ఆంధ్రప్రదేశ్ కేంద్రీయ విశ్వవిద్యాలయం आंध्रप्रदेश केंद्रीय विश्वविद्यालय

CENTRAL UNIVERSITY OF ANDHRA PRADESH

(Established by an act of Parliament in 2019)

Vidya Dadati Vinayam

(Education Gives Humility)

School of Interdisciplinary and Applied Sciences

M.Sc. Molecular Biology

"Our own genomes carry the story of evolution, written in DNA, the language of molecular genetics, and the narrative is unmistakable."

-Kenneth R. Miller

Structure and Syllabus

(2024-25 Batch)

CONTENTS

Important Information to Students

I. Programme: M.Sc. Molecular Biology

II. Eligibility: Candidate with a Bachelor's degree in any branch of Life Sciences (Zoology, Botany, Microbiology, Biotechnology, Bio-informatics, Genetics or equivalent), Chemical, Medical, Veterinary, Pharmacy, and Agricultural Sciences.

III. The minimum duration for completion of the programme is four semesters (two academic years) and the maximum duration is eight semesters (four academic years) or as per amendments made by the regulatory bodies from time to time.

IV. A student should attend at least 75% of the classes, seminars, and practicals in each course of study.

V. All theory courses in the programme carry a Continuous Internal Assessment (CIA) component to a maximum of 40 marks and for End Semester Examination (ESE) for a maximum of 60 marks. The minimum pass marks for a course is 40%. All a,b, components carry a Continuous Internal Assessment (CIA) component to a maximum of 60 marks and End Semester Practical Examination (ESE) for a maximum of 40 marks. The minimum pass marks for a course is 40%.

VI. A student should pass separately in both CIA and ESE, i.e., student should secure 16 (40% of 40) out of 40 marks for theory and24 (40% of 60) out of 60 marks for lab components in the CIA. Therefore, a student should secure 24 (40% of 60) out of 60 marks for theory and 16 (40% of 40) out of 40 marks for lab components in the end semester examination.

VII. A student failing to secure the minimum pass marks in the CIA is not allowed to take the end semester examination of that course. She / he has to redo the course by attending special classes for that course and get the pass percentage in the internal tests to become eligible to take the end-semester examination.

VIII. Students failing a course due to lack of attendance should redo the course.

IX. Re-evaluation is applicable only for theory papers and shall not be entertained for other components such as practical's/thesis/dissertation/ internship, etc.

X. A non-campus elective course is offered only if a minimum of tenor 40% of the students registered, whichever is higher, exercise their option for that course.

XI. The semester-end question paper pattern:
Student should answer any five questions out of 6 questions. Q1 and Q6 are compulsory.

Q1. Objective type questions (24X0.5) 12 Marks
(It may include mix of MCQs; fill in the blanks, True/False, Matching and any other objective type of question from all 4 units without any choice.)

Q2. Descriptive questions from Unit-1 12 Marks
(Should be minimum of with two or more questions with varying marks to each question. For example: 6+6 or 4+4+4 or 3+3+3+3 or 3+4+5 or 5+7 or 4+8 or any other combinations)

Q3. Descriptive questions from Unit-II 12Marks
(Should be minimum of with two or more questions with varying marks to each question.
For example: 6+6 or 4+4+4 or 3+3+3+3 or 3+4+5 or 5+7 or 4+8 or any other combinations)

Q4. Descriptive questions from Unit-III 12 Marks
(Should be minimum of with two or more questions with varying marks to each question.
For example: 6+6 or 4+4+4 or 3+3+3+3 or 3+4+5 or 5+7 or 4+8 or any other combinations)

Q5. Descriptive questions from Unit-IV 12 Marks
(Should be minimum of with two or more questions with varying marks to each question.
For example: 6+6 or 4+4+4 or 3+3+3+3 or 3+4+5 or 5+7 or 4+8 or any other combinations)

Q6. Short answer questions **12 Marks**

(Should answer 4 short answer questions carrying 3 Mark and questions has to take from 1 to 4 units)

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Introduction to the Programme

M.Sc. Molecular Biology is one of the fine new Post Graduate programmes being offered by CUAP in the 2022-23 academic years. This programme provides the students with a great opportunity for job-seeking, higher education, and research. While preparing the syllabus of the core courses and the basket elective courses one has to take into account to provide the following points.

a) The core courses should help the students to write the competitive examinations on (like CSIR- UGC NET) to pursue molecular biology in later years.

b) The course contains more applied probabilities rather than concepts involving deeper analysis.

c) The elective courses should facilitate the student to seek jobs in case he/she does not want to continue molecular biology.

d) The course also encourages the department to float elective courses that are inter-disciplinary.

e) The student-centric approach of the curriculum has been designed to equip learners with appropriate knowledge, skills and values of the discipline.

Objectives of the Programme

Up on completion of the M.Sc. programme, the graduate will

- Have professional and ethical responsibility and able to adopt new skills and techniques.
- Be able to plan, organize, lead and work in a team to carryout tasks for the success of the team.
- Understand the need for continuous learning and prepare himself /herself with relevant interpersonal skills as an individual, as a member, or as a leader throughout the professional career.
- Be motivated to prepare him/her to pursue higher studies and research to meet out academic demands of the country.

- Communicate biological ideas with clarity and the ability to identify, formulate, and solve biological problems.
- Have knowledge of a wide range of molecular biology techniques and the application of biological methods / tools in scientific domains.
- Have both analytical and computational skills in biological sciences.

Learning Outcomes of the Programme

On successful completion of the programme students should be able to

- Solve diverse biological problems and are capable of analyzing the obtained results.
- Analyze and interpret the outcomes and develop new ideas based on the issues in a broader social context.
- Apply the knowledge and design the methodology to real-world problems.
- Use the learned techniques, skills, and modern biological tools suitable to the problem encountered.
- Acquire problem-solving skills, analytical thinking, creativity, and biological reasoning.
- Write effective reports and documents, prepare effective presentations, and communicate the findings efficiently.
- Develop confidence to crack the competitive exams like NET, SET, and GATE etc.

M.Sc. Molecular Biology: Semester and Course-wise Credits

Sem	Discipline Specific Core (DSC) (L+T+P)	Discipline Specific Elective (DSE)/ Elective (EL)	Project Work / Dissertation	Common Compulsory Course (CCC)	Inter-Disciplinary Elective (IDE)	Internship	Lab	Total Credits
I	DSC1(3) DSC2(3) DSC 3 (3) Add-on/SEC (2)	Elective-1(3) DSE- 1 DSE – 2	-		MOOC-1 (3)		DSC-1 Lab:(1) DSC-2 Lab:(1) DSC-3 Lab:(1)	20
II	DSC4(3) DSC5(3) DSC6 (3)	Elective- II (3) DSE-1 DSE-2	-	CCC-1 AI&ML (4)	MOOC-1I (3)		DSC-4 Lab:(1) DSC-5 Lab:(1) DSC-6 Lab:(1)	22
III	DSC 7 (3) DSC8 (3) DSC 9 (3)	Elective- III (3) DSE-1 DSE-2	-	CCC-2 Building Mathematical Ability and Financial Literacy (4)	MOOC-1II (3)	Internship (2)	DSC-7 Lab:(1) DSC-8 Lab:(1) DSC-9 Lab:(1)	24
IV	DSC 10 (4)	-	Dissertation (16)				-	20
Total	33	09	16	8	9	2	09	86

Programme Structure
Semester-I

S.No	Course Code	Title of the Course	Credits Points	Credits Distribution		
				L	T/L	P/S
1.	MMB-101	Biomolecules and Biochemistry	3	2		1
2.	MMB-102	Cell Biology	3	2		1
3.	MMB-103	Microbiology and Microscopy	3	2		1
4.	**Any one of the following electives**		3	3		
	MMB-104	Biophysics and Structural Biology				
	MMB-105	Biodiversity and Evolutionary Biology				
6	MMB-106	Academic Writing	2	2		
5	MMB-112	MOOC-I	3	3		
7.	**Practicals**					
	MMB-125	Lab-I (Based on MMB-101,102, &103)	3	2		1
Total			20	16		4

Semester-II

S.No	Course Code	Title of the Course	Credits	Credits Distribution		
				L	T/L	P/S
1.	MMB-201	Immunology	3	2		1
2.	MMB-202	Molecular Biology	3	2		1
3.	MMB-203	Genetic Engineering and Genome Editing	3	2		1
4.	**Any one of the following electives**		3	2		1
	MMB-204	Signal Transduction and Cancer Biology				
	MMB-205	Biostatistics and Bioinformatics				
5.	MMB-212	MOOC-II	3	3		
6.	MMB-213L	Introduction to Artificial Intelligence and Machine Learning (AI&ML)	4	2		2
7.	**Practicals**					
	MMB-225	Lab-II (Based on MMB-201,202&203)	3	2		1
Total			22	15		7

Semester-III

S.No	Course Code	Title of the Course	Credits	Credits Distribution		
				L	T/L	P/S
1.	MMB-301	Plant Physiology	3	2		1
2.	MMB-302	Animal Physiology	3	2		1
3.	MMB-303	Genomics and Proteomics	3	2		1
4.	**Any one of the following electives**		3	2		1
	MMB-304	Developmental Biology				
	MMB-305	Metabolomics and Metabolic Engineering				
	MMB-306	Internship	2	2		
6.	MMB-312	MOOC-III	3	3		
5.	MMB-313	Building Mathematical Ability and Financial Literacy	4	3	1	
7.	**Practicals**					
	MMB-325	Lab-III (Based on MMB-301,302,303)	3	2		1
Total			24	18	1	**5**

Semester-IV

S.No	Course Code	Title of the Course	Credits	Credits Distribution		
				L	T/L	P/S
1.	MMB-401	Research Techniques in Molecular Biology	4	4		
2.	MMB-402	Project Work/Dissertation	16			16
Total			20	4		16
Programme Total			**86**	**53**	**1**	**32**

L: Lectures; **T:** Tutorials; **L:** Lab; **P:** Presentations; **S:** Seminars

*Internship shall be completed before the commencement of IV-Semester.

