CENTRAL UNIVERSITY OF ANDHRA PRADESH

Anantapuramu - 515002, Andhra Pradesh

Learning Outcome-based Curriculum Framework (LOCF) for Post Graduate Programme

Vidya Dadati Vinayam

(Education Gives Humility)

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

(With effect from 2022-2023 Batch)

CONTENTS

CENTRAL UNIVERSITY OF ANDHRA PRADESH

M.Sc. Molecular Biology

Important Information to Students

I. Programme: M.Sc. Molecular Biology

II. Eligibility: Candidate with the degree of Bachelor of Science in any branch of Life Sciences (Zoology, Botany, Microbiology, Biotechnology, Bioinformatics, 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 lab 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 mark for a course is 40%.

VI. A student should pass separately in both CIA and the ESE, i.e., students should secure 16 (40% of 40) out of 40 marks for theory and 24 (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. S/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 practicals/ thesis/dissertation/ internship, etc.

X. An on-campus elective course is offered only if a minimum of ten or 40% of the students registered, whichever is higher, exercise their option for that course.

CENTRAL UNIVERSITY OF ANDHRA PRADESH

M.Sc. Molecular Biology

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 year. 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:

Upon 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 carry out 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 himself/ herself 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 analysing the obtained results.
- Analyse 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, GATE etc.

CENTRAL UNIVERSITY OF ANDHRA PRADESH
M.Sc. Molecular Biology

Semester and Course-wise Credits

Semester	*Discipline Specific Core (DSC) (L+T+P)	*Discipline Specific Elective (DSE) / Elective (EL)	Skills Enhancement Courses (SEC)		Internship	Project Work/ Dissertation	Lab	Total Credits
			Skill Based	Value-Added /Add-on Courses				
I	DSC 1(3) DSC 2(3) DSC 3(3)	DSE-1(3) EL by MOOCs (3)		Add On (2)	-	-	DSC 1 (1) DSC 2 (1) DSC 3 (1)	20
II	DSC 4(3) DSC 5(3) DSC 6(3)	DSE-2(3) EL by MOOCs (3)	SEC-1 Academic Writing (2)	Add On (2)	Internship (2)	-	DSC 4 (1) DSC 5 (1) DSC 6 (1)	24
III	DSC 7(3) DSC 8(3) DSC 9(3)	DSE-3(3) EL by MOOCs (3)	SEC-2 e-Resources (2)	Add On (2)	-	-	DSC 7 (1) DSC 8 (1) DSC 9 (1)	22
IV	-	-	-	-	-	DSC 10 (20) Project Work /Dissertation	-	20
Total	**27**	**18**	**4**	**6**	**2**	**20**	**09**	**86**
Percentage	31%	20%	4%	6%	2%	23%	10%	-

* The courses of DSE & DSC may teach in blended (offline/online) mode.

CENTRAL UNIVERSITY OF ANDHRA PRADESH

M.Sc. Molecular Biology

Programme Structure

Semester-I

S. No	Course Code	Title of the Course	Credits	Contact Hours		
				L	T/L	P/S
1.	MMB-101	Biomolecules and Biochemistry	3	40	-	05
2.	MMB-102	Cell Biology	3	40	-	05
3.	MMB-103	Microbiology and Microscopy	3	40	-	05
4.	MMB-104	MOOCs/Online/Elective	3	-	-	-
5.	MMB-111	Add-on Course	2	25	-	05
6.	Any one of the following electives		3	40	-	05
	MMB-115	Biophysics and Structural Biology				
	MMB-116	Biodiversity and Evolutionary Biology				
7.	Practicals					
	MMB-125	Lab-I (Based on MMB-101, 102, 103)	3	-	60	-
Total			20	185	60	25

