KANNUR UNIVERSITY

DEPARTMENT OF MOLECULAR BIOLOGY

M.Sc. MOLECULAR BIOLOGY

Scheme and Syllabus

(under Choice Based Credit Semester System -CBCSS, effective from 2023)

CONTENTS

KANNUR UNIVERSITY

DEPARTMENT OF MOLECULAR BIOLOGY

Regulations, Scheme and Syllabus for
M.Sc. MOLECULAR BIOLOGY
(w.e.f. 2023 Admission)

1. About the Department

The Department of Molecular Biology was established in the year 2008, at Dr. P.K. Rajan Memorial Campus, Puthariyadukkam, Nileshwaram, Kasaragod district, which was moved to Dr Janaki Ammal Campus, Palayad in 2022. The Department offers Postgraduate (M.Sc.) and Doctoral (Ph.D.) programmes in Molecular Biology. The subject Molecular Biology is an emerging area of modern biology with vast potential for application in diverse areas including basic sciences, biomedical sciences and other allied applied areas. The department is well equipped with smart classrooms, MSc practical labs and research lab with the basic instruments needed for the successful conduct of this programme. The department has a bioinformatics lab with computers and internet facility, and a library with more than one thousand books and 13 journals.

2. About the Programme

The MSc Molecular Biology program envisages empowering the blended students to equip to conduct research in any area of interest in modern biology and hence is amenable to a multidisciplinary approach. The M.Sc. programme is a research oriented collaborative course comprising most of important and recent Sciences like genetic Engineering, Industrial Biotechnology, Environmental Science, genetics etc. giving the students job opportunities in various fields like Teaching, research, Industry, Medical laboratories and more. It also provides the students exposure to most important and recent techniques and information in Life science.

This program is intended for young students with high academic caliber from diverse fields and provides greater opportunity to prepare themselves for competitive examinations like UGC-CSIR JRF/NET, ICMR-JRF/NET, DBT- JRF/NET. GATE etc for those who are ambitious of becoming a teacher or a scientist. This program will prepare students to take research in Molecular Biology and allied areas as a possible career option as well as will enable generation of manpower for the emerging Molecular Biology industry. The student strength is 16. The M.Sc. Molecular Biology program is offered under the Choice based Credit and Semester System with duration of 2 years (4 Semesters), which comprises Classroom

Teaching, Laboratory Practical's, Tutorials in the form of Seminars and a Dissertation (research) in the last semester.

3. Introduction to Choice Based Credit Semester System (CBCSS)

The CBCSS provides an opportunity for the students to choose courses of their interest from the prescribed courses comprising core, elective, open elective courses. The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. Grading system provides uniformity in the evaluation and computation of the Cumulative Grade Point Average (CGPA) based on student's performance in examinations which enables the student to move across institutions of higher learning. The uniformity in evaluation system also enable the potential employers in assessing the performance of the candidates.

3.1. Definitions

(i) **Academic Programme** means an entire course of study comprising its programme structure, course details, evaluation schemes etc. designed to be taught and evaluated in a teaching Department/Centre or jointly under more than one such Department/Centre.

(ii) **Course** means a segment of a Programme limited to one semester in a subject.

(iii) **Programme Structure** means a list of courses (Core, Elective, Open Elective) that makes up an Academic Programme, specifying the syllabus, Credits, hours of teaching, evaluation and examination schemes, minimum number of credits required for successful completion of the programme etc. prepared in conformity with University Rules,

(iv) **Core Course** means a course that a student admitted to a particular programme must successfully complete to receive the degree and which cannot be substituted by any other course.

(v) **Elective Course** means an optional course to be selected by a student out of such courses offered in the same Department/Centre.

(vi) **Open Elective Course** means an elective course which can be opted in any of the semesters during the entire Programme other than the first semester. ln the third semester all students shall compulsorily register for an Open Elective Course offered by other Departments or MOOC. Students of other Departments may opt these courses subject to fulfilling of eligibility of criteria as laid down by the Department offering the course.

(vii) **Credit** means the value assigned to a course which indicates the level of instruction; Normally, one-hour lecture per week equals 1 Credit, 2/3 hours practical class per week equals 1 credit. Credit for a practical could be proposed as part of a course or as a separate practical course.

(viii) **SGPA** means Semester Grade Point Average calculated for individual semester.

(ix) **CGPA** is Cumulative Grade Points Average calculated for all courses completed by the students in the last year of the course by clubbing together SGPA of four semesters.

