC303	Molecular methods	3 0 0	3		20MMD313	Nanosciences in Biology	3 0 0	3	
20BIC301	Human Physiology and anatomy	3 0 0	3		20RM301	Research Methodology	2 0 0	2	
20MMD304	Principles of Pathology	0 0 6	2		20MMD399	Project	9	9	
20BIC381	Cell culture lab	0 0 6	2						
20MMD381	Molecular methods lab	0 0 6	2			<b>Total</b>	<b>21</b>		
	<b>Total</b>	<b>20</b>							

**Total Credits 124**

**Preamble**

Connecting Physics to biology is an essential factor which eventually determines quantifying primary factors in a physical process that occur at cell level. Physics serves as a nanoscopic visualization tool to dissect such processes to reveal the information to students. This course introduces applications of Physics into Biology.

**Unit 1****(5 lectures)**

**Physics:** general overview, Does Physics treats disease? Why Physics for Biology and Molecular Medicine? Concepts in Physics to apply in Biology, Methods in Physics to elucidate Biology.

**Unit 2****(10 lectures)**

**Bioenergetics:** Laws of thermodynamics. Concept of state functions, free energy change, equilibrium constant, coupled reactions, energy charge, ATP cycle, phosphorylation potential, and phosphoryl group transfers. Electron transport in membrane for oxidative phosphorylation, Chemical basis of hydrolysis of ATP and thioesters. Redox reactions, standard redox potentials and Nernst equation.

**Unit 3****(10lectures)**

**Biophysics in Medicine:** Applications of physical principles in biology and its significance in the development of various biophysical methods for analysing the complexity of biological system. Principles of Medical-imaging, Image analysis, Instrumentation and Working principles, Medical applications of X-ray: Imaging, Introduction to Fluoroscopy.

**Unit 4****(10 lectures)**

**Nuclear medicine and Radiotherapy:** Pros and cons, Nano-bioelectronics: Monitoring and recording bioelectric signals, Transducers in physiology, Diagnostic and Therapeutic Techniques: Cardiac pace makers, Blood flow monitors, Pulmonary function analyzers, Hemodialysis machines, Defibrillators, Short/ wave diathermy, Electrically stimulated pain management, Laser: operating principles, types, Biomedical applications in surgery.

**Unit 5****(10 lectures)**

**Nanophotonics for Biology and Nanomedicine:** Near-Field Bioimaging, Semiconductor Quantum Dots for Bioimaging, Up-Converting Nanophores for Bioimaging, Biosensing, Nanoclinics for Optical Diagnostics and Targeted Therapy, Nanoclinics for Photodynamic Therapy

**Text books:**

(1) Biophysics: An Introduction by Rodney M. J. Cotterill, Published by John Wiley & Sons Ltd, 2002.

(2) Biological Physics: Energy, Information, Life by Philip Nelson, [www.physics.upenn.edu/~pcn/](http://www.physics.upenn.edu/~pcn/).

## 20BIC111

## Metabolism of Carbohydrates & Lipids

### Preamble

Existence of a cell requires energy and nutrients for cell maintenance and homeostasis. Thus production of energy is vital for every function a cell execute. The question is how effective the cell is able to achieve this and what are the mechanisms involved in this process and the role of various enzymes in this process. Enzymes are the key components responsible for are vital in the chemical rearrangements and modifications of various biological molecules carried out at 37°C with utmost specificity. These changes are responsible for various communications and modifications that happens as a result of environmental and internal cues a cell receives essential for the production of energy and various other metabolites essential maintaining the cell structure function.

### Unit-1

(Lectures 2)

Significance of six carbon sugar glucose in cellular homeostasis.

### Unit 2

(13 lectures)

Breakdown of glucose in energy production. Glycolysis, Tricarboxylic acid cycle, pentose phosphate pathway and how they are connected together with energy production and growth. Mitochondrial structure and its significance in the oxidative phosphorylation leading to energy production.

### Unit 3

(5 lectures)

What are Lipids, How they are made, Lipid metabolism: lipid synthesis and degradation

### Unit 4

(10 lectures)

Oligosaccharides, different types of oligosaccharides, their synthesis and significance in biology.

### Unit 5

(15 lectures)

Gluconeogenesis and its connection with the pentose phosphate pathway, metabolism of other important sugars (fructose metabolism and glycogen metabolism), glycogenesis, glycogenolysis, regulation of glycogen metabolism.

**Text book:**

- (1) Lehninger Principles of Biochemistry by David L. Nelson; Michael M. Cox, Freeman publications; Seventh Edition 2017.

## **20BIC181**

### **Biophysics Practicals**

1. Study the principle of spectrophotometer. To verify the Lambert Beer's law.
2. Determine the beer's limit and measurement of molar and percent extinction coefficient.
3. Estimate the percent purities of dyes and inorganic compounds.
4. Establish the absorption spectrum and determine the absorption maxima of pNitro phenol.
5. Plot absorption spectrum of DNA and protein(BSA/Egg Albumin) and find  $\lambda_{max}$
6. Obtain relation between concentration & Refractive Index for solutions of proteins and sugars and estimation of specific refraction increment for proteins
7. Determine refractive index of a given liquid as a criterion for its purity (Benzene i.e. commercial benzene + A.R. acetone)
8. Study the principle of colorimeter and spectrophotometer and determine suitable filter for light absorption studies of inorganic salts. Verify Beer-Lambert law. Determine molar Extinction coefficient
9. Plot absorption spectrum of DNA and protein and find  $\lambda_{max}$ .
10. study the effect of different solvents on UV absorption spectra of proteins
11. Study of spectral changes of proteins at different pH using Spectrophotometry
12. Study of structural changes of proteins at different temperature using UV spectrophotometry

#### **Text Books:**

Biophysical Chemistry (2013), Schimmel, C.R.C., Macmillan Higher Education, ISBN : 0716738619, 9780716738619.

## **20BIC184**

### **Biochemistry lab-2**

- (1) Preparation of buffers;
- (2) Determination of pKa value;
- (3) Estimation of proteins by Biuret method;
- (4) Estimation of proteins by Lowry's method;
- (5) Separation of sugars by Thin Layer chromatography,
- (6) Effect of pH and temperature on the activity of an enzyme,
- (7) Progress curve of an enzyme.

#### **Text book:**

- (1) Biochemistry in the Lab A Manual for Undergraduates by Benjamin F. Lasseter.

**Preamble:**

Protein structure and function is a sub-discipline that integrates structural bioinformatics and molecular medicine. This course aims at understanding the biomolecular sequence, structure and function which form the fundamental concepts in structural bioinformatics. This course is divided into different units: Molecular structure of biomolecules; physico-chemical properties of amino acids; Biomolecular structure and function, Pattern identification and recognition.

**Unit 1****(12 Lectures)**

Classification of proteins on the basis of composition, conformation of proteins. Software involved in judging conformation generation and optimization. The amino acid building blocks-classification, structure and physical properties of the standard amino acids. chemistry of peptide bond, non-ribosomal peptide bond formation, Proteinaceous and non-proteinaceous, essential and non-essential amino acids. amino acids as precursors of other bioactive compounds, zwitterion, isoelectric point, optical properties of amino acids, Lambert-Beer Law.

**Unit 2****(14 Lectures)**

Primary, secondary (alpha helix, beta sheet, beta turn, collagen helix), tertiary and quaternary structure of biomolecules. Ramachandran Plot, Errat plot, Different normal databases and integrated databases in molecular biology. Biomolecular structure and function of myoglobin and hemoglobin. Molecular physiology of myoglobin and hemoglobin, Bohr effect, Hill's coefficient. Concept of lock and key and induced fit theory, concept of activation, energy and binding energy. Enzyme kinetics and its physiological significances, Enzyme Inhibition, types of inhibitors of enzyme with examples.

**Unit 3****(4 Lectures)**

Symmetry, Identification of three dimensional structural pattern, Pattern recognition and function of biomolecules.

**Reference Books:**

(1) Introduction to protein structure, by Carl Branden and John Tooze. 2<sup>nd</sup> Edition, New York: Garland Publishing Company, 410, (1999). ISBN 9780815323051.

**20BIC203****Biotechniques****Unit 1****(25 Lectures)**

Purification methods, Affinity chromatography, Metal ion binding Immobilized metal ion affinity chromatography, Charge Ion exchange chromatography, Size Gel filtration, Hydrophobicity, Hydrophobic interaction chromatography, Reversed phase chromatography, Isoelectric point, Chromato focusing, chromatography media, buffers for chromatography, Poly-acrylamide gel electrophoresis, Blotting techniques.

**Unit 2****(20 Lectures)**

FPLC and HPLC, Mass spectrometry.

**Text Book:**

(1) Paul Cutler; Protein Purification Protocols, Humana Press.