Semester – II

S. No	Course Code	Title of the Course	Credits	Contact Hours		
				L	T/L	P/S
1	MMB-201	Immunology	3	40	-	05
2.	MMB-202	Molecular biology	3	40	-	05
3.	MMB-203	Genetic Engineering and Genome Editing	3	40	-	05
4.	MMB-204	MOOCs/Online/Elective	3	-	-	-
5.	MMB-205	SEC: Academic Writing	2	25	-	05
6.	MMB-211	Add on Course	2	25	-	05
7.	MMB-213	Internship*	2	20	-	05
	Any one of the following electives					
8.	MMB-215	Signal transduction and cancer biology	3	40	-	05
	MMB-216	Biostatistics and Bioinformatics				
9.	Practicals					
	MMB-225	Lab-II (Based on MMB-201, 202, 203)	3	-	60	-
Total			24	230	60	35

Semester – III

S. No	Course Code	Title of the Course	Credits	Contact Hours		
				L	T/L	P/S
1.	MMB-301	Plant physiology	3	40	-	05
2.	MMB-302	Animal physiology	3	40	-	05
3.	MMB-303	Genomics and Proteomics	3	40	-	05
4.	MMB-304	MOOCs/Online/Elective	3	-	-	-
5.	MMB-305	SEC: e-Resources	2	25	-	05
6.	MMB-311	Add-on Course	2	25	-	05
	Any one of the following electives					
7.	MMB-315	Developmental Biology	3	40	-	05
	MMB-316	Metabolomics and Metabolic Engineering				
8.	Practicals					
	MMB-325	Lab-III (Based on MMB-301, 302, 303)	3	-	60	-
Total			22	210	60	30

Semester – IV

S. No	Course Code	Title of the Course	Credits	Contact Hours		
				L	T/L	P/S
1.	MMB-401	Project Work /Dissertation	20	0	400	0
Total			20	0	400	0
Programme Total			**86**	**725**	**580**	**90**

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

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

Note 1: 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 (44 credits).

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	24	44
Semester-III	22	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 = 30marks) -- and seminar/ assignments/ attendance (10 marks)] and 60% (summative evaluation -- end of semester examination).

End Semester Examination

Maximum Marks: 60 Time: 3 Hours

SEMESTER-WISE DETAILED SYLLABUS

SEMESTER-I

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

Objectives

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

Course Outcome

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

Unit I: Carbohydrates and Lipids

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

Unit II: Proteins, Enzymes and Nucleic acids:

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 Chymotrypsin. 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: Bioenergetics

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, phosphoenol 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.

Integration of metabolic pathways to bioenergetics- Glycolysis, TCA cycle, Glycogen metabolism, Pentose phosphate pathway, Gluconeogenesis, Amino acid metabolism, fatty acid metabolism, Nucleic acid metabolism.

Unit IV: Biochemical Techniques

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, fluorimetry, turbidometry and flame spectrophotometry. Principle and applications of CD, IR, NMR, ESR in the study of macromolecular structures. Mass Spectrometry– Electron Spray Ionization (ESI), Matrix Assisted Laser Desorption Ionization (MALDI).

References:

Berg, Jeremy M, John L. Tymoczko, Lubert Stryer, and Lubert Stryer. *Biochemistry*. New York: W.H. Freeman, 2007.

Elliott, William H, and Daphne C. Elliot. *Biochemistry and Molecular Biology*. Oxford: Oxford University Press, 2009.

Glaser, Roland. *Biophysics: An Introduction*., 2012. Internet resource.

Lindon, John C, George E. Tranter, and John L. Holmes. *Encyclopedia of Spectroscopy and Spectrometry: [volume 2]*. San Diego, CA: Academic Press, 2000.

Mainwaring, W I. P. *Nucleic Acid Biochemistry and Molecular Biology*. Oxford: Blackwell Scientific Publications, 1982.

Miller, James M. *Chromatography: Concepts and Contrasts. 2nd Ed (9780470530252)*. Wiley, 2009.

Moran, Laurence A, Robert A. Horton, Gray Scrimgeour, Marc Perry, and David Rawn. *Principles of Biochemistry*. Harlow: Pearson Education UK, 2013. Internet resource.

Moran, Laurence A, Robert A. Horton, Gray Scrimgeour, Marc Perry, and David Rawn. *Principles of Biochemistry*. Harlow: Pearson Education UK, 2013. Internet resource.