3.2. Program Objectives:

The M.Sc. programme in Molecular Biology will:

(1) provide training and understanding of basic concepts as well as cutting edge advancement in the field of Molecular Biology,

(2) impart practical skills through laboratory courses and understanding of modern scientific techniques,

(3) enhance analytical, statistical and validation skills through hands on training,

(4) expose students to various aspects of research through dissertation, and

(5) introduce applications of Molecular Biology in order to prepare highly trained and skilled workforce for teaching, research and entrepreneurship.

3.3. Program Outcomes:

On successful completion of this programme students will:

(1) have an in-depth understanding of the basic and recent developments in the field of Molecular Biology,

(2) acquire skills of critical, analytical and problem solving in order to enable them to be successful in various national and international examinations,

(3) conduct independent work in a laboratory,

(4) possess skills for independent thinking and in writing scientific proposal and presentations, and

(5) capable of becoming successful academicians/researchers and/or entrepreneurs.

SYLLABUS

The M. Sc. Molecular Biology program comprises of the following courses.

SEMESTER-I		
MSMOB01DSC01	Cell Biology	4 credits
MSMOB01DSC02	General Microbiology	4 credits
MSMOB01DSC03	Biochemistry	4 credits
MSMOB01DSE01	Biophysics and Bioinstrumentation	3 credits
MSMOB01DSE02	Biostatistics	
MSMOB01DSC04	Lab in Cell Biology & Microbiology	3 credits
MSMOB01DSC05	Lab in Biochemistry & Biophysics	3 credits

SEMESTER-II		
MSMOB02DSC06	Genetics & Molecular Biology	4 credits
MSMOB02DSC07	Molecular Physiology	4 credits
MSMOB02DSE03	Immunology	
MSMOB02DSE04	Environmental Biotechnology	3 credits
MSMOB02DSE05	Life style disorders	
MSMOB02DSE06	Ecology, Biodiversity & Evolution	
MSMOB02DSE07	Ethics, Patency & Intellectual Property Rights	3 credits
MSMOB02DSE08	Human Genetics	
MSMOB02DSC08	Lab in Genetics & Molecular Biology	3 credits
MSMOB02DSC09	Lab in Physiology & Immunology	3 credits
MSMOB02MDC01	Drug Discovery & Development#	2 credits
MSMOB02MDC02	Protein purification strategies#	2 credits

#Multidisciplinary courses offered by the department for students of other departments

SEMESTER-III		
MSMOB03DSC10	Advanced Molecular Biology	4 credits
MSMOB03DSC11	Genetic Engineering & Applied Biotechnology	4 credits
MSMOB03DSE09	Genomics & Bioinformatics	
MSMOB03DSE10	Molecular Neurobiology	3 credits
MSMOB03DSE11	Forensic Biology & DNA profiling	
MSMOB03DSE12	Developmental Biology	
MSMOB03DSE13	Bioprocess Technology	3 credits
MSMOB03DSE14	Molecular Evolution	
MSMOB03DSC12	Lab in Molecular Biology, Genetic Engineering & Biotechnology	2 credits
MSMOB03SEC01	Lab in Genomics & bioinformatics	2 credits
MSMOB03DSC13	Internship (Industrial visit/Study tour/Field visit)	2 credits
MSMOB03MDC03	Life & Genes#	4 credits
MSMOB03VAC01	Value Added Course-offline/online-2 credits*	

#Multidisciplinary courses offered by the department for students of other departments
**Credits for VAC will not be added in the marklist, but passing VAC with 2C is mandatory for the successful completion of the program*

SEMESTER-IV		
MSMOB04DSC14	Research project related to Molecular Biology and General Viva-voce	16 credits

DETAILED SCHEME OF VALUATION

SEMESTER- I

DS Core: 5 (Theory-4; Practical-2);
DS Elective: 1
Total Credits: 21
Core-18 (Theory-12; Practical-6); Elective-3

Sl. No.	Course Code	Title of the course	Contact hours/week			Marks			Credits
			L	T/S	P	ESE	CE	Total	
1.	MSMOB01DSC01	Cell Biology	3	1		60	40	100	4
2.	MSMOB01DSC02	General Microbiology	3	1		60	40	100	4
3.	MSMOB01DSC03	Biochemistry	3	1		60	40	100	4
4.	MSMOB01DSE01	Biophysics and Bioinstrumentation	2	1		60	40	100	3
	MSMOB01DSE02	Biostatistics							
5.	MSMOB01DSC04	Lab in Cell Biology & Microbiology			6	60	40	100*	3
6.	MSMOB01DSC05	Lab in Biochemistry & Biophysics			6	60	40	100*	3
TOTAL			**11**	**4**	**12**	**360**	**240**	**600**	**21**

*There is no external practical examination. CE includes marks for lab record, test/practical viva.