**20BIC211****Bioinformatics****Preamble**

Bioinformatics is a discipline that integrates different sub-disciplines of informatics, chemistry, physics, molecular biology, biochemistry and molecular medicine. This course aims at understanding the molecular basis of life by looking into genes, proteins and small molecules on the basis of different biological databases, sequence algorithms, computational biology and its related software. Latest trend in introduction of machine learning and its applications addressed.

**Unit 1****(10 Lectures)**

History of Bioinformatics. The notion of Homology. Sequence Information Sources, EMBL, GENBANK, Entrez, Unigene, Understanding the structure of each source and using it on the web. Searching Databases: Integrated databases.

**Unit 2****(15 Lectures)**

Sequence Similarity Searches-BLAST, FASTA, Data Submission. Genome Annotation: Consensus sequence, Sequence Pattern and repeat finding, Gene identification tools; Protein Information Sources, SWISSPROT, TREMBL, protein data bank, Understanding the structure of each source and using it on the web.

**Unit 3****(15 Lectures)**

Protein Sequence and Phylogeny analysis, Detecting Open Reading Frames, Outline of sequence Assembly, Mutation/Substitution Matrices, Pairwise Alignments, Introduction to BLAST, using it on the web, Interpreting results.

**Unit 4****(5 Lectures)**

Data mining, Introduction of machine learning and its applications.

**Text Books:**

(1) Bioinformatics: Genes, Proteins and Computers By Christine Orengo, David Jones, Janet Thornton, 2002 by Taylor & Francis, 320 Pages.

(2) Mount D W, "Bioinformatics Sequence and Genome Analysis", Cbs Publishers & Distributors (2003), ISBN: 8123909985.

**20BIC212****Biosafety and bioethics****Preamble**

The recent advances in the field of biotechnology/biomedical technologies have brought into focus several safety and ethical issues. The inventions in the field of genetic engineering, molecular medicine and related fields of molecular biology not only affect us but also the plants, microorganisms, animals and the entire environment and the way we practice agriculture, medicine and food processing. An increase in our ability to change life forms in recent years has given rise to the new science of bioethics. The present course focus on the biosafety and bioethical issues the modern society confronts. Topics such as biosafety levels, biosafety guidelines, Biomedical technologies its health and human rights perspectives, Clinical ethics, emerging trends in biomedical and genetic technologies and regulatory frame works, legal and ethical implications of cryonics, cloning and its ethical legal and scientific aspects, regulation of biobanks and responsible conduct of biomedical research will be discussed in the curriculum.

**Unit I****(3 Lectures)**

Introduction Historical background, introduction to biological safety cabinets, primary containment for biohazards, biosafety levels of specific microorganisms, recommended biosafety levels for infectious agents and infected animals.

**Unit 2****(3 lectures)**

General laboratory practice: Familiarise students with Code of Practice for Safe Working in the biological sciences laboratories, waste disposal, handling of biological hazards, equipment and apparatus, reporting of accidents, first aids, fire instructions and other emergencies

**Unit 3****(8 Lectures)**



Biosafety guidelines Government of India definition of genetic modified organism (GMOs) and living modified organisms (LMOs), roles of institutional biosafety committee, review committee on genetic manipulation (RCGM), genetic engineering approval committee (GEAC) for GMO applications in food and agriculture, environmental release of GMOs. The GM-food debate and biosafety assessment procedures for biotech foods and related products, including transgenic food crops, case studies of relevance. Biosafety assessment of pharmaceutical products such as drugs/vaccines etc.

**Unit 4**

**(2 Lectures)**

Foundation of Bioethics: Definition, historic evolution, codes and guidelines, universal principles.

**Unit 5**

**(2 Lectures)**

Clinical ethics Describe the sanctity of human life and the need to preserve human life, what makes research involving human subjects ethical, explain about issues related to prenatal screening, clinical trials (Phase I/II/III/IV) studies. Biomedical ethics.

**Unit 6**

**(2 lectures)**

Legal and ethical implications of cryonics: Introduction, origin of cryonic preservation in humans, procedure, meaning of death, its suspension and legal implications, its position in india.

**Unit 7**

**(2 lectures)**

CRISPER Revolution, its future and legal issues: Introduction, advances in genomic research and its legal aspects, ethical and human rights issues in human DNA editing, genome editing technology its legal and regulatory challenges

**Unit 8**

**(2 lectures)**

Ethical use of animals in the laboratory: Introduction to animal ethics, bioethics and animals, animal rights, animal use in biological research,

**Unit 9**

**(2 lectures)**

Ethics and regulation of biobanks: Introduction, types of biobanks, barriers of biobanking, biobanking framework in india, ethical issues of biobanks

**Unit 10**

**(4 lectures)**

Conduct in Research: Introduction to responsible conduct of research, advising and mentoring, treatment of data, research misconduct, competing interests, commitments and values.

**Text books:**

(1) Bioethics and Biosafety, 1st edition (2008), M. K Sateesh, I K International Pvt Ltd, ISBN-13: 978-8190675703.

(2) The Cambridge Textbook of Bioethics, 1st edition (2008), Peter A. Singer and A. M. Viens; Cambridge University Press, ISBN-13: 978-0511545566.

(3) Foundation of Bioethics, 2nd edition (1996), E. H Tristram; Oxford University Press, ISBN-13: 9780195057362.

## **20BIC281**

### **Biotechniques Practicals**

1. Protein purification
2. Chromatography
3. SDS\_PAGE
4. Measurement of Molecular weight
5. Protein estimation
6. Western blotting
7. Chemiluminiscence reaction
8. Image capturing following chemiluminiscece reaction

#### **Text Books:**

1. Introductory Practical biochemistry, S. K. Sawhney & Randhir Singh (eds) Narosa Publishing House, New Delhi, ISBN 81-7319-302-9, p 1- 15 2.
2. Hawk's Physiological Chemistry, Bernard L. Oser (ed) TATA McGRAW Hill Publishing Company LTD, New Delhi, p 10- 15.

## **20BIC282**

### **Bioinformatics Practicals**

- (1) Sequence information database resource;
- (2) Understanding and use of various web resources: EMBL, Genbank, Unigene, Protein information resource (PIR);
- (3) Understanding and using: PDB, Swissprot, TREMBL;
- (4) Pair wise sequence alignment and interpretation of results;
- (5) Data mining and small molecule structure optimization;
- (6) Macromolecular structure visualization interaction and function interpretation.

Text Book:

(1) Practical Bioinformatics, by Michael Agostino, 2013, ISBN 9780815344568.

## **20BIC301**

## **Human physiology and Anatomy**

This course integrates various functions of tissues and organs and presents the entire human physiology as one unit. Since function is dependent on tissue and organ structure, topics taught in this course will also stress on functional anatomy. This course can be viewed as a link between basic sciences and Medicine.

### **UNIT 1:**

**(7 lectures)**

Body organization and integumentary system: General anatomy of the body, introduction to various kinds of body planes, cavities their membranes, tissues level of organization (Types, origin, function & repair).

### **UNIT 2:**

**(6 lectures)**

Blood composition and function. Haemostasis, blood coagulation mechanism, blood groups and blood banking. Basic concepts about anaemia, abnormal haemoglobin, Polycythaemia, Thalassemia, Leukemia.

### **UNIT 3:**

**(7 lectures)**

Nerve physiology: Resting membrane potential structure and function of neuron. Action potential, electrophysiology of ion channels and conduction of nerve impulse

### **UNIT 4:**

**(7 lectures)**

The synapse, synaptic transmission, neurotransmitters; types and function. Concept of receptors in the body and their types, structure, functional anatomy, regulation and common disorders

### **UNIT 5:**

**(7 lectures)** Muscular

system: Muscular functional anatomy of muscular system, types of muscles, neuromuscular transmission, general and molecular mechanism of skeletal muscle excitation and contraction, energetics of muscle contraction and characteristics of whole muscle contraction. An overview of concepts of muscle fatigue, oxygen debt, shivering/tremor, muscle degeneration, tetany, muscular dystrophy.

**UNIT 6:** (6 lectures) Skeletal system:  
Cartilage, structure, function and types. Bones: structure, function, location and types. Joints:  
structure, function and types.

**UNIT 7:** (5 lectures)  
Fundamentals of the endocrine system. Glands, their secretions, function and regulation

**Text book:**

Guyton and Hall Textbook of Medical Physiology, 2nd edition (2016), J. E. Hall; Elsevier

**20BIC311 Antimicrobial agents**

**Preamble**

These are chemical entities that prevent the growth of microorganisms specifically. They are non-toxic to other organisms and are largely safe for the environment. There are different types of anti-microbial agents,

**Unit 1 (2 Lectures)**

Antiseptics: Commonly used antiseptics.