Note1: Total number of credits may go beyond 86 depending on the credits of MOOC courses Note 2: Exit option with PG Diploma / B.Sc., Honours after II semester with open elective (44credits).
Any Online/MOOC course taken by the student must be approved by a competent authority.

Credit Distribution

Semester	Total Credits	Cumulative Credit at the end of the Semester
Semester I	20	20
Semester II	22	42
Semester III	24	66
Semester IV	20	86

• **Assessment Pattern:** 40% of internal [formative evaluation—two best out of three tests (For a maximum of 15 marks each = 30 marks) -- and seminar/ assignments/ attendance (10 marks)] and 60% (summative evaluation—end of semester examination).

End Semester Examination
Maximum Marks: 60 Times: 3Hours

Dissertation / Project Report Evaluation: 60Marks

Seminar and Viva-Voce: 40 Marks.

SEMESTER-WISE
DETAILED SYLLABU

SEMESTER-I

Course Code: MMB-101 **Core/Elective:** Core **No. of Credits:** 3 **Total Hours :**45	**Course Title** **Biomolecules and Biochemistry**

Objectives

- To study the basic chemistry of biomolecules.
- To understand the structure, functions, and properties of biomolecules.

Learning Outcome

- The students are expected to gain an insight into the structure-function relationship of biomolecules.

Unit-I (12 Hours)

Carbohydrates: Classification, configurational and conformational aspects of carbohydrates. Structure, properties, and functions of homo and hetero-polysaccharides. Blood groups and bacterial polysaccharides. Glycoproteins, Cardio glycosides. Lipids: Classification and types of lipids. Structure and properties of fatty acids, acyl glycerols, phospholipids, glycolipids. Structure and function of steroids, and leukotrienes. Composition and biological role of lipoproteins.

Unit-II (12 Hours)

Amino acids and Proteins: Classification and properties of amino acids. Non-protein amino acids. Primary structure of proteins. Secondary structure-α-helix, β-sheet, triple helical structure. Tertiary structure of protein-Insulin, keratin, and chymo trypsin. Quaternary structure - Hemoglobin. Structure-function relationship: Hair, silk. Enzymology: Enzyme classification, characterization and Enzyme kinetics; Relevance of enzymes in metabolic regulation, activation, inhibition and covalent modification; Single substrate enzymes, Allosteric enzymes. Nucleic acids: Introduction to RNA and DNA.

Unit-III **(10 Hours)**

Energy Utilization: I, II and III laws of thermodynamics. Enthalpy, entropy, free energy and chemical equilibrium. High energy compounds: Energy currency, ATP, ADP, Creatine phosphate, phosphorenol pyruvate as energy rich compound. ATP synthesis, ATP synthase complex, binding change mechanism, proton motive force, Mitchell's hypothesis. Substrate level phosphorylation, futile cycles and their application.

Unit-IV **(11 Hours)**

Chromatography: Principle, procedure and applications of - Thin Layer Chromatography, Ion exchange Chromatography, Molecular exclusion Chromatography, Gas-Liquid Chromatography, High Performance Liquid Chromatography, and Affinity Chromatography. Centrifugation: Principle and types. Ultracentrifugation - Preparative and Analytical, Differential and Density gradient centrifugation. Spectrophotometry: Principles and biochemical applications of UV-Vis spectrophotometry,

Suggested Reading

1. Berg, Jeremy M, John L.Tymoczko, Lubert Stryer, and Lubert Stryer. *Biochemistry*, New York: W.H. Freeman, 2007.
2. Glaser, Roland. *Biophysics: An Introduction*, 2012. Internet resource. Lindon, John C, George E. Tranter, and JohnL. Holmes. *Encyclopedia of Spectroscopy and Spectrometry:* [volume2]. San Diego, CA: Academic Press, 2000.
3. Nelson, David L, Michael M. Cox, AaronA. Hoskins, and Albert L. Lehninger. *Lehninger Principles of Biochemistry*, 2021.

References

1. Elliott, William H, and Daphne C.Elliot. *Biochemistry and Molecular Biology*, Oxford: Oxford University Press, 2009.
2. Mainwaring, WI.P. *Nucleic Acid Biochemistry and Molecular Biology*, Oxford: Blackwell Scientific Publications, 1982.
3. Miller, James M. *Chromatography: Concepts and Contrasts,2nd Ed,* Wiley, 2009. Harlow: Pearson Education UK, 2013. Internet resource.

4.Moran, Laurence A, Robert A. Horton, Gray Scrimgeour, Marc Perry, and David Rawn. *Principles of Biochemistry*, Harlow: Pearson Education UK, 2013. Internet resource.
5.Voet, Donald, and Judith G.Voet. *Biochemistry*, Singapore: J.Wiley & Sons, 2021.
6.Wilson, Keith. *Principles and Techniques of Biochemistry and Molecular Biology*, Cambridge: Cambridge Univ. Press, 2010.
7.Zubay, Geoffrey L, William W. Parson, and Dennis E.Vance. *Principles of Biochemistry*, Dubuque, Iowa: Wm. C. Brown, 1995. Internet resource.

Course Code: MMB-102 **Core/Elective:** Core **No. of Credits:** 3 **Total Hours:** 45	**Course Title** **Cell Biology**

Objectives

- To study the basic components of a cell.
- To study the organization of prokaryotic and eukaryotic cells and to study various cellular processes.

Learning Outcome

- Ability to understand fundamental aspects in biological phenomenon.
- Students are expected to gain an insight in to cellular organelles and their coordinated functions.

Unit-I **(12 Hours)**

Dynamic organization of the cell: Cell theory, Ultra-structure of prokaryotic and eukaryotic cells; chemical organization of the cell; cell membranes-structure models; internal organization of the cell; intracellular organelles: endoplasmic reticulum and Golgi apparatus; Mitochondria, Chloroplast, Lysosomes. Nucleus- Internal organization, Nucleosomes, Chromatin- structure and function, cellular cytoskeleton.

Unit-II **(10 Hours)**

Cell-cell communications: Cell-environment communications. Role of different adhesion molecules: Desmosomes, Hemi-desmosomes, Gap junctions, Tight Junctions, Plasmodesmata. Organelle Interconnectivity and communications.

Unit-III **(11 Hours)**

Cellular processes: cell division: mitosis, meiosis and cytokinesis, cell differentiation: Introduction to stem cells, Molecular mechanisms of membrane transport active, passive, facilitated. Cellular responses to environmental signals in plants, animals, and microorganisms.

Unit-IV **(12 Hours)**

Regulation of cell cycle: Discovery of MPF, cyclins and cyclin dependent kinases, Check points - role of Rb and p53, apoptosis. Neurotrophic factors, caspases, pathways of apoptosis. Cell Cycle mis regulation and cancer-Cancer. Types and stages. Tumor suppressor genes and proto-oncogenes. Molecular basis of cancer, cell senescence.

Suggested Reading:

1.Lodish, Harvey F, Arnold Berk, Chris Kaiser, Monty Krieger, Matthew, P.Scott, Anthony Bretscher, Hidde L. Ploegh, and Paul, T.Matsuda *Molecular Cell Biology*, New York: W.H. Freeman, 2008.

2.Karp, Gerald, and Nancy L. Pruitt. *Cell and Molecular Biology: Concepts and Experiments*, Hoboken, N.J: John Wiley & Sons, 2008.

References:

1. Pecorino, Lauren. Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics, 2021.

2. Wilson, John H, and Tim Hunt. Molecular Biology of the Cell, 5th Edition, New York: Garland Science,2008

Course Code: MMB-103 **Core/Elective:** Core **No. of Credits:** 3 **Total Hours:** 45	**Course Title** **Microbiology and Microscopy**

Objectives

- To study early discoveries and recent developments in microbiology.
- To study the various culture techniques employed for microbes and their control.
- To study the molecular mechanisms of host pathogen interactions.

Learning outcomes

- Ability to identify the major categories of microorganisms and analyse their classification, diversity, and ubiquity.
- Ability to control microbial growth, evaluate the interactions between Microbes, hosts and environment.
- To understand the applications of microscopy in microbiology.

Unit- I (11 Hours)

Introduction to microbiology and microbes, history and scope of microbiology, morphology, structure, growth, and nutrition of bacteria, bacterial growth curve, bacterial culture methods; Antimicrobial resistance. Microbial diversity, microbial taxonomy, criteria for classification of bacteria. Cyanobacteria, acetic acid bacteria, Pseudomonads, lactic and propionic acid bacteria, endospore forming bacteria, Mycobacteria. Archaea: Halophiles, Methanogens, Hyper thermophilic Archaea, Thermoplasm; Eukarya: Algae, fungi, slime molds and protozoa

Unit-II (10 Hours)

Control of microorganisms: Sterilization, disinfection, and antisepsis: Physical and chemical methods for control of microorganisms, antibiotics, antiviral, and antifungal drugs, biological control of microorganisms.