Nelson, David L, Michael M. Cox, Aaron A. Hoskins, and Albert L. Lehninger. *Lehninger Principles of Biochemistry*. , 2021.

Voet, Donald, and Judith G. Voet. *Biochemistry*. Singapore: J. Wiley & Sons, 2021. Print.

Wilson, Keith. *Principles and Techniques of Biochemistry and Molecular Biology*. Cambridge: Cambridge Univ. Press, 2911.

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**	Course Title **Cell Biology**

Objective:

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

Course outcome

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

Unit I:

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:

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:

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 and animals and microorganisms.

Unit IV:

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 misregulation and cancer: Cancer. Types and stages. Tumor suppressor genes and protooncogenes. Molecular basis of cancer, cell senescence

References:

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

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

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

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**	Course Title **Microbiology and Microscopy**

Objective:

- 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.

Course outcome

- 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:

Introduction to microbiology and microbes, history & 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 and Mycoplasma. Archaea: Halophiles, Methanogens, Hyperthermophilicarchae, Thermoplasm; eukarya: algae, fungi, slime molds and protozoa; extremophiles and unculturable microbes.

Unit II:

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:

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:

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, Fluorescence and Confocal Microscope, Electron Microscope: Transmission Electron Microscope (TEM), Scanning Electron Microscope (SEM), Cryogenic electron microscopy.

References:

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.

Pelczar, Michael J. R. D. R. E. C. S. C, Michael J. Pelczar, and E C. S. Chan. *Microbiology*. New York: McGraw-Hill, 2001

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-115** Core/Elective : **Elective** No. of Credits : **3**	Course Title **Biophysics and Structural Biology**

Objective:

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

Course outcome:

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

Unit 1:
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:
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:
X-ray Crystallography: Elements of X-ray crystallography. Production and properties of X-rays, diffraction of X-rays by crystals, Laue equations, Bragg'sLaw, 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:
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 (briefly), application of peptides.

References:

Van, Holde K. E, Pui S. Ho, and W C. Johnson. *Principles of Physical Biochemistry*. Upper Saddle River, N.J: Pearson Education International, 2006.

Cantor, Charles R, and Paul R. Schimmel. *Biophysical Chemistry: 1*. New York: W. H. Freeman, 1980.

Tinoco, Ignacio, Kenneth Sauer, and James C. Wang. *Physical Chemistry: Principles and Applications in Biological Sciences*. Englewood Cliffs: Prentice-Hall, 1978.

Cavanagh, John, Wayne J. Fairbrother, III A. G. Palmer, and Nicholas J. Skelton. *Protein Nmr Spectroscopy: Principles and Practice*. Burlington: Elsevier Science, 1995. Internet resource.

Kurt Wüthrich. NMR of Proteins and Nucleic Acids. , 1986.

Leach, Andrew R. *Molecular Modelling: Principles and Applications*. Harlow, England: Prentice Hall, 2001.

Schulz, G E, and R H. Schirmer. *Principles of Protein Structure*. New York: Springer-Verlag, 1979.

Cantor, Charles R, and Paul R. Schimmel. *Biophysical Chemistry*. San Francisco: W.H. Freeman, 1980.

Upadhyay, Avinash, Kakoli Upadhyay, and Nirmalendu Nath. *Biophysical Chemistry: (principles and Techniques)*. Himalaya Publishing House, 2009.

Course Code : **MMB-116** Core/Elective : **Elective** No. of Credits : **3**	Course Title **Biodiversity and Evolutionary Biology**

Objective:

- 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.

Course outcome:

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

Unit I:

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:

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:

Introduction; History of Evolutionary Thoughts- Lamarckism and Darwinism; Evidence for Evolution, Phylogeny & 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:

Macroevolution and Molecular Evolution; Animal Diversity, Extinctions and Adaptive Radiations; Introduction to ecology; Behavioural ecology, Organismal Ecology: Plants & 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.

Reference:

Maynard, Smith J. *Evolutionary Genetics*. Oxford: Oxford University Press, 1989.

Harvey, Paul H, and Mark D. Pagel. *The Comparative Method in Evolutionary Biology*. OUP, 1991.