**Unit 2 (8 Lectures)**

Antibiotics: Bacterial cell wall synthesis, DNA replication, transcription, folate synthesis, protein synthesis inhibitors etc.

**Unit 3 (5 Lectures)**

Antibiotic resistance mechanisms: modification/destruction of antibiotics, efflux pumps, target modification, biofilm, quorum sensing; MDR bacteria, ESKAPE pathogens, MRSA, VRSA etc; modes of transmission of antimicrobial resistance genes.

**Unit 4 (5 Lectures)**

Antifungal, antiviral and anti-parasitic agents and their resistance mechanisms.

**Unit 5 (5 Lectures)**

Problems associated with antimicrobial resistance across healthcare.

**Unit 6 (5 Lectures)**

Other antimicrobial agents (Fatty acids, phytochemicals, antimicrobial peptides etc).

**Text Books:**

(1) Antimicrobial Agents: Antibacterials and Antifungals by André Bryskier (Editor); ASM Press.

(2) Antimicrobial Chemotherapy by David Greenwood (Editor); Oxford University Press; 4 edition.

**20BIC381**

**Cell culture lab**

- (1) Fundamentals of cell culture.
- (2) Facilities and Applications.
- (3) Media preparation for Animal cells culture.
- (4) Types of cell culture: Primary and secondary cell culture, cell lines, stem cell cultures,
- (5) Tests: cell viability and cytotoxicity,
- (6) Cryopreservation.

**Text book:**

- (1) Basic Cell Culture Protocols (3<sup>rd</sup> edition) by Cheryl D. Helgason, Cindy L. Miller.
- (2) Masters, J.R.W. *Animal Cell Culture: A Practical Approach*. 3rd Edition. Oxford University Press. 2000.

**20CHE102**

**Chemistry-1**

**Preamble**

This course deals with the basic introduction to organic chemistry, focusing primarily on the basic principles to understand the structure and reactivity of organic molecules, emphasis is on substitution, elimination, alkanes, alkenes, alkynes and their related reactions, understanding of different reaction mechanism and methods used for organic compound preparation.

**Unit-1**

**(3 lectures)**

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation.

**Unit-2**

**(4 lectures)**

Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles.

**Unit-3**

**(6 lectures)**

Reactive Intermediates: Carbocations, Carbanions and free radicals. Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values.

**Unit-4**

**(3 lectures)**

Aromaticity: Benzenoids and Hückel's rule. Aliphatic Hydrocarbons: Functional group approach for the following reactions (preparations and reactions) to be studied in context to their structure.

**Unit-5**

**(8 lectures)**

Alkanes: Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis and, from Grignard reagent. Reactions: Free radical Substitution: Halogenation.

**Unit-6**

**(12 lectures)**

Alkenes: Preparation: Elimination reactions: Dehydration of alcohols and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alk.  $\text{KMnO}_4$ ) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymercuration-demercuration, Hydroboration-oxidation.

**Unit-7**

**(9 lectures)**

Alkynes: Preparation: Acetylene from  $\text{CaC}_2$  and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides. Reactions: Formation of metal acetylides, addition of bromine and alkaline  $\text{KMnO}_4$ , ozonolysis and oxidation with hot alk.  $\text{KMnO}_4$ .

**Text books:**

- (1) Graham Solomons, T.W., Fryhle, C.B. & Snyder, S.A. Organic Chemistry, John Wiley & Sons (2014);
- (2) Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988);
- (3) Finar, I.L. Organic Chemistry (Vol. I & II), E.L.B.S; Morrison, R.T. & Boyd, R.N. Organic Chemistry, Pearson, 2010;
- (4) Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.

**Preamble**

This course deals with the microscopic properties of a gas, liquids and solids and their related intermolecular forces, effects of different kind of forces on phase transitions, understanding about phase diagrams, properties of acid and bases and their strength, concept of buffer solution, understanding of surface properties and colloidal suspension, emulsion etc, understudying of chemical kinetics and chemical thermodynamics.

**Unit-1****(5 lectures)**

Solid, liquids and phase transition: Bulk properties of gases, liquids, and solids.

**Unit-2****(5 lectures)**

Intermolecular forces, origin of molecular structure, Intermolecular forces in liquids, phase equilibrium, phase transitions, phase diagrams.

**Unit-3****(5 lectures)**

Acid-base Equilibrium: Classifications of acids and bases, properties of acid and bases, Acid and base strength, Buffer solutions, Polyprotic acids, organic acid and bases.

**Unit-4****(8 lectures)**

Surface Chemistry: Types of adsorption, factors affecting adsorption of gases on solids, properties of colloids; Tyndall effect, Brownian movement, electrophoresis, coagulation, emulsion – types of emulsions.

**Unit-5****(14 lectures)**

Chemical Kinetics: The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions. Half-life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation. Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions.

**Unit-6****(8 lectures)**

Chemical Thermodynamics: Objectives and limitations of Chemical Thermodynamics, state functions, thermodynamic equilibrium, work, heat, internal energy, enthalpy. Laws of Thermodynamics.

**Text books:**

(1) Oxtoby, D.W, Gillis, H.P and Campion, A. Principles of Modern Chemistry, 7<sup>th</sup> Edition, Cengage

(2) Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).

(3) Physical Chemistry by P.C. Rakshit

(4) Atkins, P.W. & Paula, J. Physical Chemistry, 10th Ed., Oxford University Press, 2014.

**20CSA103****Computational Skills****Preamble**

Understanding computer and computer related skills is a must and the interface between biology and computer is intertwined. The course provide an introduction to beginners on different aspects of computer knowledge for tackling biology related aspect.

**Unit-1****(15 lectures)**

Computer Fundamentals

Introduction to Computers: Characteristics of Computers, Uses of computers, Types and generations of Computers, Basic Computer Organization Units of a computer, CPU, ALU, memory hierarchy, registers, I/O devices User Interface with the Operating System, System Tools

Data Representation

**Unit-2****(15 lectures)**

Binary representation of integers and real numbers, 1's Complement, 2's Complement, Addition and subtraction of binary numbers, BCD, ASCII, Unicode

Networks terminology

Types of networks, router, switch, serverclient architecture

Multimedia

Introduction, Characteristics, Elements, Application, Problem Solving, Notion of algorithms, stepwise methodology of developing an algorithm, developing macros in spreadsheet

General Awareness IT Act, System Security (virus/firewall etc.)

**Text Books**

[1] V Rajaraman, Fundamentals of Computers, Fourth Edition, PHI.

[2] Anita Goel, Fundamentals of Computers; Forthcoming title in Pearson Education.



**20CSA185****Computational Skills Practicals**

1. Defined projects will be done by the students and evaluated by the instructor.
2. Document Preparation
3. Presentation Software
4. Familiarizing with the Operating System, Control Panel, Networking Configuration, Firewall setting
5. Spreadsheet Handling, Working with worksheets, Creating a spreadsheet, entering and formatting information, basic functions and formulas, creating charts, tables and graphs.

**Text Books**

[3] V Rajaraman, Fundamentals of Computers, Fourth Edition, PHI.

[4] Anita Goel, Fundamentals of Computers; Forthcoming title in Pearson Education.

**20CUL201****Cultural Education****Unit 1****(15 lectures)**

Culture – definition and scope. Values and culture, cultural freedom, Culture and Education  
Culture of Research – creativity and responsibility in research. Spirituality and Culture –  
spirituality as a way of life, spirituality and religion. Culture and women – gender oppression,  
motherhood. Culture and the Media. Culture and Politics – national values and political  
harmony. Philosophy and Culture, epistemology.

**20ENG102****English I****Unit-1****(20 lectures)**

Adopting the platform of English for the expression of science. Understanding the English language for constructing meaningful sentences. Basics of English, Writing structured sentences, Articulating for clear and efficient delivery of concepts. Includes a) Ability to speak and write clearly in English b) Ability to listen to and follow scientific viewpoints and engage with audience. Develop strategies and skills to enhance their ability to read. Reading science related books and comprehension. Articulated presentation on books and scientific articles in layman's language. Writing exercise

should contain sentence structure correctness, comprehending the concepts effectively. Developing capabilities to communicate science in layman's language through seminars.

## Unit-2

(25 lectures)

Skill development: Critical Thinking: a) Ability to substantiate critical readings of scientific texts in order to persuade others. b) Ability to place scientific statements and themes in contexts and also evaluate them in terms of generic conventions. Problem Solving: a) Ability to closely observe the situation, and apply lateral thinking and analytical skills. Analytical Reasoning: a) Ability to evaluate the strengths and weaknesses in scholarly texts spotting flaws in their arguments. b) Ability to use critics and theorists to create a framework and to substantiate one's argument in one's reading of scientific texts.