Virology: Virus and bacteriophages, general properties of viruses, viral structure, taxonomy of virus, viral replication, cultivation and identification of viruses; sub-viral particles-Satellite virus, virusoids, viroids and prions.

Unit-III **(12 Hours)**

Host-microbes interaction Host-pathogen interaction; Symbiosis (Nitrogen fixation and ruminant symbiosis); Microbial communication system; Bacterial quorum sensing; Microbial biofilm; Prebiotics and probiotics, microbiome. Environmental microbiology, Ecological impact of microbes; Microbes, and nutrient cycles; Microbial fuel cells.

Unit-IV **(12 Hours)**

Microscopy and Specimen preparation; Lenses and the Bending of Light, Magnification, Resolution, Numerical aperture, Working principle of types of Microscopes: Bright-Field, Dark-Field, Phase-Contrast, Electron Microscope: Transmission Electron Microscope (TEM), Cryogenic electron microscopy.

Suggested Reading:

1.Pelczar, Michael J.EC.S. Chan, Noel R. Krieg, *Microbiology*, New York: Mc Graw-Hill, 1986

References:

1.Matthai, William C, Jacquelyn G. Black, and Christina Y. Berg. *Study Guide [to] Microbiology, Principles and Explorations, Fourth Edition, Jacquelyn G. Black*, New York: J. Wiley, 1999.

2.Willey, Joanne M, Linda Sherwood, Christopher J. Woolverton, Lansing M. Prescott, and Joanne M.Willey. *Prescott's Microbiology*, New York: McGraw Hill,2011.

Course Code: MMB-104 **Core/ Elective:** Elective **No. of Credits:** 3 **Total Hours:** 45	**Course Title** **Biophysics and Structural Biology**

Objective

- To give exposure and orientation of different aspects of biophysics to the students.

Learning Outcome

- The students will acquire the knowledge of the links between physical and biological sciences including Molecular Biology and Biological Physics.

Unit-I **(8 Hours)**

Conformational and Structural aspects of biopolymers: Basic ideas on structure and conformation of simple molecules structural features of proteins, nucleic acids and carbohydrates, aspects of biomolecular forces.

Unit-II **(14 Hours)**

Molecular Spectroscopy: Principles and biological applications of UV-Vis, fluorescence, vibrational and circular dichroism spectroscopy. Mass spectrometry and basics of one-and two-dimensional NMR spectroscopy with applications to peptide and protein structure determination and Ramachandran Plot. Absorption spectroscopy, circular dichroism spectroscopy, IR, Raman, mass spectrometry, isothermal titration calorimetry, ESR.

Unit-III **(12 Hours)**

X-ray Crystallography: Elements of X-ray crystallography. Production and properties of X-rays, diffraction of X-rays by crystals, Laue equations, Bragg's Law, Fourier transformation. Thermodynamics: Basics of thermodynamics, ligand binding and co-operativity in biological systems, kinetics, diffusion and sedimentation**.** Kinetics of conformational transition of proteins.

Unit-IV **(11 Hours)**

Peptide design, synthesis of peptides (solution phase and solid phase), protection and deprotection of amino and carboxyl group, unnatural amino acids, conformation of peptides, purification and crystallization of peptides, determination of structure of small molecules, application of peptides.

Suggested Reading

1. Tinoco, Ignacio, Kenneth Sauer, and James C. Wang. *Physical Chemistry:Principles and Applications in Biological Sciences*, Engle wood Cliffs: Prentice- Hall, 1978.
2. Leach, Andrew R. *Molecular Modelling : Principles and Applications*, Harlow, England: Prentice Hall, 2001.
3. Cavanagh, John,Wayne J. Fairbrother, IIIA. G. Palmer, and Nicholas J. Skelton. *Protein Nmr Spectroscopy: Principles and Practice*, Burlington: Elsevier Science, 1995. Internet resource.

References:

1. Van, Holde K. E, Pui S. Ho, and W C. Johnson. *Principles of Physical Biochemistry*, Upper S addle River, N.J: Pearson Education International, 2006.
2. Cantor, Charles R, and Paul R. Schimmel. *Biophysical Chemistry:1*, New York: W.H.Freeman,1980.
3. Kurt Wüthrich. *NMR of Proteins and NucleicAcids*, 1986.
4. Schulz, GE, and RH. Schirmer. *Principles of Protein Structure*, NewYork: Springer-Verlag, 1979.
5. Upadhyay, Avinash, Kakoli Upadhyay, and Nirmalendu Nath. *Biophysical Chemistry:(Principles and Techniques)*,Himalaya PublishingHouse,2009.

Course Code: MMB-105 **Core/ Elective:** Elective **No. of Credits:** 3 **Total Hours :**45	**Course Title** **Biodiversity and Evolutionary Biology**

Objectives

- The course focuses on modern evolutionary theory in relation to the origins and dynamics of genetic diversity.
- To understand the interactions between the evolutionary forces, mutation, Recombination, selection, migration and genetic drift.

Learning Outcome

- Students will be able to apply evolutionary theory and concepts to address empirical and theoretical questions in evolutionary biology.

Unit-I **(8 Hours)**

Introduction - Definition: Genetic diversity, species diversity, ecosystem diversity, biogeographic regions of India, value of biodiversity: Consumptive, productive use, social, ethical, aesthetic and option values.

Unit-II **(11 Hours)**

Magnitude of biodiversity at global, national and local levels, India as a mega diversity country, hotspots of biodiversity, threats to biodiversity: Habitat loss, poaching, human-wildlife conflicts, RET (Rare, Endangered and Threatened) species of India, strategies for conservation of biodiversity: In-situ and ex-situ conservation and their types.

Unit-III **(12 Hours)**

Introduction-History of Evolutionary Thoughts- Lamarckism and Darwinism; Evidence for Evolution, Phylogeny and the Tree of Life, Species Concepts and Speciation; Mechanisms of Evolution, Origin of Earth and Early Life, The evolutionary time scale; Eras, periods and epoch; Origin of unicellular and multi cellular organisms; Major groups of plants and animals; Stages in primate evolution including Homo.

Unit-IV **(14 Hours)**

Macro evolution and Molecular Evolution; Animal Diversity, Extinctions and Adaptive Radiations; Introduction to ecology; Behavioural ecology, Organismal Ecology: Plants and animal adaptations. Population Ecology: Characterization of populations. Concepts of neutral evolution, molecular divergence and molecular clocks.

Ecology: Population growth and life history traits; Community Ecology: Characterizing communities, Community Ecology: Disturbance and succession; Ecosystem ecology: Energy flow and nutrient cycles; Climate patterns and Biomes, Conservation Biology, Global Climate Change.

Suggested Reading:

1. Harvey, Paul H, and Mark D.Pagel. *The Comparative Method in Evolutionary Biology*, OUP, 1991.
2. Levin, Simon A. *Encyclopedia of Biodiversity,2* Second Edition, Amsterdam: Elsevier, 2013.

Reference:

1. Maynard, Smith J. *Evolutionary Genetics*, Oxford: Oxford University Press,1989.
2. Hall, Brian K, Benedikt Hallgrimsson, and Monroe W. Strick berger. *Strickberger's Evolution: The Integration of Genes, Organisms and Populations*, Sudbury, Mass: Jones and Bartlett, 2008.
3. Maiti, Prabodh K,and Paulami Maiti. *Biodiversity: Perception, Peri*

Course Code: MMB-106 **Core/Elective:** SEC **No. of Credits:** 2 **Total Hours:** 30	**Course Title** **Academic Writing**

Objectives:

- To enable learners to cope with academic tasks to be carried out in English across the curriculum
- To equip learners with the skills of making notes while processing the texts or writing purposes, paraphrasing, and summarizing
- To enable students to understand and produce written texts in English for different functions in academic settings

Learning Outcomes:

- To write coherent paragraphs with both explicit and implicit cohesive Devices
- To make notes while processing the text
- To paraphrase and summarize ideas from other sources to build into their texts

Course Design:

Unit I: **Understanding Scientific Writing** **(10 Hours)**

Types of scientific writing

Reading strategies for dense scientific texts Identifying

arguments, evidence, methods, and results

Effective note-making for literature reviews and research gaps

Unit II: Paraphrasing, Summarizing, and Citation (10 Hours)

Writing literature reviews and discussions

Referencing styles

Drafting introductions and literature reviews

Writing discussions: interpreting findings, acknowledging limitations

Unit III: Writing Research Papers (10 Hours)

Writing effective research abstracts and keywords

Preparing conference papers

Revising, editing, and responding to peer reviews

Ethics in publishing, plagiarism, and authorship guidelin

Course Code: MMB-125 **Core/ Elective:** Core **No. of Credits:** 3 **Total Hours:** 90	**Course Title** **Practicals: Biomolecules Biochemistry, Cell Biology, Microbiology and Microscopy**

1. Introduction to molarity and normality.
2. Preparation of buffers and pH measurement.
3. Chromatography- Paper and thin layer chromatography.
4. Estimation and analysis of nucleic acid and proteins (Agarose and SDS-PAGE analysis).
5. Estimation of sugar by DNS and Anthrone methods.
6. Sterilization techniques, hot air oven, autoclave/pressure cooker, filtration unit.
7. Media preparation; Nutrient broth, nutrient agar.
8. Study of pure culture techniques: Serial dilution, pour plate, spread plate, streak plate, point inoculation.
9. Measurement of growth using- Turbidometer / Photo colorimeter/ spectrometer and Haemo cytometer (Yeast cells).
10. Staining: Simple staining and negative staining, Differential (Gram's staining).
11. Observation of bacterial motility by hanging drop method.
12. Antibiotic sensitivity tests.
13. Microscopic observation of cells undergoing Mitosis & Meiosis.