Hall, Brian K, Benedikt Hallgri msson, and Monroe W. Strickberger. *Strickberger's Evolution: The Integration of Genes, Organisms and Populations*. Sudbury, Mass: Jones and Bartlett, 2008.

Maiti, Prabodh K, and Paulami Maiti. *Biodiversity: Perception, Peril and Preservation*. , 2017. Print.

Levin, Simon A. *Encyclopedia of Biodiversity: 2*. Amsterdam: Elsevier, 2013. Print.

Course Code : **MMB-125** Core/Elective : **Core** No. of Credits : **3**	Course Titles **Practicals: Biochemistry, Cell Biology, and Microbiology**

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. Hypo and hyper-chromicity of nucleic acid on heat denaturation.
7. Sterilization techniques, hot air oven, autoclave/pressure cooker, filtration unit.
8. Media preparation; nutrient broth, nutrient agar.
9. Study of pure culture techniques: Serial dilution, pour plate, spread plate, streak plate, point inoculation.
10. Measurement of growth using -Turbidometer/ photocolorimeter/ spectrometer and Haemocytometer (Yeast cells)
11. Staining: Simple staining and negative staining, Differential (Gram's staining).
12. Observation of bacterial motility by hanging drop method.
13. Antibiotic sensitivity tests
14. Microscopic observation of cells undergoing Mitosis & Meiosis

References:

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

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

Benson, Harold J. Benson's Microbiological Applications: Laboratory Manual in General Microbiology. , 2015.

Cappuccino, James G, and Natalie Sherman. Microbiology: A Laboratory Manual. , 2014

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

Cappuccino, James G, and Natalie Sherman. Microbiology: A Laboratory Manual. , 2014.

SEMESTER-II

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

Objective:

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

Course 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:
Fundamental concepts and overview of the immune system: Organs of immune system- primary and secondary lymphoid organs. Haematopoiesis 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:
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:
Antigen-antibody interactions and Vaccinology: Precipitation and agglutination. RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence microscopy, flow cytometry and immunoelectron microscopy; bone marrow chimera generation, lymphoproliferation 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), dendritic cell-based vaccines.

Unit IV:
Hypersensitivity and autoimmunity: Types of hypersensitivity, autoimmunity and autoimmune diseases, peripheral tolerance and T regulatory cells,

Transplantation: immunological basis of graft rejection, autoimmune disorder.

References:

Goding, James W. *Monoclonal Antibodies: Principles and Practice : Production and Application of Monoclonal Antibodies in Cell Biology, Biochemistry and Immunology*. London: Academic Press, 1996.

Kindt, Thomas J, Richard A. Goldsby, Barbara A. Osborne, and Janis Kuby. *Kuby Immunology*. New York: W.H. Freeman, 2007.

Murphy, Kenneth, Paul Travers, Mark Walport, and Charles Janeway. *Janeway's Immunobiology*. New York: Garland Science, 2012.

Owen, Judith A, Jenni Punt, Sharon A. Stranford, Patricia P. Jones, and Janis Kuby. *Kuby Immunology*. New York: W.H. Freeman, 2013.

Parham, Peter. *The Immune System*. New York: Garland Science, 2005.

Roitt, Ivan M, Jonathan Brostoff, and David K. Male. *Immunology*. Edinburgh: Mosby, 2001.

Course Code : **MMB-202** Core/Elective : **Core** No. of Credits : **3**	Course Title **Molecular biology**

Objective:

- 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.

Course outcome

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

Unit I:

Nucleic acid structure and function: DNA supercoiling: superhelical density, Lk, Wr and Tw, topoisomerases, 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 DNA into chromosomes: DNase I sensitive regions, heterochromatin and euchromatin, DNA methylation (e.g. X chromosome inactivation)

Unit II:

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:

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 and mechanism.

Unit IV:

Regulation of gene expression: Promoters and enhancers. Transcriptional regulation in bacteria: 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.

References:

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

Cooper, Geoffrey M, and Robert E. Hausman. *The Cell: A Molecular Approach*. Sunderland, MA: Sinauer Associates, 2013.