### Suggested Reading

- 1.H.G. Wells. ***A short History of the world***. Penguin Classics. U.K 2006. (A book recommended by Einstein).
2. Walter Isaacson. ***Einstein: His Life and Universe***, Published by Simon & Schuster 2007.
3. Alexander Graham Bell ***How to Improve the Race***
4. Linus Pauling ***A Lifelong Quest for Peace*** Editor: Richard L. Gage 1990
5. Stephan Hawkings ***On the Shoulders of Giants*** by Running Press 2002Preamble

## 20ENG112

## English II

### Unit-1

(20 lectures)

Research-Related Skills: a) Ability to problematize; to formulate hypothesis and research questions, and to identify and consult relevant sources to find answers. b) Ability to plan and write a research paper. Teamwork and Time Management: a) Ability to participate constructively in class room discussions. b) Ability to contribute to group work. c) Ability to meet a deadline. Scientific Reasoning: a) Ability to analyze texts, evaluating ideas and scientific strategies. b)

Ability to formulate logical and convincing arguments. Reflective Thinking: Ability to locate oneself and see the influence of location—regional, national, global— on critical thinking.

## Unit-2

(25 lectures)

Self-Directing Learning: a) Ability to work independently in terms of organizing laboratory, and critically analyzing research literature. b) Ability to postulate hypothesis, questions and search for answers. Digital Literacy: a) Ability to use digital sources, and apply various platforms to convey and explain concepts of biochemistry. Multicultural Competence: a) Ability to engage with and understand cultures of various nations and respect and transcend differences.

Leadership Readiness: Ability to lead group discussions, to formulate questions related to scientific and social issues. Life-long Learning: a) Ability to retain and build on critical thinking skills, and use them to update scientific knowledge and apply them in day to day basis of learning.

### Suggested Reading

1. Roger Holloway. C. V. **Raman: 51 Success Facts - Everything You Need to Know About C. V. Raman**, Published by Lightning Source, 2014.
2. Carl Edward Sagan. **Cosmos** by Random House Publishers
3. Alexander Graham Bell **How to Improve the Race** or
4. Linus Pauling **A Lifelong Quest for Peace** Editor: Richard L. Gage 1990
5. Stephan Hawking **On the Shoulders of Giants** by Running Press 2002

## 20IPR201

### IPR

#### Unit-1

(15 lectures)

Introduction to IPR, Types of IP - Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge and Geographical Indications. Importance of IPR – patentable and non patentables, patenting life, legal protection of Biotechnological inventions.

Agreements and Treaties - History of GATT & TRIPS Agreement; Madrid Agreement; Hague Agreement; WIPO Treaties; Budapest Treaty; PCT; Indian Patent Act 1970 & recent amendments.

## 20MAT102

### Biostatistics

#### Preamble

Strategy to execute a research is central to the successful completion and execution of a scientific endeavour. Based on the literature, several methodologies have been developed to

tailor a particular strategy and the appropriate use of sample numbers for reliable results and meaningful outcome.

**Unit-1**

**(10 lectures)**

Introduction to Biostatistics-Need for Statistical Methods in Medicine, Public Health, Biology, Biotechnology & Nano Sciences –Their uses and Misuses, Types of Variables, Data collection Methods, Population and Sample. Basics of Mathematics- (a) Differential & Integral Calculus Differentiation – Derivative of a function, Integration as the inverse operation of Differentiation, Methods of Integration. (b) Linear Algebra – Set Theory, Matrix Algebra (i) Set Theory- Sets and their operations. (ii) Matrix Algebra- Special type of Matrices, Determinants.

**Unit-2**

**(10 lectures)**

Study Designs-Prevalence and incidence studies, Case control and Cohort studies, Experimental studies – randomization. Estimation of Minimum Sample size in Different Designs of Studies and Sampling Methods. Descriptive Data Analysis Methods- Statistical Tables, Diagrams & Graphs, Measures of Averages, Measures of Dispersion, Correlation Analysis Methods, Regression Analysis Methods. Theory of probability and Standard Distributions- Probability: Random experiment, Sample space, Events, Mutually exclusive and exhaustive events, Frequency and classical definition of probability, Axiomatic definition of probability, Addition and multiplication theorems, Conditional probability and independence, Baye's theorem Random Variables and

**Unit-3**

**(15 lectures)**

Probability Distributions :- Definition of discrete and continuous random variables, Probability density functions and distribution functions, Standard univariate discrete distributions – Binomial, poisson & Negative Binomial, Standard univariate continuous distributions – Normal, Log normal & Exponential. Sampling distributions – Chi- square distribution and F & 't' distributions. Logic of Statistical Inference- Concept of 'statistic' and 'parameter', Estimators and its properties, point and Interval estimation of parameters, Confidence intervals, concepts of standard error Principles of test of significance, Bayesian Inference Methods. Methods of tests of Significance of Significance of Statistical Hypotheses- Concept of Statistical Hypotheses –Null and Alternative hypotheses, Type I and Type II errors, Significance level, Critical region and Power of a test, P- value and its interpretation; Large and Small Sample Test – Normal test, Student's 't' test, Chi-square tests, Analysis of variance & Non parametric methods.

**Unit-4**

**(10 lectures)**

Statistical methods in planning and analysis of clinical trials;  
Statistical aspects of diagnostic tests.

Nonparametric methods-Non-parametric methods for estimation, Methods for tests of significance for the independent and correlated samples, Nonparametric Methods for more than two populations.

Multivariate analysis Methods- Principles of Multivariate analysis, Multivariate regression analysis, Multivariate logistic regression analysis.

Practicals- (Statistical Software to be used: SPSS & SAS): (i) Practical in Descriptive Data Analysis Methods, (ii) Practical in Study Designs, (iii) Practical in Sampling Theory, (iv) Practical in Biostatistical Inference, (v) Practical in Testing of Hypotheses, (vi) Practical in Nonparametric Methods, (vii) Practical in Clinical Trials, (viii) Practical in Multivariate Regression Analysis.

## **20MMD101**

## **Biochemistry-1**

### **Preamble**

Amino acids are building blocks of proteins. The 20 different amino acids at various permutations and combinations give rise to different proteins with different functions. These different protein interaction and function is responsible for keeping the cellular complexities intact and live.

### **Unit-1**

**(15 lectures)**

Composition, different types of amino acids, Synthesis of different types of amino acids, Contribution of amino acids to biochemistry, Amino acids as source for energy production, Amino acids are derivatives for various metabolites.

### **Unit-2**

**(15 lectures)**

Protein as a biopolymer, synthesis of proteins, primary sequence of proteins and its significance in folding and structure. Role of proteins in different biochemical contexts, Proteins as enzymes, receptors, different types of signalling molecules, carriers of different cargos and elements.

### **Text Books:**

1. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13:978-1-4641-0962-1 / ISBN:10:14641-0962-1.
2. Biochemistry (2010) 4th ed., Garret, R. H. and Grisham, C.M., Cengage Learning (Boston), ISBN-13:978-0-495-11464-2.
3. Principles of Biochemistry (2008) 3rd ed., Voet, D.J., Voet, J.G. and Pratt, C.W., John Wiley & Sons, Inc. (New York), ISBN:13: 978-0470-23396-2

**20MMD102****Cell Biology 1****Preamble**

This course is to introduce the cell as a basic unit of life to the students of molecular medicine. It will elaborate the basic structure of the eukaryotic cells and the differences between the prokaryotic and eukaryotic cells. Further, the course will make the students understand the basic organization of eukaryotic cells, the endomembrane system, structure and functions of cell organelle, intracellular transport, the cytoskeleton, communication of cells with its surroundings and other cells and how cells reproduce through cell division. The course is devised in such a manner that the students will get a basic idea on the cellular bases of diseases.

**Unit 1****(5 lectures)**

The Cell: Introduction to cell theory, Comparison of a generalized pro- and eukaryotic cell  
Methods in Cell Biology: Elementary idea of microscopy and cell fractionation.

**Unit 2****(5 lectures)**

Organization of cell: Extranuclear (Elementary knowledge of structure and function of plasma membrane; Introduction to endomembrane system (endoplasmic reticulum, Golgi complex, lysosome, peroxisome; Introduction to cytoskeleton; Structure and functions of mitochondria); Nuclear (Nuclear envelope, nucleolus and biogenesis of ribosome).

**Text Books:**

(1) Karp: Cell and Molecular Biology (2008, John Wiley)

(2) Lodish et al: Molecular Cell Biology (2008, Freeman)

**20MMD111****Cell biology-2****Preamble:**

This course is to introduce the cell as a basic unit of life to the students of molecular medicine. It will elaborate the basic structure of the eukaryotic cells and the differences between the prokaryotic and eukaryotic cells. Further, the course will make the students understand the basic organization of

eukaryotic cells, the endomembrane system, structure and functions of cell organelle, intracellular transport, the cytoskeleton, communication of cells with its surroundings and other cells and how cells reproduce through cell division. The course is devised in such a manner that the students will get a basic idea on the cellular bases of diseases.