SEMESTER- II

DS Core: 6 (Theory-4 [includes 2 MDCs]; Practical-2)
DS Elective: 2
Total Credits: 24
Core-18 (Theory-12 [2 x 4+ 2x2]; Practical-6); Elective-6

Sl. No.	Course Code	Title of the course	Contact hours/week			Marks			Credits
			L	T/S	P	ESE	CE	Total	
1.	MSMOB02DSC06	Genetics & Molecular Biology	3	1		60	40	100	4
2.	MSMOB02DSC07	Molecular Physiology	3	1		60	40	100	4
3.	MSMOB02DSE03	Immunology	2	1		60	40	100	3
	MSMOB02DSE04	Environmental Biotechnology							
	MSMOB02DSE05	Lifestyle Disorders							
4.	MSMOB02DSE06	Ecology, Biodiversity & Evolution	2	1		60	40	100	3
	MSMOB02DSE07	Ethics, Patency & Intellectual Property Rights							
	MSMOB02DSE08	Human Genetics							
5.	MSMOB02DSC08	Lab in Genetics & Molecular Biology			6	60	40	100*	3
6.	MSMOB02DSC09	Lab in Physiology & Immunology			6	60	40	100*	3
7.	MSMOB02MDC01	Drug Discovery & Development#	1	1		60	40	100	2
8.	MSMOB02MDC02	Protein purification strategies#	1	1		60	40	100	2
		Course offered by other departments	2			60	40	100	2
		Course offered by other departments	2			60	40	100	2
TOTAL			**12**	**6**	**12**	**480**	**320**	**800**	**24**

*****There is no external practical examination. CE includes marks for lab record, test/practical viva*

#*Multidisciplinary courses offered by the department for students of other departments*

SEMESTER- III

DS Core: 5 (Theory-4 [includes 1 SEC, I Internship]; Practical-1)
DS Elective: 2
MDC: 1
Total Credits: 24
Core-14 (Theory-12 [2 x 4+ 2x2]; Practical-2); Elective-6; MDC-4

Sl. No.	Course Code	Title of the course	Contact hours/week			Marks			Credits
			L	T/S	P	ESE	CE	Total	
1.	MSMOB03DSC10	Advanced Molecular Biology	3	1		60	40	100	4
2.	MSMOB03DSC11	Genetic Engineering & Applied Biotechnology	3	1		60	40	100	4
3.	MSMOB03DSC12	Lab in Molecular Biology, Genetic Engineering & Biotechnology			4	60	40	100*	2
4.	MSMOB03DSE09	Genomics & Bioinformatics	2	1		60	40	100	3
	MSMOB03DSE10	Molecular Neurobiology							
	MSMOB03DSE11	Forensic Biology & DNA profiling							
5.	MSMOB03DSE12	Developmental Biology	2	1		60	40	100	3
	MSMOB03DSE13	Bioprocess Technology							
	MSMOB03DSE14	Molecular Evolution							
6.	MSMOB03SEC01	Lab in Genomics & Bioinformatics			4	60	40	100*	2
7.	MSMOB03VAC01 /02	MOOC/Academic Scientific Writing/Advanced forensic DNA analysis and profiling			4	60	40	100	2**
8.	MSMOB03DSC13	Internship-Industry visit/Field visit/Study tour			4	60	40	100	2
9.	MSMOB03MDC03	Life & Genes#	3	1		60	40	100	4
		Course offered by other departments	4			60	40	100	4
TOTAL			**13**	**5**	**12**	**480**	**320**	**800**	**24**

**There is no external practical examination. CE includes marks for lab record, test/practical viva*

***Credit for Value added course is not counted, but a pass in VAC is mandatory for the successful completion of the program. VAC & Internship includes 30 hr of engagement.*
#Multidisciplinary course offered by the department for students of other departments

SEMESTER- IV

DS Core: 1

Sl. No.	Course Code	Title of the course	Contact hours/week			Marks			Credits
			L	T/S	P	ESE	CE	Total	
1.	MSMOB04DSC14	Research Project related to Molecular Biology/allied subjects and General Viva-voce			32	60	40	100	16

Total Credits: 16

SEMESTER -I

MSMOB01DSC01: Cell Biology

60 hours **4 Credits**

Course Objectives:
The objective of this course is to offer detailed knowledge about cell biology, various cellular organelles and the signal transduction pathways associated with the cellular processes of the cells. The course also aims to provide into the insights of how classical cellular pathways were experimentally discovered.