Krebs, Jocelyn E, Benjamin Lewin, Stephen T. Kilpatrick, and Elliott S. Goldstein. *Lewin's Genes Xi*. Burlington, Mass: Jones & Bartlett Learning, 2014.

Lodish, Harvey F, Arnold Berk, Chris Kaiser, Monty Krieger, Anthony Bretscher, Hidde L. Ploegh, Angelika Amon, and Kelsey C. Martin. *Molecular Cell Biology*. , 2016.

Maniatis, Tom, Edward F. Fritsch, and Joseph 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**	Course Title **Genetic Engineering and Genome Editing**

Objective:

- 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.

Course 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:

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 bluntended DNA fragments; linkers, adaptors; homopolymeric tailing, nucleic acids modifying enzymes.

Unit II:

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, hot start PCR, colony PCR, LAMP, digital droplet PCR; Site-specific mutagenesis *in vitro* and *in vivo*; methods of mutation detection (SSCP, DGGE, RFLP). PCR in molecular diagnostics (viral and bacterial detection).

Unit III:

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:

Application of Genetic engineering: Gene silencing techniques: siRNA and miRNA, construction of shRNA vectors; methods to generate transgenic animals and plants; DNA and protein microarrays Introduction to genome editing technologies: ZFNs, TALEN, Cre-Lox; total and conditional gene knock outs.

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 Knockin 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.

References:

Barrangou, Rodolphe, and John . Oost. *Crispr-cas Systems: Rna-mediated Adaptive Immunity in Bacteria and Archaea*. Berlin: Springer, 2013.

Brown, T A. *Genomes 3*. New York: Garland Science Pub, 2007.

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

Luo, Yonglun. *Crispr Gene Editing: Methods and Protocols*. , 2019.

Primrose, Sandy B, Richard M. Twyman, and R W. Old. *Principles of Gene Manipulation*. Cambridge: Blackwell Science, 2004.

Singh, Vijai, and Pawan K. Dhar. *Genome Engineering Via Crispr-Cas9 System*. , 2020.

Course Code : **MMB-205** Core/Elective : **SEC** No. of Credits : **2**	Course Title **Academic Writing**

Course Objectives:

- To enable undergraduate 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 for writing purposes, paraphrasing, and summarizing.
- To enable students to understand and produce written texts in English for different functions in academic settings.

Learning Outcome:

- 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.
- Write different types of texts based on the purpose of writing.
- Develop outlines for essays before developing them into essays.

Unit-I:
Organising paragraphs

Unit-II:
Finding key points and note-making

Unit-III:
Paraphrasing
Summarizing

Unit-IV:
Functions of Academic English
Understanding essay titles and planning essays

Unit-V:
Writing essays

References:

Bailey S. (2011). *Academic Writing: A Handbook for International Students* (3rd edition). London: Routledge

Jordan R. (1999). *Academic Writing Course*. London: Longman

Oshima A & Hogue A. (2006). *Writing Academic English*. Harlow: Pearson Longman

Course Code : **MMB-215** Core/Elective : **Elective** No. of Credits : **3**	Course Title **Signal transduction and cancer biology**

Objective:

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

Course 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:

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, signalling by growth factors and Wnt signalling.

Unit II:

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:

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

Unit IV:

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

References:

Alberts, B, D Bray, J Lewis, M Raff, K Roberts, and J D. Watson. *Molecular Biology of the Cell*. NY, Garland Publishing Inc, n.d.

Darnell, James E, Harvey F. Lodish, and David Baltimore. *Molecular Cell Biology*. New York: Scientific American Books, 1990.

Ettinger, David S, and Ross C. Donehower. *Current Cancer Therapeutics*. Philadelphia, Pa: Current Medicine, 2010.

Kleinsmith, Lewis J. *Principles of Cancer Biology*. San Francisco: Pearson Benjamin Cummings, 2006.

Knowles, Margaret A, and P Selby. *Introduction to the Cellular and Molecular Biology of Cancer*. New York: Oxford University Press, 2005.