**Unit 1** (Lectures 5)

**Membrane transport:** Principles of membrane transport, Channel proteins, carrier proteins; Passive and active transport

**Unit 2** (Lectures 5)

**Intracellular transport and protein sorting;** Signal peptides and protein targeting; Entry and passage of proteins through endoplasmic reticulum; Processing and sorting of proteins in Golgi Apparatus; Endosomes and lysosomes; Nuclear pore complex and nuclear transport.

**Unit 3** (Lectures 5)

**Mitochondria and energy transfer:** Electron transport and oxidative phosphorylation

**Unit 4** (Lectures 5)

**Cytoskeleton:** Organisation and functions; Microtubular organelles

**Unit 5** (Lectures 5)

**Cell-cell communication:** Cell junctions; Cell adhesion and extracellular matrix; General principles of cell signaling.

**Unit 6** (Lectures 5)

**Cell reproduction:** Basic features of cell cycle; Mitosis, mitotic spindle and chromosome movement; Process and phases of meiosis and its significance; Genetic regulation of cell cycle

**Text books:**

(1) Karp: Cell and Molecular Biology (2008, John Wiley;

(2) Lodish et al: Molecular Cell Biology (2008, Freeman).

**20MMD112**

**Immunology**

**Unit 1** (5 Lectures)

Immune system, Concept of Innate and Adaptive immunity; Immune Cells and Organs.

**Unit 2** (9 Lectures)

Antigens; Adjuvants; Antibodies; Antigenic determinants on antibodies; VDJ rearrangements; Monoclonal and Chimeric antibodies.

**Unit 3** **(5 Lectures)**

Major Histocompatibility (Organization of MHC locus (Mice & Human); Structure and Functions of MHC I & II molecules; Antigen processing and presentation.

**Unit 4** **(5 Lectures)**

Complement System.

**Unit 5** **(6 Lectures)**

Generation of Immune Response, Introduction to tolerance, Immunological Disorders and Tumor Immunity.

**Unit 6** **(7 Lectures)**

Types of autoimmunity and hypersensitivity with examples; Immunodeficiencies - Animal models (Nude and SCID mice), SCID, DiGeorge syndrome, Chediak- Higashi syndrome.

**Unit 7** **(8 Lectures)**

Immunological Techniques (Principles of Precipitation, Agglutination, Immunodiffusion, Immunoelectrophoresis, ELISA, ELISPOT, Western blotting, Immunofluorescence, Flow cytometry, Immunoelectron microscopy).

**Text book:**

(1) Janeway's Immunobiology, Ken Murphy, Paul Travers, Mark Walport, 9th edition, Garland science publishing, 2007.

**20MMD181**

**Chemistry lab – 1**

- (1) Preliminary identification and detection of functional groups (Heating on a crucible lid; Identification of elements present;
- (2) Heating with soda-lime;
- (3) Treatment with sodium hydroxide solution;
- (4) Treatment with sodium carbonate solution;
- (5) Treatment with concentrated sulphuric acid;
- (6) Reactions and colorations with ferric chloride solution;
- (7) Treatment with 2,4-dinitrophenylhydrazine;



(8) Treatment with hydroxylamine and ferric chloride; Identifications of unknown organic compound.

**Text Books:**

- (1) Practical organic chemistry by F. G. Mann and B. C. Saunders.
- (2) A text-book of practical organic chemistry including qualitative organic analysis by A. I. Vogel.

**20MMD182**

**Chemistry lab -2**

- (1) Determination of the melting point;
- (2) Determination of the mixed melting point;
- (3) Determination of the boiling point;
- (4) Purification of solid organic compounds by re-crystallisation,
- (5) Determination of the saponification equivalent of an Ester,
- (6) Determination of molecular weight of an acid by titration with standard alkali Solution,
- (7) Estimation of the number of hydroxyl groups in a given polyhydric alcohol or phenol,
- (8) Estimation of the Number of Amino Groups in Aniline,
- (9) Determination of number of acetyl groups,
- (10) Estimation of glucose in a given sample, chromatographic separation

**Text books:**

- (1) Practical organic chemistry by F. G. Mann and B. C. Saunders
- (2) A text-book of practical organic chemistry including qualitative organic analysis by A. I. Vogel.

**20MMD183**

**Immunology Practicals**

- (1) Separation of serum & plasma,
- (2) Blood staining,
- (3) Blood grouping,
- (4) Antigen-Antibody reactions: agglutination, precipitation, immuno-electrophoresis, Coomb's test,
- (5) ELISA,
- (6) RIA,
- (7) WIDAL.

**Text Book:**

1. Manual of Molecular and Clinical Laboratory Immunology, Eighth Edition by Barbara Detrick, John L Schmitz, Robert G Hamilton.

**20MMD184****Cell Biology Practicals**

This lab is aimed to demonstrate use of microscopy in the study of cells, the morphology and internal organization of various types of cells, permeability of plasma membrane and different phases in mitosis and meiosis.

- (1) Drawing of ultrastructure of cell and different organelles (from photographs provided).
- (2) Familiarization with the student's light microscope and stereobinocular microscope.
- (3) Application of centrifuge – separation of sperm from other testicular cells by low speed centrifugation.
- (4) Diversity of eukaryotic cells – methylene blue staining of buccal epithelium, sperm, neurons, striated muscle cells; Leishman staining of mammalian blood cells.
- (5) Permeability of plasma membrane – effect of isotonic, hypotonic and hypertonic solutions on mammalian RBC.
- (6) Staining of nucleolus (RNA) and chromatin (DNA) with methyl green-pyronin Y.
- (7) Staining of mitochondria with Janus green in buccal epithelium.
- (8) Mitosis using somatic cells.
- (9) Meiosis using germ cells.

**Text books:**

- (1) Karp: Cell and Molecular Biology (2008, John Wiley).
- (2) Lodish et al: Molecular Cell Biology (2008, Freeman).

**20MMD201****Microbiology****Preamble**

Microbiology deals with the organisms that are at micron range can only be seen through a microscope. They are highly adaptable to different environment and exist in symbiotic relationship with higher order organisms. Their biology is explained in detail.

**Unit-1****(2 lectures)**

History and classification of microorganisms.

**Unit-2** **(10 lectures)**

Morphology and cell structure of major groups of microorganisms eg. Bacteria, Algae, Fungi, Protozoa and Unique features of viruses.

**Unit-3** **(7 lectures)**

Cultivation and Maintenance of microorganisms: Nutritional categories of micro-organisms, methods of isolation, Purification and preservation.

**Unit-4** **(6 lectures)**

Microbial growth: Growth curve, Generation time, synchronous batch and continuous culture, measurement of growth and factors affecting growth of bacteria.

**Unit-5** **(5 lectures)**

Bacterial Reproduction: Transformation, Transduction and Conjugation.

**Unit-6** **(4 lectures)**

Endospores and sporulation in bacteria.

**Unit-7** **(15 lectures)**

Control of Microorganisms: By physical, chemical and chemotherapeutic Agents.

**Unit-8** **(11 lectures)**

Food and industrial microbiology; probiotics, biological waste management.

**Text book:**

(1) Microbiology by Prescott, L.M., 6th Edition. McGraw-Hill Companies. 2002.

**20MMD202**

**Developmental Biology.**

**Preamble**

This course will describe the general patterns and mechanisms involved in the development of bilateral organisms including the mammals. Specifically, the course will deal with sex determination, gametogenesis, developmental organization, axis formation, 3 germ layer formation, organogenesis and implications of development in health and disease. The course is expected to provide the students a deeper understanding about the developmental origin of health and disease in adulthood.

**Unit-1** **(6 lectures)**

Patterns and Processes of Becoming: A Framework for Understanding Animal Development (Making New Bodies: Mechanisms of Developmental Organization; Specifying Identity:

Mechanisms of Developmental Patterning; Differential Gene Expression: Mechanisms of Cell Differentiation; Cell-to-Cell Communication: Mechanisms of Morphogenesis).

**Unit-2 (3 lectures)**

Gametogenesis and Fertilization: The Circle of Sex (Sex Determination and Gametogenesis; Fertilization: Beginning a New Organism).

**Unit-3 (3 lectures)**

Early Development: Cleavage, Gastrulation, and Axis Formation (The Genetics of Axis Specification in Drosophila; Mammals).