Suggested Readings:

1. Wilson, Keith, John M. Walker, Andreas Hofmann, and Samuel Clokie. Wilson and Walker's *Principles and Techniques of Biochemistry and Molecular Biology*.2018.

2. Cappuccino, James G. and Natalie Sherman. *Microbiology: ALaboratory Manual*, 2014.
3. Benson, Harold J.Benson's *Microbiological Applications: Laboratory Manualin General Microbiology*, 2015.

References:

1.Segel, Irwin H., *Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry.* New York: Wiley, 1968. Internet resource.

2. Cappuccino, James G. *Microbiology: A Laboratory Manual*, Global Edition. Place of publication not identified: Pearson Education Limited, 2016.

3. Beishir, Lois. *Microbiology In Practice:A Self-Instructional Laboratory* Course , New York , NY : HarperCollins,1991.

SEMESTER-II

Course Code: MMB-201 **Core/Elective:** Core **No. of Credits:** 3 **Total Hours :**45	**Course Title** **Immunology**

Objectives

- To study the basics of defense-system.
- To study the fundamentals of immune responses.
- To study various immunological methods and their applications.

Learning Outcome

- Students are expected to gain an insight into the immune system- how the immune system can differentiate between self and foreign antigens.
- Immune response to infections.

Unit-I (12 Hours)

Fundamental concepts and overview of the immune system: Organs of immune system - Primary and secondary lymphoid organs. Hematopoiesis and the importance of bone marrow and the thymus in the immune system. Components of innate and acquired immunity; Innate immune response, phagocytosis; Pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP); Antigens and antigenicity, antibodies, their structure and function, major histocompatibility complex.

Unit-II (11 Hours)

B and T lymphocytes: Positive and negative selection - The central dogma of immune system, immune responses generated by B and T lymphocytes. Structure of TCR and BCR, RAG genes and generation of TCR and BCR - antibody diversity. Complement system, basics of antigen processing and presentation - importance of MHC. Immunological memory and immunodeficiency.

Unit-III **(12 Hours)**

Antigen-antibody interactions and Vaccinology: Precipitation and agglutination. RIA, ELISA, Western blotting, ELISPOT assay, flow cytometry and immune electron microscopy; bone marrow chimera generation, lympho proliferation assay, mixed lymphocyte reaction. Monoclonal, polyclonal antibody, humanized antibodies and catalytic antibodies.

Vaccinology: Active and passive immunization; Live, killed, attenuated, subunit vaccines; Role and properties of adjuvants, recombinant DNA vaccines, RNA vaccines, conjugate vaccines, viral-like particles (VLPs),

Unit-IV **(10 Hours)**

Hypersensitivity and autoimmunity: Types of hypersensitivity, autoimmunity and autoimmune diseases, peripheral tolerance and T regulatory cells, Transplantation: Immunological basis of graft rejection, auto immune disorder.

Suggested Reading

1. Roitt, Ivan M, Jonathan Brostoff, and David K. Male. *Immunology*, Edinburgh: Mosby, 2001.
2. Kindt, Thomas J, Richard A. Golds by, Barbara A. Osborne, and Janis Kuby. *Kuby Immunology*, New York: W.H. Freeman,2007.
3. Parham, Peter. *The Immune System*, New York: Garland Science,2005.

References:

1. Goding, James W. *Monoclonal Antibodies: Principles and Practice: Production and Application of Monoclonal Antibodies in Cell Biology, Biochemistry and Immunology*, London: Academic Press, 1996.
2. Murphy, Kenneth, Paul Travers, Mark Walport, and Charles Janeway. *Janeway's Immunobiology*, New York: Garl and Science,2012.
3. Owen, Judith A, Jenni Punt, Sharon A. Stranford, Patricia P.Jones and Janis Kuby. *Kuby Immunology*, New York: W.H. Freeman, 2013.

Course Code: MMB-202 **Core/ Elective:** Core **No. of Credits:** 3 **Total Hours :** 45	**Course Title** **Molecular Biology**

Objectives

- To study the central dogma of molecular biology.
- To study the structure and function of DNA and RNA and the mechanism by which genetics information is translated to proteins.

Learning Outcome

- Ability to understand the diverse mechanisms of gene regulation.
- Ability to understand the molecular basis of various biological processes.

Unit-I **(11 Hours)**

Nucleic acid structure and function: DNA super coiling: super helical density, Lk, Wr and Tw, topo isomerases, Genome complexity: DNA re-association kinetics, Cot curve, C-value paradox, repetitive and unique sequences.

DNA to Chromosome: Genomes of bacteria, eukaryotes, organelle and viruses: linear and circular chromosomes, single stranded and doubles stranded DNA / RNA viral genome, Organization of DNA in to chromosomes: DNase I sensitive regions, hetero chromatin and euchromatin, DNA methylation (X chromosome inactivation).

Unit-II **(12 Hours)**

DNA replication: DNA polymerases, synthesis of leading and lagging strands DNA replication in prokaryotes and eukaryotes: Initiation, elongation and termination; Regulation of replication, segregation of chromosomes to daughter cells.

Transcription and RNA processing: Prokaryotic and Eukaryotic transcription; RNA modification: Splicing, alternative splicing, capping, polyA addition, editing, rRNA processing, base modification, tRNA processing and modifications.

Translation: Genetic code, Translation initiation, elongation, termination, ribosome recycling in prokaryotes and eukaryotes, IRES in eukaryotes: Codon, anticodon interaction, ribosome profiling, co-translational protein folding. Non-ribosome protein synthesis.

Unit-III **(12 Hours)**

DNA repair and recombination: Pyrimidine dimer, nick and gap in DNA, AP sites, base mispairing; Mismatch, base excision and nucleotide-excision repair mechanisms, SOS response. Translation DNA synthesis, regulation of Y- family of polymerases in bacteria and eukaryotes, Non-homologous end joining (NHEJ), Homologous recombination, Holliday model, double strand break repair model, gene conversion, mating type switching in yeast, site specific recombination, FLP/FRT and Cre-Lox recombination, transposition - DNA transposons and retroposons mechanism.

Unit-IV **(10 Hours)**

Regulation of gene expression: Promoters and enhancers. Transcriptional regulation in D : Regulation of lac and trp operons in bacteria, regulation by sigma factors, anti-sigma factors, anti-sense RNA, two component regulatory system in bacteria, Concept of eukaryotic gene regulation, RNA in gene regulation: RNA binding proteins, RNA stability, UTR mediated gene regulation, Riboswitch, RNA interference, nonsense and nonstop mediated decay, Post translational gene regulation: Covalent modification of proteins: Phosphorylation, methylation, acetylation, adenylation, arginylation.

Suggested Readings:

1. Krebs, Jocelyn E, Benjamin Lewin, Stephen T. Kilpatrick, and Elliott S. Goldstein. *Lewin's Genes Xi*, Burlington, Mass: Jones & Bartlett Learning, 2014.
2. Cooper, Geoffrey M, and Robert E. Hausman. *The Cell: A Molecular Approach*, Sunderland, MA: Sinauer Associates, 2013.
3. Lodish, Harvey F, Arnold Berk, Chris Kaiser, Monty Krieger, Anthony Bretscher, Hidde L. Ploegh, Angelika Amon, and Kelsey C. Martin. *Molecular Cell Biology*, 2016.

References:

1. Alberts, Bruce, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter. *Molecular Biology of the Cell*, New York: Garl and Science,2002.

2. Maniatis,Tom, Edward F.Fritsch, andJ oseph Sambrook. *Molecular Cloning: A Laboratory Manual*, Cold Spring Harbor: Cold Spring Harbor Laboratory, 1982.

Course Code: MMB-203 **Core/ Elective:** Core **No. of Credits:** 3 **Total Hours :** 45	**Course Title** **Genetic Engineering and Genome Editing**

Objectives

- To study the basics of genetic engineering.
- To study the applications of various plasmids / vectors, blotting, PCR technique in cloning and gene editing.
- To understand the importance and applications of gene therapy and transgenics.

Learning Outcome

- Ability to isolate gene from any organism and amplify using PCR.
- Ability to clone gene in cloning and expression vectors and transform them in suitable host.
- Ability to express the recombinant protein in different host.
- Ability to do gene silencing and editing.

Unit-I **(11 Hours)**

Introduction and tools for genetic engineering, Overall impact of genetic engineering; Tools required for genetic engineering experiments- Host strains; Restriction endonucleases, restriction mapping, restriction-modification methylases; DNA and RNA ligase, DNA ligation using - Cohesive-ended and blunt-ended DNA fragments; Linkers, adaptors; Homo polymeric tailing, nucleic acids modifying enzymes.