Mazurek, Sybille, and Maria Shoshan. *Tumor Cell Metabolism: Pathways, Regulation and Biology*. , 2015.

Rees, Robert C, and Robert C. Rees. *Tumor Immunology and Immunotherapy*. , 2014. Internet resource.

Weinberg, Robert A. *The Biology of Cancer*. New York, N.Y: Garland Science, 2014. Print.

Course Code : **MMB-216** Core/Elective : **Elective** No. of Credits : **3**	Course Title **Biostatistics and Bioinformatics**

Objective:

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

Course outcome:

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

Unit I:

Bioinformatics basics Computers in biology and medicine; Database concepts; Protein and nucleic acid databases; Structural databases; Biological XML DTD's; pattern matching algorithm basics; databases and search tools: biological background for sequence analysis; Identification of protein sequence from DNA sequence; searching of databases similar sequence; NCBI; publicly available tools; resources at EBI; resources on web; database mining tools.

DNA sequence analysis gene bank sequence database; submitting DNA sequences to databases and database searching;

Unit II:

Sequence alignment; pairwise 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 throughput screenings.

Unit III:

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

Unit IV

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.

References:

Aitken, Michael R. F, Bill Broadhurst, and S B. Hladky. *Mathematics for Biological Scientists*. New York, NY: Garland Science, 2010.

Baxevanis, Andreas D, and B F. F. Ouellette. *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins*. New York: Wiley-Interscience, 2001.

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

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

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

Mount, David W. *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor, N.Y: Cold Spring Harbor Laboratory Press, 2006.

Pevsner, Jonathan. *Bioinformatics and Functional Genomics*. , 2009.

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

Course Code : **MMB-225** Core/Elective : **Core** No. of Credits : **3**	Course Title **Practicals: Immunology, Molecular Biology, Genetic Engineering**

1. ELISA and its applications.
2. Blood grouping
3. Immunoblotting.
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, PCR or microscopy.
13. RNA isolation, cDNA synthesis and real time PCR.
14. EMSA
15. Genotyping

References:

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

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

Sambrook, Joseph, Edward F. Fritsch, and Tom Maniatis. *Molecular Cloning: : a Laboratory Manual*. Plainview, NY: Cold Spring Harbor Laboratory Press, 1989.

SEMESTER-III

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

Objective

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

Course outcome

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

Unit-I:

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, Short Distance Intracellular transport.

Unit-II:

Water relations in plants: Polarity; water potential in plants; movement of water in plants; soil-plant-atmosphere continuum. Photoperiodism: Photoperiodic response, Physiology of flowering, phytochrome chemistry and mechanism; Senescence and its molecular aspects; Dormancy & Vernalization mechanism. Sensory photobiology - Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; stomatal movement and biological clocks.

Unit-III:

Photosynthesis: Photophosphorylation, Thylakoid membrane in photophosphorelation, C3 cycle, C4 cycle and CAM pathways, photorespiration. Respiration and photorespiration – Citric acid cycle; plant mitochondrial electron transport and ATP synthesis; alternate oxidase; photorespiratory pathway. Nitrogen metabolism - Nitrate and ammonium assimilation; amino acid biosynthesis.

Unit IV:

Plant hormones – Biosynthesis, storage, breakdown and transport; physiological effects and mechanisms of action. Plant growth regulators: Auxins, gibberellins, cytokinins, ethylene, abscissic acid, brassinosteroids, salicylic acid, jasmonic acid, mode of senescence. Rhizosphere physiology: Root respiration, rhizosphere and allelopathy, types of chemicals and volatiles. 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.

References

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

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

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

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

Objective:

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

Course 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:

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:

Respiratory system: Anatomy of lungs in mammals; Mechanism and regulation of breathing; Hemoglobin & Oxyhemoglobin dissociation curve, oxygen and 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:

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:

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 in vertebrates (mammals); Mechanism of hormone action and signal transduction; thyroid and pancreatic metabolic disorders.

References:

Barrett, Kim E, and William F. Ganong. *Ganong's Review of Medical Physiology*. New York: McGraw-Hill Medical, 2010.