**Unit 4 (3 Lectures)**

Building with Ectoderm: The Vertebrate Nervous System and Epidermis: Neural Tube Formation and Patterning; Brain Growth; Neural Crest Cells and Axonal Specificity; Ectodermal Placodes and the Epidermis.

**Unit 5 (4 Lectures)**

Building with Mesoderm and Endoderm: Organogenesis; Paraxial Mesoderm: The Somites and Their Derivatives; Intermediate and Lateral Plate Mesoderm: Heart, Blood, and Kidneys; Development of the Tetrapod Limb; The Endoderm: Tubes and Organs for Digestion and Respiration

**Unit 6 (3 Lectures)**

Postembryonic Development: Metamorphosis: The Hormonal Reactivation of Development; Regeneration; Aging and Senescence

**Unit 7 (8 Lectures)**

Development in Wider Contexts: Development in Health and Disease: Birth Defects, Endocrine Disruptors, and Cancer; Development and the Environment: Biotic, Abiotic, and Symbiotic Regulation of Development; Development and Evolution: Developmental Mechanisms of Evolutionary Change.

**Text Books:**

- (1) Gilbert: Developmental Biology (11th ed., 2006, Sinauer);
- (2) Balinsky: An Introduction to Embryology (1981, CBS);
- (3) Wolpert: Principles of Development (3rd ed. 2007, Oxford).

Molecular Biology encompasses the basic study and understanding of the execution of central dogma.

**Unit 1**

**(10 Lectures)**

Genome organization: Structure of DNA, Types of DNA, Organization of Chromatin, Histone and Non-histone proteins, Nucleosome. Concept of Gene, Introns and Exons. Nature and Properties of Genetic Code.

**Unit 2**

**(10 Lectures)**

The replication of DNA in Prokaryotes and Eukaryotes: Chemistry of DNA synthesis, Mechanism of Replication: Initiation, Elongation, synthesis of Leading and lagging strands, Termination. Various models of DNA replication ( D-loop mitochondrial, Theta mode of replication, rolling circle model, Replication of linear ds-DNA). Enzymes and proteins involved in DNA replication. Denaturation and renaturation of DNA, Cot curves.

**Unit 3**

**(5 Lectures)**

The mutability and Repair of DNA: Replication Errors (Transitions, transversion and thymine dimer), DNA Damage (deamination, depurination and dimerization) and their repair: mismatch repair, SOS response (recombination), Excision Repair, Photoreactivation. Types of mutations.

**Unit 4**

**(10 Lectures)**

Information Transfer –I: Mechanism of Transcription: Basic transcription apparatus, Initiation, elongation and termination of transcription, Eukaryotic transcription of mRNA, tRNA and rRNA, types of RNA polymerases, transcription factors, Inhibitors of transcription- rifampicin and  $\alpha$ -amanitin.

**Unit 5**

**(5 Lectures)**

Post-Transcriptional Modifications: Split Genes, Concept of introns and exons, RNA splicing, Spliceosomes and Self splicing introns, alternative splicing and exon shuffling, mRNA transport.

**Unit 6**

**(5 Lectures)**

Mechanism of Translation: Features of genetic code and exceptions in some systems, Ribosome structure- rRNA and proteins, Charging of tRNA, aminoacyl tRNA synthetases, Proteins involved in initiation (both in prokaryotes and eukaryotes), elongation and termination of polypeptides, Fidelity of translation, Inhibitors of protein synthesis – tetracyclins, aminoglycosides, chloramphenicol and aminoglycosides.

**Text Books:**

(1) Friefelder, D. Molecular Biology.2nd Edition.Narosa Book Distributors Pvt. Ltd. 2008.

(2) Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walter, P. Molecular Biology of the Cell. 5th Edition. Garland Science. 2007.

(3) Molecular Biology of the Gene, 6th edition (2007), Watson, J. D., Baker T. A., Bell, S. P., Gann, A., Levine, M., and Losick, R; Benjamin Cummings Publishers, ISBN-13: 978-0805395921.

(4) The Cell: A Molecular Approach, 6th edition (2013), Cooper and Hausman; Sinauer Associates, Inc. ISBN-13: 978-1605351551.

## **20MMD212**

## **Genetics**

### **Preamble**

Genes are complexities in which the informations for a cellular complexity is stored. The study of this complexity is genetics and genomics.

### **Unit 1:**

**(5 Lectures)**

Elements of heredity and variation: Mendel and his experiments; Principles of segregation and independent assortment and their chromosomal basis; Test cross; Application of laws of probability to Mendelian inheritance

### **Unit 2:**

**(5 Lectures)**

Extension of Mendelism: Dominance relationships (complete dominance, incomplete dominance and co-dominance); Multiple allelism; Lethal alleles; Pleiotropy; Epistasis; Penetrance and expressivity; Phenocopy; Polygenic inheritance.

### **Unit 3:**

**(5 Lectures)**

Cytoplasmic and infective inheritance; Linkage: Linkage and crossing over; Structural and numerical alterations of chromosomes; Transgenic animals: strategies and applications

### **Unit-4**

**(8 lectures)**

Introduction: What Is in a HumanGenome? Meiosis, Development and Aging

### **Unit-5**

**(8 lectures)**

Transmission Genetics: Single-Gene Inheritance; Beyond Mendel'sLaws; Matters of Sex ; Multifactorial Traits; Genetics of Behavior

### **Unit-6**

**(8 lecture)**

Genes and Regulation: Gene Expression and Epigenetics; Gene Mutation; Chromosomes

### **Unit-7**

**(6 lecture)**

Population Genetics: Constant Allele Frequencies and DNA Forensics; Changing Allele Frequencies; Human ancestry and Evolution.

**Text books:**

- (1) Gardner et al: Principles of Genetics (1991, John Wiley).
- (2) Ricki Lewis: Human Genetics (12th edition, McGraw Hill).
- (3) Griffith et al: An Introduction to Genetic Analysis (2005, Freeman).
- (4) Gardner et al: Principles of Genetics (1991, John Wiley)
- (5) Ricki Lewis: Human Genetics (12th edition, McGraw Hill)
- (6) Griffith et al: An Introduction to Genetic Analysis (2005, Freeman)

**20MMD213****Proteome and Proteomics****Preamble**

Despite having the same number of chromosomes in all cells, there are different types of cells and different functions they elicit. This is due to differential gene expression. As a result, the protein expression pattern and proteome of the tissue or cell type is going to be very different. Understanding the cellular proteins by proteome analysis is essential for deciphering the importance of cell/tissue specific proteins role in homeostasis and related functions

**Unit 1****(15 lectures)**

What is proteome and proteomics and its significance. How proteins of a cell can be identified. Significance of different methods for studying proteomics. Significance of protein mass in proteomics. Mass spectrometry. Principles of mass spectroscopy.

**Unit 2****(15 lectures)**

Identification of proteins using mass spectrometry, Protein fragmentation; Peptide enrichment and separation; Ionization and its Importance; Time of Flight, MS/MS analysis, Peptide fragmentation and peptide sequencing. Significance of mass spectrometry in clinics.

**Text Books:**

1. Nawin C. Mishra, "Introduction to Proteomics: Principles and Applications" Wiley, 2010, ISBN: 0471754021
2. Proteomics for Biological Discovery: Timothy Veenstra and John Yates

**20MMD281****Microbiology Practicals**

- (1) Isolation of bacteria & their biochemical characterization;
- (2) Staining methods: simple staining,

- (3) Gram staining,
- (4) Spore staining,
- (5) Negative staining,
- (6) Hanging drop;
- (7) Preparation of media & sterilization methods,
- (8) Methods of isolation of bacteria from different sources;
- (9) Antimicrobial activity assays;
- (10) Enumeration of microorganism - total & viable count.
- (11) Bacterial mutagenesis – physical & chemical.
- (12) Preparation of *Escherichia coli* competent cells, Transformation of bacteria.

**Text Books:**

- (1) Bailey & Scott's Diagnostic Microbiology, 14th Edition.

**20MMD282                      Developmental Biology Practicals (2 CREDITS)**

This lab is devised to demonstrate different types of eggs, motility of sperms, how gametes fuse in vitro, embryonic development in vertebrates using fish as a model organism and hen's fertilized egg. Additionally, development of humans will be taught using educational videos.

1. Study of different types of eggs
2. Demonstration of sperm motility in rat
3. Demonstration of in vitro fertilization in vertebrate models
4. Study of vertebrate development through models
5. Study of organogenesis in humans using educational videos
6. Window preparation on hen's fertilized egg and observation of organogenesis

**20MMD283                      Molecular Biology Practicals**

1. Preparation of various stock solutions required for Molecular Biology Laboratory.
2. Preparation of culture medium (LB) for *E. coli* (both solid and liquid) and raise culture of *E. coli*.
3. Isolation of chromosomal DNA from bacterial cultures and visualization on Agarose Gel Electrophoresis.
4. Quantitative estimation of DNA using colorimeter (Diphenylamine reagent) and Spectrophotometer (A260 measurement).
5. Isolation of genomic DNA from blood/ tissue.