Unit-II **(12 Hours)**

Nucleic acid hybridization methods: Radioactive and non-radioactive labelling of nucleic acids and proteins, southern, northern, western, fluorescence in situ hybridization (FISH) and detection of chromosomal abnormalities.

Polymerase chain reaction and its applications. Principles of PCR: Primer design;Types of PCR - Inverse PCR, multiplex, nested; Reverse-transcription PCR, real time PCR, touchdown PCR, hotstart PCR, colony PCR, Site-specific mutagenesis *invitro* and *invivo*; PCR in molecular diagnostics (viral and bacterial detection).

Unit-III **(12 Hours)**

Molecular vectors and expression systems: Plasmids, Bacteriophages, cosmids, YACs, BACs, Ti plasmid and Ri plasmids and viral vectors. Construction of cDNA and genomic DNA libraries; Library screening methods; Transformation, transduction and transfection methods. Expression vectors (pET vectors). Overexpression of recombinant protein in bacteria, baculovirus, yeast and mammalian cells; Purification of recombinant proteins.

Unit-IV **(10 Hours)**

Application of Genetic Engineering: Gene silencing techniques: siRNA and miRNA, construction of shRNA vectors; DNA and protein microarrays. Introduction to genome editing technologies: ZFNs, TALEN,

Origins of CRISPR, CRISPR Knockout basics (Experimental Design, Guide RNA design, Delivery into Cells, Genotyping, Validation), CRISPR Knockin (Inserting or Mutating DNA Sequences in the Genome), CRISPR Editing in Animal Models (Knockout and Knock in Strategies in Mice), CRISPR Interference (dCas9 Fusions Inhibition or Activation), CRISPR to target RNA and Other Cas Proteins, CRISPR-Based Gene Therapy (Gene editing, Clinical Applications). Ethical principles and IPR.

Suggested Readings:

1. Brown, TA. *Genomes 3*, New York: Garl and SciencePub, 2007.
2. Green, Michael R, Joseph Sambrook, and Joseph Sambrook. *Molecular Cloning:A Laboratory Manual*, Cold Spring Harbor, N.Y: Cold Spring Harbor Laboratory Press, 2012.

References:

1. Barrangou, Rodolphe, and John. Oost. *Crispr-cas Systems: Rna-mediated Adaptive Immunity in Bacteria and Archaea*, Berlin: Springer, 2013.
2. Luo, Yonglun.*Crispr Gene Editing: Methods and Protocols*,2019.
3. Primrose, Sandy B, Richard M. Twyman, and R W. Old. *Principles of Gene Manipulation*, Cambridge: Black well Science, 2004.
4. Singh, Vijai, and Pawan K. Dhar. *Genome Engineering Via Crispr-Cas9 System*, 2020.

Course Code: MMB-204 **Core/ Elective:** Elective **No. of Credits:** 3 **Total Hours:** 45	**Course Title** **Signal Transduction and Cancer Biology**

Objectives

- To understand the basics of cell-cell communication in the context of cancer biology.
- To understand the hallmarks of cancer.

Learning Outcome

- Able to understand the mechanism of oncogenesis and gain insights into oncogenes and tumor suppressors.
- How abnormal activation of signalling pathways cause cancer.
- Able to understand the Strategies of anticancer therapy.

Unit-I **(12 Hours)**

Cell signalling: Hormones and their receptors, cell surface receptors. Signal transduction pathways, second messengers, Oncogenic signalling: NF-kB signalling. Ras-MAPK signalling, G-protein mediated signalling, RTK signalling,Ca++signalling,signaling by growth factors and Wnt signalling.

Unit-II **(13 Hours)**

Hallmarks of cancer: Basics of apoptosis and escape from apoptosis in cancer. Uncontrolled proliferation and anchorage independent growth signals. Mechanism of invasion and metastasis. Angiogenesis, inflammation. Tumor metabolism.

Unit-III **(10 Hours)**

Different types of cancers, mitogens, oncogenes and tumor suppressors. Genetic and epigenetic regulation of tumor suppressor and oncogenes in cancer progression.

Unit-IV **(10 Hours)**

Tumor immunology: An overview on tumor micro environment, tumor antigens; immune response to tumors and tumor evasion of the immune system. Cancer immunotherapy. General anticancer therapeutics and future perspectives.

Suggested Reading

1. Alberts, B, D Bray, JL ewis, MRaff, KR oberts, and JD. Watson. *Molecular Biology of the Cell*, NY, Garl and Publishing Inc, n.d., 1994.
2. Klein smith, Lewis J. *Principles of Cancer Biology*, San Francisco: Pearson Benjamin Cummings, 2006.
3. Darnell, James E, Harvey F. Lodish, and David Baltimore. *Molecular CellBiology*, New York: Scientific American Books, 1990.

References:

1. Ettinger, David S, and Ross C. Done hower. *Current Cancer Therapeutics*, Philadelphia, Pa: Current Medicine, 2010.
2. Knowles, Margaret A,and P Selby. *Introduction to the Cellular and Molecular Biology of Cancer*, New York: Oxford University Press, 2005.
3. Mazurek, Sybille, and Maria Shoshan. *Tumor Cell Metabolism:Pathways, Regulation and Biology*, 2015.
4. Rees, Robert C, and Robert C. Rees. *Tumor Immunology and Immunotherapy*, 2014. Internet resource.
5. Weinberg, Robert A. *The Biology of Cancer*, New York,N.Y:Garland Science, 2014.

Course Code: MMB-205 **Core/ Elective:** Elective **No. of Credits:** 3 **Total Hours**: 45	**Course Title** **Biostatistics and Bioinformatics**

Objectives

- The course is aimed at introducing the students to the field of Bioinformatics and biostatistics.

Learning Outcome

- Ability to use computational tools for bioinformatics.
- Ability to investigate specific contemporary biological questions using bioinformatics.
- Ability to critically analyze and interpret the results of their study using Computational and statistical methods.

Unit-I **(13Hours)**

Bio informatics basics Computers in biology and medicine; Data base concepts; Protein and nucleic acid databases; Structural databases; Biological XML DTD's; Pattern matching algorithm basics; Databases and search tools: Biological back ground for sequence analysis; Identification of protein sequence from DNA sequence; Searching of data bases similar sequence; NCBI; Publicly available tools; Resources at EBI; Resources on web; Data base mining tools.

DNA sequence analysis gene bank sequence database; Submitting DNA sequences to data bases and data base searching.

Unit-II **(12 Hours)**

Sequence alignment; Pair wise alignment techniques; Motif discovery and gene prediction. Multiple sequence alignment; Flexible sequence similarity searching with the FASTA3 program package; Use of CLUSTALW and CLUSTALX for multiple sequence alignment; Submitting DNA protein sequence to databases: SEQUIN, genome centres; Submitting aligned sets of sequences, updating submitted sequences, methods of phylogenetic analysis.

Molecular docking: Types and principles, Semi-flexible docking, Flexible docking; Ligand and protein preparation, Macromolecule and ligand optimization, Ligand conformations, Clustering, Analysis of docking results and validation with known information. Extra-precision docking platforms, Use of Small-molecule libraries, Natural compound libraries for virtual high through put screenings.

Unit-III **(10 Hours)**

Statistical concepts: Data structure, sampling methods, descriptive statistics - Data collection, tabulation, graphical representation - Histogram, frequency polygon, frequency curve, bar graphsetc. Measures of central tendency: Mean, median, mean deviation, standard deviation, standard error, coefficient of variation, confidence limits.

Unit-IV **(10 Hours)**

Types of distribution of data: Normal, Binomial, Poisson hypothesis testing:Z-test, t-test, ANOVA, multiple comparisons- LSD and DMRT, chi-square test; Regression and correlation; Non-parametric significance tests; Experimental designs - CRBD, RCBD, LSD, factorial; Data transformation - Arcsine, log, square-root.

Suggested Reading:

1. Aitken, Michael R.F, Bill Broad hurst, and SB. H ladky. *Mathematics for Biological Scientists*, New York, NY: Garland Science, 2010.

2. Lesk, Arthur M. *Introduction to Bioinformatics*, New York: Oxford University Press, 2002.

3. Stroud, K A, and Dexter J. Booth. *Foundation Mathematics*, New York: Palgrave Macmillan, 2009.

References:

1. Baxevanis, Andreas D, and BF.F. Ouellette. *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins*, NewYork: Wiley-Inter science, 2001.

2. Gu, Jenny, and Philip E. Bourne. *Structural Bioinformatics*, Hoboken, N.J: Wiley- Blackwell, 2009.

3. Lesk, Arthur M. *Introduction to Protein Science: Architecture, Function, and Genomics*, Oxford: Oxford University Press, 2010.

4.Mount, David W. *Bioinformatics: Sequence and Genome Analysis*,

Cold Spring Harbor, N.Y:Cold Spring Harbor Laboratory Press, 2006.
5. Pevsner, Jonathan. *Bioinformatics and Functional Genomics*, 2009.