Course Learning Outcomes:
Upon completion of this course, students will be able to

- learn about cell theory, cell cycle mechanisms, various cellular organelles and their structure and function.
- acquire insight into the processes of transport across cell membranes, process of endocytosis and protein sorting/translocation to various organelles.
- gain knowledge about the concepts of various cellular signal transduction pathways.
- acquire insight into the mechanisms of cellular responses under varying conditions.
- learn the association of the defects in the signalling processes to various diseases.

MODULE-1

Introduction to Cell Biology- Cell theory-Basic properties of cells- different classes-Cellular dimension-Size of cells and their composition-Cell origin and Evolution (Endosymbiotic theory)– Molecules of the Cell.

MODULE-2

Cell Membrane-Proteins and Lipids-Organisation-Lipid bilayer: Composition and properties (Hydropathic plot)-Membrane permeability and transport-Principles of membrane transport-Pores and Channels-Pumps-Differentiation of cell membrane– microvilli – tight junction – belt and spot desmosomes - intercellular communications and gap junctions – cell coat and cell recognition.

MODULE-3

Synthesis, sorting and trafficking of proteins: site of synthesis of organelle and membrane proteins – transport of secretory and membrane proteins across ER – post-translational modification in RER – transport to mitochondria, nucleus, chloroplast and peroxisome - protein glycosylation – mechanism and regulation of vesicular transport – golgi and post-golgi sorting and processing – receptor mediated endocytosis; Synthesis of membrane lipids.

Ribosomes: Specific association rRNA and r-proteins –Nucleolus- ribosome biogenesis – in-vitro assembly experiments to understand ribosome formation and also for understanding the functions of various ribosomal components – active centers of ribosomes.

MODULE-4

Nucleus: Nuclear envelope – Nuclear pore complexes-nuclear matrix – organization of chromatin – supercoiling, linking number, twist - nucleosome and high order of folding and organization of chromosome (Solenoid and Zigzag model)-Global structure of chromosome –(Lamp brush and polytene chromosomes). Cytoskeleton. Cell cycle and its regulation (Cyclin and kinases)-Experiments (Fission Yeast, Xenopus, Sea Urchin) -Check points-mitosis and meiosis. Cell Death: Apoptosis versus necrosis-Apoptotic pathways –

autophagy – ageing.

References:

1. Lodish *et al*., Molecular Cell Biology. W H Freeman & Co.
2. Becker W M *et al*., The World of the Cell. Pearson.
3. DeRobertis E D F and DeRobertis E MF, Cell and Molecular Biology. Saunders
4. Karp and Gerald, Cell and Molecular Biology. John Wiley.
5. Polland Thomas D, Cell Biology. Saunders.
6. Standzinski George P Editor, Cell growth, differentiation and senescence. Oxford University Press.
7. Alberts B, Molecular Cell Biology.
8. Casimeris *et al*., Lewin's cells. Jones and Bartlett.
9. Plopper, Principles of cell Biology. Jones and Bartlett.
10. Gartner, Cell Biology and Histology. LWW.
11. Pollard et al., Cell Biology. Sounders.
12. Copper, The Cell a Molecular approach. Sinauer.

MSMOB01DSC02: General Microbiology

60 Hours **4 Credits**

Course Objectives:

The objective of this course is to offer detailed knowledge about the history and diversity of microorganisms; benefits of microorganisms and the various mechanisms of disease, cause, transmission, detection, treatment and prevention.

Course Learning Outcomes:

Upon completion of this course, students will be able to

- learn in detail the adaptations of microorganisms that help them to invade the host cell, how they evade the host immune system and colonise the host cell causing diseases.
- gain overall knowledge about the mechanisms of disease cause, transmission, detection, treatment and prevention.
- develop the ability to relate to any existing or emerging infection as well as will learn about drug resistance and its mechanisms.
- have the know-how to research and develop new tools in the field of microbial science.

MODULE-1

History and scope of Microbiology. Microbial Diversity: Place of microorganisms in the living world – criteria used in microbial taxonomy; Classification of bacteria – past and present status – classification based on morphology- gram's staining and culture characteristics – classification based on Bergey's manual of systematic bacteriology (details of sections not expected); Classification of viruses – classification based on host, viral morphology and nucleic characteristics.