6. Demonstration of Polymerase Chain Reaction (PCR) technique
7. Demonstration of AMES test or reverse mutation for carcinogenicity

**Text books:**

(1) Cell and Molecular Biology: Concepts and Experiments, 7th edition (2013), Gerald Karp; Wiley Publishers ISBN-13: 978-1118206737.

(2) Molecular Cloning: A Laboratory Manual, 4th edition (2012), Michael R. Green and Joseph Sambrook; Cold Spring Harbor Laboratory Press, ISBN-13: 978-1936113422.

**20MMD301**

**Stem cell Biology (2 Credits)**

**Preamble:**

Advancements in stem cell biology are occurring at a rapid pace. Breakthroughs in this field may lead to regenerative therapies for diabetes, heart disease, age-related organ failure, genetic diseases, Parkinson's, and severe tissue traumas such as spinal cord injuries. Stem cells are revolutionizing the regenerative medicine sector and it provides immense hope for the medical world to treat the diseases that are once considered as non-treatable. Stem cells are also being used to gain a better understanding of mammalian development, cell differentiation and gene regulation. This course aims to provide a comprehensive overview of the basic biology and some applications of stem cells. This course will cover the basics of stem cells, classification of stem cells, embryonic stem cells, adult stem cells, self renewal and quiescence of stem cells, applications of stem cells, induced pluripotent stem cells and its applications, current controversies associated with stem cell research.

**Unit 1**

**(4 Lectures)**

Introduction to stem cells, self-renewal, clonality, potency, types of stem cells, differentiation potential of stem cells, basic concepts and definitions.

**Unit 2**

**(3 Lectures)**

Embryonic stem cells, defining properties of embryonic stem cells, Human embryonic stem cells, human embryonic germ cells

**Unit 3**

**(3 Lectures)**

Adult stem cells, types of adult stem cells

**Unit 4**

**(4 Lectures)**

Introduction, cell cycle kinetics of stem cells in vivo, mammalian cell cycle regulation and cyclin-dependent kinase inhibitors, role of cyclin-dependent kinase inhibitors in stem cell regulation. Molecular, epigenetic, and genetic control of stem cell differentiation and specializations.

**Unit 5** (2 Lectures)

**Stem cell Niche:** Introduction, concept of stem cell niche and its importance

**Unit 6** (3 Lectures)

**Hematopoietic stem cells:** Introduction, definition, sources of HSCs, identification of HSCs, uses of HSCs

**Unit 7** (3 Lectures)

**Mesenchymal stem cells (MSCs):** Introduction, sources of MSCs, identification of MSCs, properties of MSCs, uses of MSCs

**Unit 8** (3 Lectures)

**Pluripotency and Induced pluripotency:** Introduction, definition, induced pluripotent stem cells (iPSCs), potential application of iPSCs

**Unit 9** (3 Lectures)

**Stem cell application:** Introduction, existing and potential clinical use of stem cells, application of stem cells to regenerative medicine.

**Unit 10** (2 Lectures)

Controversies in stem cell research: Introduction, ethical issues associated with stem cell research, current controversies surrounding stem cell research.

**Text book:**

(1) Essentials of Stem Cell Biology, Second Edition, 2009, Edited by Robert Lanza, M.D., ISBN: 978-0-12-374729-7, Elsevier Inc.

(2) Stem Cell Biology, Daniel Marshak, Richard L. Gardener and David Gottlieb, Cold Spring Harbour Laboratory Press.

## **20MMD302** **Biopolymers and its medical applications**

Biopolymers in nature are produced by a range of microorganisms and plants. Biopolymers produced by microorganisms require specific nutrients and controlled environmental conditions. This course deals with the recent developments and trends of biopolymers especially in the field of nanotechnology, a basic introduction, a detailed discussion on various characterization techniques used for characterizing biopolymers, applications of biopolymers in various fields, especially in the field related to nanoscience and nanotechnology for medical application.

**Unit-1****(5 lectures)**

Introduction and Basic Concepts: Definition of Terminology and Basic Concepts, Nomenclature of Polymers, Polymer Architectures

**Unit-2****(8 lectures)**

Polymers in Solution, Molecular Weight, Physical State Nano Polymers and related Materials: Fracture Behavior, Tailor-Made Plastics, Cross-Linked Materials, Polymer Additives, Nanopolymers and their applications.

**Unit-3****(8 lectures)**

Polymeric nanoparticles: the future of nanomedicine, Biopolymers introduction and classification, Biopolymers: Bioplastics, biofibers, biopolymeric composites, Bio-inorganic polymeric composites, Biopolymers for Specific Applications, Biomedical, Drug delivery, Environmental, Pharmaceutical Technology.

**Unit-4****(12 lectures)**

Bio-polymeric nanomaterials and its applications: Polysaccharides, Polysaccharide Graft Copolymers – Synthesis, Properties and Applications, Chitosan bio-polymers- Basic sources, characteristics, polymer isolation process, derivatives and their various bio medical applications.

**Unit-5****(12 lectures)**

Future research trends of biopolymers. Biopolymer Blends and Biocomposites, Biopolymers as wound healing materials, Biopolymers as biofilters and biobarriers. Stimuli responsive polymers: Classifications, preparation and their various applications.

**Text Books:**

(1) Text book of Polymer Science....by Fred W. Billmeyer;

(2) Biopolymers: Biomedical and Environmental Applications by Susheel Kalia and Luc Avérous, Wiley 2011.

**20MMD303****Molecular methods****Unit 1****(10 Lectures)**

PCR Principle, procedure, types and applications. Designing primers, real-time and quantitative PCR, reverse transcription PCR, DNA fingerprinting

**Unit 2****(10 Lectures)**

Cloning, linkers, adapters, cDNA library construction and screening, DNA finger printing, chromosome walking and chromosome jumping.

**Unit 3**

**(5 Lectures)**

RFLP, RAPD, SCAR (Sequence characterized amplified region) markers characteristics, advantages and disadvantages.

**Unit 4**

**(10 Lectures)**

DNA Sequencing: Maxam-Gilbert method and Sanger method of DNA sequencing, Next Generation Sequencing (NGS).

**Unit 5**

**(10 Lectures)**

Hybridisation techniques: Principle of hybridization. Southern, Northern, in-situ Hybridization, DNA microarray and luminex assays.

**Text book:**

**(1)** Molecular Biology Techniques, 4th Edition- A Classroom Laboratory Manual by Sue Carson Heather Miller Melissa Srougi D. Scott Witherow. ISBN: 9780128157756

**20MMD304**

**Principles of Pathology**

**Preamble**

This course introduces fundamental concepts related to human pathology. Students will be exposed to concepts addressing how cells and tissue respond (both, morphologically and functionally) to various external stimuli. Tissue inflammation and ensuing cellular events including healing, tissue regeneration, and cell death will be discussed. Students will also learn about concepts in hemodynamic disorders, nutritional diseases and malignant disorders. Concepts discussed in this course will complement the topics learnt in the physiology course

**Unit 1:**

**(3 lectures)**

Introduction: History of pathology, Basic definitions and common terms used in pathology, Survival Introduction mechanism and disease, microscopic and cellular pathology, scope and techniques used.

**Unit 2:**

**(4 lectures)**

Cell Injury and responses of cells: Cellular Adaptations, and Cell Death An overview of cellular adaptation: Hyperplasia, Hypertrophy, Atrophy, Metaplasia; Causes and mechanisms of cell injury, reversible and irreversible injury, Necrosis, Apoptosis, Types of apoptosis, Intracellular accumulations, Cellular ageing

**Unit 3:**

**(7 lectures)**

Role of Inflammation in disease Basic concepts with suitable examples of general features of acute and chronic inflammation: Vascular Changes, cellular events, important chemical mediators of inflammation, Morphological effects inflammation response, Granulomatus Inflammation.

**Unit 4:** (4 lectures)

Role of Tissue repair, Healing and Fibrosis: Basic mechanism of tissue regeneration, and repair by healing, scar formation and fibrosis

**Unit 5:** (4 lectures)

Hemodynamic Disorders in diseases: An overview of Edema, hyperemia, congestion, hemorrhage, hemostasis and thrombosis, Embolism, Infarction and shock with suitable examples

**Unit 6:** (3 lectures)

Nutritional Diseases Protein energy malnutrition, deficiency diseases of vitamins, minerals, nutritional excess and imbalances. Role and effect of metals.