Course Code:MMB 213L **Core/Compulsory:** CCC **No. of Credits:** 4 **Total Hours:** 90 (30 Theory + 60 LAB)	**Course Title** **Introduction to Artificial Intelligence and Machine Learning**

Objectives

- To familiarize students with the fundamental concepts, theories, and applications of artificial intelligence. Students will gain insight into the various subfields of AI, such as machine learning, natural language processing, computer vision, and robotics.
- To introduce students to the basics of Python programming, enabling them to write code, solve problems, and understand programming constructs. This objective emphasizes building a programming foundation as a prerequisite for implementing AI algorithms.

Learning Outcomes

- Students will have a clear understanding of the fundamental concepts and terminology of Artificial Intelligence, enabling them to discuss and comprehend AI-related topics.
- Students will be proficient in writing Python programs, understanding syntax, and applying programming constructs. This skill set will serve as a solid foundation for further programming endeavours.

Unit -1 **(6 Hours)**

Introduction To Artificial Intelligence: Definition – Future of Artificial Intelligence – Characteristic of Intelligent Agents – Typical Intelligent Agents – Problem Solving Approach to Typical AI problems. Problem solving by Searching: Uninformed and informed strategies and implementation; Path planning; Constraint Satisfaction Problems.

Unit-II **(6 Hours)**

Knowledge Representaion: Logical Agents– Propositional and first order Predicate logic-–inference– Knowledge representation and Automated Planning– Uncertain Knowledge and Reasoning: Quantifying uncertainty– probabilistic reasoning;

Unit-III **(6 Hours)**

Machine learning & AI Applications: Machine learning basics - Learning from examples - forms of learning (supervised, unsupervised, reinforcement learning) -simple models (linear & logistic regression) - Deep Learning AI applications: Natural Language Processing - Language Models – Machine Translation; Speech Recognition; Computer Vision - Image classification.

Unit-IV **(6 Hours)**

Python Programming: Introduction-The Python Programming Language, History, features, Installing Python, Running Python program, Debugging: Syntax Errors, Runtime Errors, Semantic Errors – Experimental Debugging, Formal and Natural Languages, The Difference between Brackets, Braces, and Parentheses. Variables and Expressions Values and Types– Variables, Variable & Keywords Type conversion – Operator and Operands– Expressions– Interactive –Mode and script Mode, Order of Operations. Conditional Statements: if, if- else, nested if –else - Looping: for, while, nested-loops. Control statements: Terminating loops, skipping specific conditions.

Unit-V **(6 Hours)**

Functions: Function Calls, Type Conversion Functions, Math Functions, Adding New Functions, Definitions and Uses, Flow of Execution, Parameters and Arguments, Variables and Parameters. Strings: Strings, String Slices, Strings are immutable, and Searching–Looping–and counting String methods – the in operator–String Comparison – String operations Lists: Values and Accessing Elements, Lists are mutable, traversing a List, Deleting elements from List–, Built-in List Operators, Concatenation, In Operator, Built-in List functions and methods.

Suggested Reading

1.S. Russell and P. Norvig "Artificial Intelligence: A Modern Approach, Prentice Hall, 4th Edition 2022.

2.M.TimJones,"ArtificialIntelligence: ASystems Approach(Computer Science)", Jones and Bartlett Publishers, Inc.; 1st Edition,2008.
3.Python GUI programming Cook book-Burkahard A Meier, Packt Publication 2nd Edition.

References

1.Lavika Goel," Artificial Intelligence: Concept and Applications ,Willy 2021
2.NilsJ.Nilsson,"TheQuestforArtificialIntelligence",CambridgeUniversity Press,2009.
3.Barry, P. (2016). Head first Python: A brain-friendly guide. " O'Reilly Media, Inc.". Lutz, M. (2013). Learning python: Powerful object-oriented programming. "O'Reilly Media, Inc.".

Course Code: MMB-225 **Core/Elective:** Core **No. of Credits:** 3 **Total Hours :** 90	**Course Title** **Practicals: Immunology, Molecular Biology, Genetic Engineering and Genome Editing**

1. ELISA and its applications
2. Blood grouping
3. Immuno blotting
4. Separation of mononuclear cells by Ficoll- Hypaque

Gene Cloning methods

5. Genomic DNA isolation, DNA quantification and agarose gel electrophoresis
6. PCR amplification
7. Restriction digestion and gel extraction
8. Ligation
9. Preparation of competent cells
10. Transformation of bacterial cells and IPTG screening
11. Plasmid DNA purification
12. Confirmation of recombinant plasmid by RE digestion and PCR
13. RNA isolation, cDNA synthesis and real time PCR
14. EMSA
15. Genotyping

Suggested Reading

1. Sambrook, Joseph, EF. Fritsch and Tom Maniatis. *Molecular Cloning: A Laboratory Manual*, Cold Spring Harbor: Cold Spring Harbor Laboratory, 1989.

References

1. Green, Michael R, Joseph Sambrook, and Joseph Sambrook. *Molecular Cloning: A Laboratory Manual*, Cold Spring Harbor, N.Y: Cold Spring Harbor Laboratory Press, 2012.

SEMESTER-III

Course Code: MMB-301 **Core/ Elective:** Core **No. of Credits:** 3 **Total Hours:** 45	**Course Title** **Plant Physiology**

Objective

- The aim of the course is to ensure that students understand the physiology of plants.

Learning Outcome

- Ability to identify different physiological processes in plant.
- Ability to understand absorption, transpiration, photosynthesis and growth in plants.

Unit-I **(12 Hours)**

Introduction to physiology and homeostasis: Plant nutrition: Essential nutrients, deficiencies and plant disorders; Heavy metal stress and homeostasis; Mechanism of ion uptake by plants. Transport mechanism in plant: Osmosis, Active transport and Passive transport, Xylem transport, Phloem Transport; Loading and unloading mechanism of food.

Unit-II **(10 Hours)**

Water relations in plants: Polarity; Water potential in plants; Movement of water in plants; Soil-plant-atmosphere continuum. Photo periodism: Photoperiodic response, Physiology of flowering, phytochrome chemistry and mechanism; Senescence and its molecular aspects; Dormancy and Vernalization mechanism. cryptochromes and phototropins; Stomatal movement and biological clocks.

Unit-III **(12 Hours)**

Photosynthesis: Photophos phorylation, Thylakoid membrane in photo phosphorelation, C3cycle, C4cycle, and CAM pathways. Respiration and photo respiration- Citric acid cycle; Plant mitochondrial electron transport and ATP synthesis; Alternate oxidase; Photo respiratory pathway. Nitrogen metabolism - Nitrate and ammonium assimilation; Amino acid biosynthesis.

Unit-IV **(11 Hours)**

Plant hormones - Biosynthesis, storage, breakdown and transport; Physiological effects and mechanisms of action. Plant growth regulators: Auxins, gibberellins, cytokinins, ethylene, abscisic acid, salicylic acid, Jasmonic acid, mode of senescence. Rhizosphere physiology: Root respiration, Secondary metabolites - Biosynthesis of terpenes, phenols and nitrogenous compounds and their roles. Stress physiology - Responses of plants to biotic (pathogen and insects) and abiotic (water, temperature and salt) stresses.

Suggested Reading

1.Taiz L. and Zeiger E., *Plant Physiology*, 5th edition, Sinauer Associates, USA, 2012.

References:

1.Lambers H, F.S. Chapin, and Thijs L .Pons. *Plant Physiological Ecology*, New York: Springer, 1998.

2.Malik C.P. and A.K. Srivastava. *Textbook of Plant Physiology*, Ludhiana: Kalyani Publishers, 2005.

Course Code: MMB-302 **Core /Elective:** Core **No. of Credits:** 3 **Total Hours :** 45	**Course Title** **Animal Physiology**

Objective

- The major aims of this course are to provide students with a basic understanding of animal physiology.

Learning Outcome

- Ability to identify different physiological process in animals.
- Ability to understand the mechanism of digestive, circulatory, respiratory and nervous system in animals.
- Ability to understand the diseases related to physiological systems

Unit-I **(11 Hours)**

Introduction to Physiology: An overview of animal anatomy and body plan; Homeostasis,Organs and Organ systems. Circulatory system: Closed and Open circulatory system, Structure and function of heart in higher vertebrates (mammals); Blood as connective tissue- Components of blood; Blood groups; Blood clotting; Lymph and lymph nodes.

Unit-II **(10 Hours)**

Respiratory system: Anatomy of lungs in mammals; Mechanism and regulation of breathing; Hemoglobin and Oxyhemoglobin dissociation curve, oxygenand carbon dioxide transport; Acid-Base balance of the blood. Digestive system: Anatomy of alimentary canal in mammals. Role of liver and pancreas in digestion. Mechanism of digestion and absorption in mammals.

Unit-III **(11 Hours)**

Muscular system: Structure and type of muscles; neuromuscular junction, muscle contraction; Energy requirements of skeletal muscles and metabolism. Nervous system: Types of neurons and supporting cells. Nerve impulse and mechanism of impulse conduction, Neurotransmitters, Synaptic Integration, Synaptic Plasticity and inhibition.

Unit-IV **(13 Hours)**

Excretory system: Structure and function of mammalian kidney, Nephron as a functional unit of kidney, Process of filtration and urine formation: Renal control of electrolyte and acid-base balance. Reproductive and Endocrine system: Female reproduction system - reproductive cycle, Structure of Ovary. Male reproductive system: Structure of testis, mechanism of spermatogenesis, structure of sperm. Endocrine organs and hormones invertebrates (mammals); Mechanism of hormone action and signal transduction; Thyroid and pancreatic metabolic disorders.