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

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

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

Objectives:

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

Course outcome:

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

Unit-I

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, radiation hybrid maps, comparative gene mapping. Genome sequencing strategies, genome assembly, gap closure, 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 :

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 and design new drugs; determining gene location in genome sequence. Functional genomics; Transcriptome analysis and identification and functional annotation of gene, microarrays, RNA-Seq, serial analysis of gene expression (SAGE), Representational difference analysis (RDA), Rapid amplification of cDNA ends (RACE), Yeast two-hybrid systems, phage display gene function- forward and reverse genetics, gene ethics.

Unit –III:

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

Unit-IV:

Structural and functional proteomics: Mass spectrometry – fundamentals, mass spectrometry ionization techniques, mass analyzers – MALDI-TOF, MS-MS, LC-MS-MS; In-gel digestion, PMF, Mass spectra analysis – search engines: Mascot, swiss-prot, protein prospector, identification, molecular weight, determination of peptide sequence, determination of post-translational modifications, peptide sequencing using tandem mass spectrometry, quantitative proteomics-iTRAQ, functional annotation of proteins, protein chips and functional proteomics; clinical and biomedical applications of proteomics

References:

Brown, T A, and T A. Brown. *Genomes 4*. , 2018.

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

Hamdan, Mahmoud H. "Proteomics Today: Protein Assessment and Biomarkers Using Mass Spectrometry, 2d Electrophoresis, and Microarray Technol." (2005).

Lesk, Arthur M. *Introduction to Protein Science: Architecture, Function, and Genomics*. , 2016.

Posch, Anton. *Proteomic Profiling: Methods and Protocols*. , 2015.

Tibayrenc, Michel. *Genetics and Evolution of Infectious Diseases*. Amsterdam: Elsevier, 2011.

Twyman, Richard M. *Principles of Proteomics*. New York: BIOS Scientific Publishers, 2004.

Wang, Xinkun. *Next-generation Sequencing Data Analysis*. , 2016.

Course Code : **MMB-305** Core/Elective : **SEC** No. of Credits : **2**	Course Title **e-Resources**

Course Objectives:

• Comprehend the definition and importance of e-resources

• Categorize different types of e-resources

• Understand the concept of electronic databases

Learning Outcome:

• Familiarize with the innovative information searching tools and techniques

• Maximum use of Internet, library and information centres.

Unit-I
What is Electronic Sources?

Types of E-resources: E- Journals - E-books - Full-text (aggregated) databases - Indexing and abstracting databases - References databases (biographies, dictionaries, directories, encyclopedia, etc.) - Numeric and statistical databases - E-images -E-audio/visual resources –

Unit-II
Electronic Reference Sources: Off-line Ref. Sources - On-line Reference Sources - OPACS & WebOPACS - E-Publications - Multimedia materials on-line -On-line Tutorials.

Unit-III
Internet: Surfing the Wed: Search Engines -Search engines - What is an e-database? -Information Gateways -What is a portal?

References:

Dhara, Arup (2016). A personalised discovery service using Google custom search engine, Annals of Library and Information studies, 63, 298-305.

Ellingsen, M., (2004). Electronic Resource Management Systems, LIBER Quarterly, 14 (3-4), p. None. DOI: http://doi.org/10.18352/lq.7782, https://www.liberquarterly.eu/articles/10.18352/lq.7782/

Shah, Dharmesh, How to Search on Google: 31 Google Advanced Search Tips, from https://blog.hubspot.com/marketing/google-advan.

Singh, Neena (2001). Internet: Importance and usage for library and Information professionals, DESIDOC Bulletin of Information Technology, Vol., 21, No. 3, 17-28.

What is eLearning? retrieved on May 09, 2018 from http://www.elearningnc.gov/about_elearning/what_is_elearning/ 4. Definition of 'E- learning', The Economic Times, Education, from https://economictimes.indiatimes.com/definition/elearning

Course Code : **MMB-315** Core/Elective : **Elective** No. of Credits : **3**	Course Title **Developmental Biology**

Objective:

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

Course 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 :

Phases of development Developmental patterns among Metazoans – Gametogenesis: Structure of Mammalian gametes. Fertilization: Biochemical events, Cleavage (patterns & types), Gastrulation: Germ layer formation. Organogenesis. Growth and differentiation. Genetic regulations of early embryonic development – Gradient theory – Morphogenetic gradients – cell fate and cell lineage.