**Unit 7:** (5 lectures)

Cancer: Definitions, Nomenclature, characteristics of benign and malignant neoplasms, grading and staging of cancer, biology of tumor growth, invasion and metastasis, carcinogens and cancer, concept of oncogenes, tumor suppressor genes, DNA repair genes and cancer stem cells.

### **Text Books**

Robbins Basic Pathology, 9th edition, Kumar, Abbas, Fausto and Mitchell; Saunders, Publication, ISBN-13: 978-1437717815

Medical Laboratory Technology Methods and Interpretations, 6th edition, Ramnik. Sood; Jaypee Brothers Medical Publishers, ISBN-13: 978-8184484496.

## **20MMD305**

### **Regenerative medicine**

**Unit 1** (10 Lectures)

**Molecular organization of cells:** Molecules that organize cells, Cell-cell adhesion, Changes in cell–cell adhesion, Cell interaction with the basal lamina, Cell polarity, Changes in cell polarity during cell transition, The epithelial–mesenchymal transition, Molecular control of the epithelial–mesenchymal transition.

**Unit 2** (10 Lectures)

**Cell–extracellular matrix interactions in repair and regeneration:** Extracellular matrix composition and diversity, Receptors for extracellular matrix molecules, Signal transduction events during cell–extracellular matrix interaction, Cell–extracellular matrix interactions during healing process.

**Unit 3**

**(9 Lectures)**

The Biology function and biomedical applications of exosomes: Biogenesis of exosomes, Heterogeneity in exosomes, Intracellular communication, Diagnostic potential of exosomes, Exosomes in regenerative applications.

**Unit 4**

**(10 Lectures)**

Wound repair and regeneration: Molecular pathology of chronic wounds, Molecular and cellular mechanisms in normal skin repair and wound healing, Scarring and tissue fibrosis, Diabetic wounds, Current treatments and their limitations in wound healing.

**Unit 5**

**(6 Lectures)**

Stem cells and tissue engineering in regenerative medicine. Stem cell types, Natural biomaterials, Synthetic biomaterials, Design principles in biomaterials and scaffolds, Cell therapy in regenerative medicine, Tissue engineering and applications of engineered tissues in medicine.

**Text book:**

(1) Principles of Regenerative Medicine Book, 3rd Edition; 2019 edited by Anthony Atala, Robert Lanza, Antonios G. Mikos & Robert Nerem.

**20MMD311**

**Cancer Biology**

**Preamble:**

Cancer is defined as uncontrollable cell growth. The complexities of the causes and the different types of cells that give rise to this disease have underscored the need for a better understanding of the basic biology of cancer. Advancements in basic and biomedical research have led to more effective treatments, enhanced detection methods, and better prevention strategies. This course aims to provide a comprehensive overview of the biology and pathology of cancer. This course will cover the genetic and molecular basis of cancer, role of mutations in cancer cells, and how they lead to the dysregulation of essential biological properties like programmed cell death, cell proliferation and differentiation, invasion and metastases, cancer etiology and epidemiology.

**Unit 1** (4 Lectures)

Introduction to Cancer, cardinal manifestations of cancer, History of Cancer Research, Overview of the hallmarks of cancer

**Unit 2** (4 lectures)

**Cell Proliferation and Differentiation:** Tumour growth and proliferation in vivo, cell cycle control, check points, DNA damage induced check points, Check point defects in tumour cells, differentiation, extracellular and intracellular factors of differentiation, Differentiation and cancer therapy.

**Unit 3** (3 lectures)

**Apoptosis and cancer:** Apoptosis, Apoptosis caused by caspases, caspase activation pathways, apoptosis dysregulation in cancer

**Unit 4** (3 lectures)

**Growth factors and signal transduction in cancer:** Background, growth factors, classification of growth factors and its receptors, abnormalities associated with growth factors in cancer cells, signalling pathways in cancer. Signalling pathways and its implications for cancer therapy.

**Unit 5** (3 lectures)

**Oncogenes:** Mutagens, carcinogens and mutations, Tumor viruses and the discovery of oncogenes, Tumor cells and genetic abnormalities, mechanism of oncogene activation, oncogenes in the initiation and progression of neoplasia

**Unit 6** (4 lectures)

**Invasion and Metastases:** Tumour-host and tumour-stroma interactions, adhesion, tumour cell migration, angiogenesis, genetic regulation of invasion and metastases, cancer stem cells, therapeutic intervention

**Unit 7** (3 lectures)

**Tumour antigens:** Introduction, categories of tumour antigens, application of tumour antigens for clinical immunotherapy

**Unit 8** (5 lectures)

**Cancer etiology:** Genetic predisposition to cancer, chemical carcinogenesis, multistage carcinogenesis (tumour initiation, tumour promotion, malignant conversion and tumour progression), caretaker and gate keeper genes, carcinogen metabolism, DNA damage and repair, hormones and the etiology of cancer, radiation and cancer, UV-radiation and cancer, physical carcinogens and cancer, virus and cancer, parasites and cancer.

**Unit 9****(1 lecture)****Cancer Epidemiology:** Incidence of cancers in india and other parts of the world.**Text book:**

(1) Robin Hesketh. Introduction to Cancer Biology, Cambridge University Press, 2012 (ISBN: 9781107601482)

(2) Weinberg, Robert A. The Biology of Cancer, Second Edition. New York: Garland Science, 2013.

**20MMD312****Microbial diseases and vaccine technology****Unit 1****(5 Lectures)**

Entry of pathogens into the host, types of pathogens, Microbial toxins (exotoxins, enterotoxins, endotoxins, neurotoxins) and virulence factors.

**Unit 2****(20 Lectures)**

Microbial diseases caused by major human pathogens (E. coli, Salmonella, Helicobacter, Staphylococcus, Mycobacterium, Candida, HIV, HPV, Dengue, Corona virus, HBV etc).

**Unit 3****(20 Lectures)**

Vaccines & Vaccination – adjuvants, DNA vaccines, recombinant vaccines, bacterial vaccines, viral vaccines, principles of vaccination, passive & active immunization, immunization programs & role of WHO in immunization programs.

**Text book:**

(1) Essentials of Medical Microbiology by ApurbaSankar Sastry, Sandhya Bhat K, 2nd edition

**20MMD313****Nanosciences in Biology****Unit-1****(10 lecture)**

Introduction to nanotechnology; Different types of nanomaterials; Nanostructures in Biological Systems - Nucleic Acid, Amino acids, proteins, Carbohydrates and lipids; Nanobiotechnology – learning from nature - DNA nanotechnology - self-assembled DNA nanotubes and their applications, Biological nanoparticles production - plants and microbial,

**Unit-2****(25 lecture)**



Applications of nanomaterials to biology: Fluorescent biological labels - Bioimaging, Nanoparticles for biological assays, Nanoparticles for drug/gene delivery, Active and passive delivery of nanoparticles to cells, Bio detection of pathogens, Nanobiotechnological applications in health and disease - infectious and chronic, Nanoparticles in disease diagnosis - MRI, CT and optical contrast agents, Nanoparticles for therapy of diseases – cancer, diabetes, Nanomaterials in tissue engineering and regenerative medicine

### **Unit-3**

**(10 lecture)**

Biosensors – different types, Applications of molecular recognition elements in nanosensing of different analytes, Miniaturized devices in nanobiotechnology - types and applications, lab on a chip concept.

#### **Text books:**

(1) Nanotechnology in Biology and Medicine: Methods, Devices and Application by Tuan Vo-Dinh .CRC press, 2007.

(2) Nanosystem characterization tools in the life sciences by Challa Kumar. WileyVCH, 2006.

(3) Challa Kumar(Ed) - Nanomaterials for Medical Diagnosis and Therapy, Wiley-VCH, 2006

### **20MMD381**

#### **Molecular methods lab**

(1) DNA and RNA isolation and storage - from Human Blood & Microbes,

(2) Plasmid DNA isolation,

(3) cDNA synthesis,

(4) Gel electrophoresis,

(5) Polymerase Chain Reaction,

(6) Gel documentation & photography

(7) Restriction fragment length polymorphism (RFLP).

#### **Text book:**

(1) Molecular Cloning: A Laboratory Manual(4<sup>th</sup> Edition) by Michael R. Green, Cold spring harbour laboratory press.

**20RM301**

**Research Methodology**

**Unit : 1**

**(lectures 15)**

Identifying a scientific problem and collecting data to address the problem, Development of a hypothesis, Addressing the hypothesis with research question driven experiment strategy, experiment design, choosing appropriate controls, adoption of experimental techniques to address the hypothesis, sample collection and processing strategies with examples.

**Unit : 2**

**(lectures 15)**

Significance of developing protocols for experiments, execution of the experiments, generation of data, principles of data documentation. Interpreting the data, significance of critical evaluation, how to discuss and conclude your finding.

**6-7. Project**