Suggested Reading:

1. Barrett, Kim E, and William F. Ganong. *Ganong's Review of Medical Physiology*, New York: Mc Graw-Hill Medical, 2010.
2. Hall, John E, and Arthur C. Guyton. *Guyton and Hall Text Book of Medical Physiology*, 2011.

References:

1. Hill, Richard W, Daniel Cavanaugh, and Margaret Anderson. *Animal Physiology*, 2022.

Course Code: MMB-303 **Core / Elective:** Core **No. of Credits:** 3 **Total Hours** : 45	**Course Title** **Genomics and Proteomics**

Objectives

- To study the importance of omics in biology.
- To study the various techniques in genomics and proteomics.

Learning Outcome

- Understand the genome organization, mapping and various gene sequencing techniques.
- Understand the techniques in proteomics.

Unit-I **(12 Hours)**

Genome: Genome mapping: Genetic and physical maps; markers for genetic mapping; methods and techniques used for gene mapping, physical mapping, linkage analysis, cytogenetic techniques, somatic cell hybridization, comparative gene mapping. Genome sequencing strategies, Next generation sequencing, Human Genome Project, genome sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from the web.

Unit-II **(12 Hours)**

Comparative genomics: Identification and classification of organisms using molecular markers- 16S rRNA typing / sequencing, SNPs; use of genomes to understand evolution of eukaryotes, track emerging diseases; determining gene location in genome sequence. Functional genomics; Transcriptome analysis and identification and functional annotation of gene, microarrays, RNA-Seq, Rapid amplification of cDNA ends (RACE), Yeast two-hybrid systems, phage display gene function-forward and reverse genetics,

Unit-III **(10 Hours)**

Introduction to proteomics: Proteome and nature of proteome, separation of proteins/peptides by HPLC forward and reverse, single and two- dimensional gel electrophoresis and detection - staining and immune blot. Expression proteomics -*In vitro* protein synthesis and *in vivo* protein expression and purification from bacteria, yeast, insect and human cells.

Unit-IV **(11 Hours)**

Structural and functional proteomics: Mass sectrometry- fundamentals, mass spectrometry ionization techniques, mass analyzers - MALDI-TOF, Mass spectra analysis - search engines: Mascot, Swiss-Prot, protein prospector, determination of peptide sequence, determination of post-translational modifications, peptide sequencing using and emmass spectrometry, functional annotation of proteins, protein chips and functional proteomics;

Suggested Reading:

1. Brown, TA, and TA. Brown. *Genomes 4*, 2018.
   Lesk, Arthur M. *Introduction to Protein Science: Architecture, Function, and Genomics*, 2016.
2. Hamdan, Mahmoud H. "Proteomics Today: Protein Assessment and Biomarkers Using Mass Spectrometry, 2d Electrophoresis, and Microarray Technol", 2005.

References:

1. Comai, Lucio, Jonathan E. Katz, and Parag Mallick. *Proteomics: Methods and Protocols*, 2017.
2. Posch, Anton. *Proteomic Profiling: Methods and Protocols*, 2015.
3. Tibayrenc, Michel. *Genetics and Evolution of Infectious Diseases*. Amsterdam: Elsevier, 2011.
4. Twyman, Richard M. *Principles of Proteomics*, New York: BIOS Scientific Publishers, 2004.
5. Wang, Xinkun. *Next-generation Sequencing Data Analysis*, 2016.

Course Code: MMB-304 **Core/ Elective:** Elective **No. of Credits:** 3 **Total Hours :** 45	**Course Title** **Developmental Biology**

Objective

- To understand the mechanisms of cell development, and mechanisms that ensure consistency and reliability of development.

Learning Outcome

- The students will be able to understand the basic concepts of development and the role of genes in sex determination.
- Understand the concept of abnormal differentiation.
- Apply the knowledge of developmental biology in Assisted Reproductive Technologies (ART).

Unit-I **(10 Hours)**

Phases of development Developmental patterns among Metazoans –Gameto genesis: Structure of Mammalian gametes. Fertilization: Biochemical events, Cleavage (Patterns & types), Gastrulation: Germ layer formation. Organo genesis. Growth and differentiation. Genetic regulations of early embryonic development- Gradient theory- Morpho genetic gradients- cellfate and cell lineage.

Unit-II **(10 Hours)**

Embryonic induction and organizers - Spemann and Mangold experiments. Molecular biology of the Nieuwkoop center- Functions of organizer-Induction Regional specification types - Nuclear transplantation - Growth and Post embryonic development - Sex determination - Genomic equivalence and cytoplasmic determinants - Imprinting- Cell aggregation and differentiation in Dictyostelium. Axis and pattern formation in Drosophila

Unit-III **(10 Hours)**

Metamorphosis and regeneration Influence of hormones on growth and meta morphosis of Insects and Amphibians-Formation of limb budin Amphibia – Specification of limb fields- Induction of early limb bud- Eyelens induction- Cell death and the formation of digits and joints. Regenerative ability of various Inverte brates and Verte brates – Mechanism of regeneration- Blastema formation- Wolffian regeneration- Factors affecting regeneration.

Unit-IV **(15 Hours)**

Differentiation and aging Teratogenesis: Teratogenic agents. Embryonic induction and differentiation. Embryonic induction in vertebrates: Types - exogenous and endogenous. Theories of organizer or inductor. Morphology – Chemical basis of neural induction. Differentiation- Characteristics and types of differentiation. Aging and Senescence- Apoptosis. Selective action of genes in differentiation. Advanced Techniques In Developmental Biology:
Assisted Reproductive Technology (ART), Super ovulation, ICSI, GIFT- Artificial insemination, *Invitro* fertilization.

Suggested Reading

1.Berrill, N.J. *Developmental Biology*, New Delhi: Tata McGraw-Hill, 1979. Browder, Leon W. *Developmental Biology*, Philadelphia: Saunders College, 1980.

2.Balinsky, Boris I, and B.C Fabian. *An Introduction to Embryology*, Philadelphia: Saunders College Publishing, 1981.

3.Strick berger, Monroe W, Monroe W. Strick berger, Benedikt Hallgrimsson, and BrianK. Hall. *Strickberger's Evolution: The Integration of Genes, Organisms and Populations*, Sudbury, Mass. [etc.: Jones and Bartlett Publishers, 2008.

References

1. Di, Castri F, and TY ounes. *Biodiversity, Science and Development: to wardsa New Partnership*, Wallingford, Oxon, UK: CAB International in association with the International Union of Biological Sciences, 1996.

2.Gilbert, Scott F, and Michael J.F. Barresi. *Developmental Biology*, 2020.

3.Kaur, H. *Environmental Chemistry*, Meerut: Pragati Prakashan 2010

4. Oppenheimer, Steven B, and George Lefevre. Introduction to Embryonic Development, Englewood, Cliffs, NJ: Prentice Hall, 1989.

Course Code: MMB-305 **Core/ Elective:** Elective **No. of Credits:** 3 **Total Hours :**45	Course Title **Metabolomics and Metabolic Engineering**

Objectives

- Understand the uses and limitations of metabolomics.
- Gain the core knowledge about the metabolic networking in living system.

Learning Outcome

- To analyze the in born errors of metabolism.
- The metabolic engineering will lead to commercial exploitation.

Unit-I **(12 Hours)**

Introduction to metabolomics - Metabolites, and metabolism - Types of metabolism - Primary and secondary, Structural diversity of metabolites - Physical and chemical properties, metabolites in the biological system, metabolons. Metabolites isolation from the biological system - Separation methods for metabolomics - Gas chromatography (GC), HPLC, Capillary electrophoresis (CE); Detection methods-GC-MS, Secondary ion mass spectrometry (SIMS), NMR-1Dand2D.

Unit-II **(12 Hours)**

Metabolomic Data Analysis & Integration, Peak detection, retention time alignment; Identification of molecular features and metabolites; Structural confirmation of metabolites. Software- Multiquant, MZ mine, XCMS, Marker View, Lipid Search. Metabolic pathways and inborn errors of metabolism; Metabolomics in drug discovery, Metabolic profiling, Metabolic finger printing, Metabolic foot-printing.

Unit-III **(11 Hours)**

Introduction to Metabolic Engineering, basic concepts; Scopes and Applications; Metabolism (Cellular Transport processes, Fuelling Reactions)

Cellular Metabolism (Biosynthetic reactions, Polymerization, Growth Energetics); Regulation of Metabolic Pathways, Reconstruction of Genome-scale metabolic network. Examples of pathway manipulations by metabolic engineering: Ethanol, Amino acids, antibiotics, vitamins, biopolymers, etc., Improvements of cellular properties, Biodegradation.

Unit-IV **(10 Hours)**

Metabolic Flux Analysis: Flux Balance Analysis (FBA), Flux Variability Analysis, Flux Map, Determination of Metabolic Fluxes: Isotope labelled substrate, Isotope mapping, Mapping Matrix, Isotope Distribution Vector, Application of metabolic flux analysis.

Suggested Reading

1.Nelson, David L**,** Michael M.Cox, and Albert L. Lehninger. *Lehninger Principles of Biochemistry*,2017.

2.Devlin,ThomasM**.** *Textbook of Biochemistry: With Clinical Correlations*, Hoboken, N.J: Wiley,- Liss,2006.