Unit II:

Embryonic induction and organiser Embryonic induction. 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. Axes and pattern formation in Drosophila

Unit III:

Metamorphosis and regeneration Influence of hormones on growth and metamorphosis of Insects and Amphibians – Formation of limb bud inAmphibia – Specification of limb fields – Induction of early limb bud – Eye lens induction-Cell death and the formation of digits and joints. Regenerative ability of various Invertebrates and Vertebrates –Mechanism of regeneration – Blastema formation – Wolffian regeneration - Factors affecting regeneration.

Unit IV:

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, *In vitro* fertilization.

References

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

Berrill, N.J. *Developmental Biology*. New Delhi: Tata McGraw-Hill, 1979.

Browder, Leon W. *Developmental Biology*. Philadelphia: Saunders College, 1980.

Di, Castri F, and T Younes. *Biodiversity, Science and Development: Towards a New Partnership*. Wallingford, Oxon, UK: CAB International in association with the International Union of Biological Sciences, 1996.

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

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

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

Strickberger, Monroe W, Monroe W. Strickberger, Benedikt Hallgri msson, and Brian K. Hall. *Strickberger's Evolution: The Integration of Genes, Organisms and Populations*. Sudbury, Mass. [etc.: Jones and Bartlett Publishers, 2008.

Tacconi, Luca. *Biodiversity and Ecological Economics: Participatory Approaches to Resources Management*. Sterling, Va: Earthscan Publications, 2000.

Course Code : **MMB-316** Core/Elective : **Elective** No. of Credits : **3**	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.

Course Outcome:

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

Unit I:

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-1D and 2D;

Unit II:

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

Unit III:

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:

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.

References:

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

Jeevan, K P. *Metabolomics - Fundamentals and Applications*. , 2016.

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

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

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

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

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

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

1. Measurement of DPO in Plants by Gravimetric Method.
2. To Measure the Rate of Transpiration under Different Conditions of Light and Wind by Ganongsl'hotometer.
3. Suction Force due to Transpiration
4. Separation of Chlorophyll Pigments by Paper Chromatographic Method
5. Determination of water potential of plant samples by Chardakov's method.
6. Quantitative estimation of accumulated chloride ion in cell sap.
7. Study of photolysis of water by demonstration of Hill reaction.
8. Effect of high temperature stress on membrane deterioration in terms of electrical conductivity test.
9. Effect of respiratory inhibitor on the rate of respiration.
10. Quantitative estimation of dissolved oxygen due to photosynthesis by Winkler's method.
11. Effect of sodium azide on water uptake by plants.
12. Bioassay of IAA by wheat coleoptile test.
13. Action of pepsin in digestion of proteins.
14. Estimation of salivary amylase activity.
15. Estimation of lipase activity.
16. Oxygen consumption and estimation in an aquatic or terrestrial animal.
17. Action of insulin on blood sugar level.
18. Experiments on urine analysis in human urine sample-Test for urea, blood cells, bile salts, albumin, ketone bodies and sugar in human urine sample.
19. Determination of cell fragility by osmotic hemolysis experiment.
20. Chromosome banding, karyotyping and making idiogram of the banded chromosomes
21. Applications of BLAST, FASTA, CLUSTALW, GENSCAN, RASMOL, Phylodendron
22. Biological Data Base assessment tools
23. Analysis of biological information by any bioinformatics tool

References:

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

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

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

SEMESTER-IV

Course Code : **MMB-401** Core/Elective : **Core** No. of Credits : **20**	Course Title **Project Work/Dissertation**

Each student will work on a project toward a dissertation by applying the knowledge acquired in molecular biology and biochemistry. The project may be 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 a 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 chairperson on the recommendation of the supervisor concerned.