3.Jeevan,KP**.** *Metabolomics- Fundamentals and Applications*, 2016.

4.Nielsen, Jens H. *Biotechnology for the Future*, Berlin: Springer, 2011.

References

1. Stephanopoulos, G, Aristos A. Aristidou, and Jens H. Nielsen. *Metabolic Engineering: Principles and Methodologies*, San Diego: Academic Press, 1998.

2.Sussulini, Alessandra. *Metabolomics: from Fundamentals to Clinical Applications*, 2017.

3.Voet, Donald, and Judith G.Voet. *Biochemistry*, Hoboken, NJ: John Wiley and Sons, 2011.

Course Code: MMB-313 **Core/ Compulsory:** CCC **No. of Credits:** 4 **Total Hours:** 60 **(45 Hours Lecture +15 Hours Tutorial)**	**Course Title** **Building Mathematical Ability and Financial Literacy**

Objectives

- Master foundational mathematical concepts including set theory, permutations, combinations, and logical reasoning.
- Gain comprehensive knowledge of various financial instruments such as stocks, shares, loans, insurance, and income tax liabilities.

Learning Outcomes

- Develop problem-solving skills using mathematical concepts and logical reasoning.
- Acquire proficiency in financial calculations and understanding financial aspects like profit, loss, interest rates, and costs

Unit-I (15 Hours)

Mathematics: Basic set theory- Permutations and combinations - Mathematical logic: Introduction - proposition and truth values - logical connectives, tautology and contradiction - logical equivalences - converse, inverse and Contrapositive of a conditional statement.

Unit-II (13 Hours)

Commercial Mathematics: Cost price - selling price - profit and loss - simple interest – compound interest (reducing balance and flat rate of interest) - stocks and shares. Housing loan - insurance- simple equated monthly installments (EMI) calculation – Income tax: simple calculation of individual tax liability.

Unit-III (15 Hours)

Statistics: Sources of data: primary and secondary - types of data, graphical representation of data - Population, sample, variable - parameter. Statistic, simple random sampling - use of random number tables - Measures of central tendency: arithmetic mean, median and mode; measures of dispersion: range - variance - standard deviation and coefficient of variation –Bivariate data: scatter plot, Pearson's correlation coefficient, simple line regression.

Unit-IV **(17 Hours)**

Financial literacy: Definition and Function of Money: Money and its functions The concepts and definitions of money-Measurement of money - Advantages of money Scheduled and Non-scheduled Banks- Commercial Banks, its functions and credit creation High powered Money-usage of debit and credit cards-Functions of a central bank Quantitative and qualitative methods of credit control-Bank rate policy – Cash reserve ratio Open market operations – Statutory liquidity ratio- Reporate- Reverse Reporate-Selective credit control-,role and functions of Reserve Bank of India - Objectives and limitations of monetary policy With special reference to India.

Suggested Reading

1.Medhi,J. *Statistical Methods (An Introductory text); Wiley Eastern Ltd.*(latest edition).

2.Building Mathematical Ability, Foundation Course, University of Delhi, S.Chand Publications.

3.Lewis,M.K.and Monetary Economics. Oxford University press, New york,2000

References:

1. Rangarajan,C. Indian Economy: Essays in Money and Finance,1999.

2. Brahmaiah,B. P.Subbarao, Financial Futures and Options, Himalaya Publishing House,Mumbai,1998.

Course Code: MMB -325 Core / Elective : Core No. of Credits : 3 Total Hours :90	**Course Title** **Practicals : Plant Physiology,Animal Physiology, Genomics and Proteomics**

1. To demonstrate the influence of light on growth and measurement of photosynthetic pigments.
2. To study the effects of nutrient deficiency on plant growth and development and estimate total anthocyanins content in leaves.
3. Estimation of alkaline phosphatase activity in roots
4. Effect of temperature on cell membrane permeability
5. Demonstration of opening and closing of stomata and stomatal index
6. Determination of Water potential in potato
7. Quantification of SOD and Catalase antioxidative enzymes in abiotic stress leaf material
8. Electrolyte leakage from the abiotic stress plant leaf material
9. Estimation of salivary amylase activity.
10. Estimation of lipase activity.
11. Experiments on urine analysis in human urine sample-Test for urea, blood cells, bile salts, albumin, and ketone bodies in human urine sample.
12. Determination of cell fragility by osmotic hemolysis experiment.
13. Sugar analysis from human urine sample
14. Applications of BLAST, FASTA, CLUSTALW, GENSCAN, RASMOL, and phylogenetic analysis
15. Biological Data Base assessment tools
16. Analysis of biological information by any bioinformatics tool
17. Chromosome banding, karyotyping and making ideogram of the banded chromosomes
18. Cell counting using hemocytometer

Suggested Reading

1. Malik C.P. and AK. Srivastava. *Textbook of Plant Physiology*, Ludhiana: Kalyani Publishers, 2005.
2. Comai, Lucio, Jonathan E. Katz, and Parag Mallick. *Proteomics: Methods and Protocols*, 2017.
3. Kuruwanshi,V.B. Guhey, A.Practical manual on principles of plant physiology (pp501).2016

References

1. Hall, John E, and Arthur C. Guyton. *Guyton and Hall Textbook of Medical Physiology*, 2011.

SEMESTER-IV

Course Code: MMB-401 Core / Elective: Core No. of Credits:4 Total Hours: 60	Course Title: **Research Techniques in Molecular Biology**

Objectives

- Understand the major techniques which is useful in research
- To perform the research, these techniques are helpful to students and they understand the trouble shoots.
- Students learn how to write the dissertation and research articles.

Learning Outcome

- To perform the modern techniques in research to get good results.
- Students can be perform good research and can be able to write research article to communicate in research journals.

Unit-I **(15 Hours)**

Molecular Biology Techniques-Strain improvement and product enhancement strategies: Selection and screening of specific trait gene from the NCBI for development of research plan, Design and development of primers, Amplification of desired gene from the different sources (Plant, Bacteria and animals' cells) and them importance's. Selection of Restriction enzymes to prepare the gene cassette for cloning (Trouble shoots and precautions). Development of transgenic plants and animals, characterization of transgenic plants and animals by Molecular and Biochemical assays

Unit-II **(15Hours)**

Introduction of cloning and its scope, Protein expression and protein expression vectors, expression of protein in BL-21 cells, Principle and applications of MALDI-TOF, HPLC and its applications in industries, Fermentation technology: Types of different fomenters, Principle and applications of fermentation technology, Safety and Precautions to be taken in fermentation technology.

Unit-III **(15 Hours)**

Plant tissue culture: Basic principles of Plant tissue culture, Preparation of MS media and their composition, Production of medicinal and ornamental plants by Micro propagation techniques.

Animal tissue culture: cell line culture techniques, Different pHs required for animal cell culture and their safety and precautions. Types of cultures and application of animal cell culture in industry.

Unit-IV **(15 Hours)**

Preparation and development of research articles: Methods for the collection of research articles, How to write the dissertation: How to develop the objectives, review of articles, selection of best method to execute the experiment. How to interpretation the research data by using statistical tools (Mean, ANOVA, t- test, Standard deviation, S. Error, Corelation and Regression) and their importance's in research. Collection and arrangement of references, Selection of appropriate journals based on their impact factor, SCI- indexing, Scopus, WoS, Pubmed of indexing, and H-index), How to upload the research articles in the research journals.

Suggested Reading

1. Upadhyay, Avinash, Kakoli Upadhyay, and Nirmalendu Nath. *Biophysical Chemistry: (Principles and Techniques)*, Himalaya PublishingHouse,2009.
2. Martin Clynes. Animal cell culture Techniques.Springer Lab Manual,1998.
3. Sambrook, Joseph, EF. Fritsch, and Tom Maniatis. *Molecular Cloning: A Laboratory Manual*, Cold Spring Harbor: Cold Spring Harbor Laboratory, 1989.
4. Sunghun Park. Plant tissue culture techniques and experiments.Fourth edition. Elsevier Science.
5. Kothari, C.R. Research Methadology, methods and techniques. New Age Publishers.

References:

1.Comai, Lucio, Jonathan E. Katz, and Parag Mallick. Proteomics: Methods and Protocols, 2017.

2.Ritu Khasa and Sushil Kumar. Techniques in plant tissue culture. Akinik Publications, 2022.

3.Mark Stephan Felix and Ian Smith, A Practical Guide to Dissertation and Thesis Writing. Cambridge Scholars Publications, 2019. ISBN (10): 1-5275-3681-5.

Course Code: MMB-402 **Core/ Elective**: Core **No. of Credits**: 16 **Total Hours**: 480	**Course Title:** **Project Work /Dissertation**

Each student will work on a project towards a dissertation by applying the knowledge acquired in molecular biology and biochemistry. The project maybe selected based on a literature survey and available resources as suggested by the respective supervisors.

The students may conduct the project work either at the CUAP or laboratory of their choice in India or abroad upon obtaining approvals from the competent authority. Student is required to submit a detailed project report on the selected topic for their project as per the guidelines decided by the department.

The project work is to be evaluated through presentation and viva-voce during the semester and the final evaluation will be done at the end of the semester as per the guidelines decided by the department from time to time.

Candidate may visit research labs/institutions with the due permission of the head on the recommendation of the supervisor concerned.