MODULE-2

Structural organization of bacteria, fungi and viruses: Ultra structure of bacterial cell wall – cell membrane – flagella – pili – capsule and genome; Structure and architecture of bacteriophages. Fungi-Molds and Yeasts. Bacterial culturing: Physical and chemical methods of sterilization – growth media – mixed microbial population – selection of pure culture – physical conditions of growth – growth curve – storage and transport of microbes.

MODULE-3

Microbial toxins: Exotoxins – endotoxin and other virulence factors. Disinfectants and antibiotics: Methods of testing antimicrobial substances – mechanism and action of important classes of disinfectants and antibiotics – drug resistance of antibiotics.

MODULE-4

Benefits of microbes in various fields: Microbes in fermentation – microbial biogas from biological wastes – microbes in value addition of fish and meat – microbial bioremediation. Microbes and diseases: Bacterial diseases – Streptococcal diseases – Tuberculosis –Plague – Anthrax – Syphilis – Cholera – Tetanus – Leprosy; Viral diseases – Chicken pox – Small pox – Influenza – Rabies – AIDS-SARS and Ebola.

References:

1. Prescott, Harley and Klein, Microbiology. McGraw-Hill
2. Jacquelyn G Black, Microbiology: Principles and Exploration. John Wiley & Sons.
3. Nester et al., Microbiology: A human perspective. McGraw Hill.
4. Albert G Moat et al., Microbial Physiology. John Wiley & Sons.
5. Kathleen Park Talaro, Arthur Talaro, Foundations in Microbiology. Mc Graw Hill.
6. Alcamo, Foundations of Microbiology. Jones and Bartlett Publishers.
7. Cappuceino James, Microbiology: A Laboratory Manual. Pearson Education
8. Toratora Gerad, Microbiology: An Introduction. Pearson Education.
9. Edward A I, Microbiology. Tata McGraw Hill.
10. Lim Daniel, Microbiology. Mc Graw Hill.
11. Pelczar M J Jr, Chan E C S Krieg, Microbiology.
12. Wheelis, Principles of Modern Microbiology. Jones and Barttlett.
13. C.J.Alexopoulos. Introducing Mycology. Wiley.
14. Basman. Microbiology with diseases by holy systems. Pearson.
15. Madigan et al. Biology of Microorganisms. Pearson.

MSMOB01DSC03: Biochemistry

60 Hours **4 Credits**

Course Objectives:
The objective of this course is to offer advanced knowledge of the core principles and topics of biochemistry and their experimental basis. This course provides details about the biomolecules and cellular metabolism.

Course Learning Outcomes:
Upon completion of this course, the students will be able to
- explain/describe the synthesis of proteins, lipids, nucleic acids, and carbohydrates and their role in metabolic pathways along with their regulation including protein folding, modification, and degradation.
- learn the use of current biochemical and molecular techniques to plan and carry out experiments.

MODULE-1

Atomic bond and molecular interaction: Covalent bonds – ionic interactions – hydrogen bonds – Vander Waal's interactions – hydrophobic effect – binding of biomolecules. Biomolecules: Carbohydrates – classification, structure and properties – carbohydrate derivatives – sugar alcohols, sugar acids, amino sugars etc. – biological function of carbohydrates; Proteins – classification of amino acids, structure and properties – classification of proteins and biological functions – levels of organization – primary, secondary, tertiary, quaternary and quinary – sequencing of proteins; Lipids – classification, structure and properties – biological application; Nucleic acids – structure of nitrogen bases – nucleosides – structure of DNA and RNA.

MODULE-2

Enzymes: IUB classification, nomenclature and specificity – mechanism of enzyme action – Michaeli's-Menten equation – derivation, double reciprocal plot – Line-Weaver-Burk-method – significance of K_m and V_{max} values – factors effecting enzyme action – regulation of enzymatic activity – enzyme inhibition – allosteric enzymes – positive and negative modulation – vitamin as co-enzymes – and RNA as enzymes.

Bioenergetics: Enthalpy – entropy – free energy concepts – living body as thermodynamic system – energy of activation – standard free energy – energy rich compounds – ATP – creatine phosphate and pyrophosphate.

MODULE-3

Cellular metabolism: Carbohydrate metabolism – Glycolysis – Kreb's cycle – glycogenolysis – glycogenesis – glucogenesis – gluconeogenesis – pentose phosphate pathway – glyoxylic acid cycle; Amino acid metabolism - Biosynthesis and degradation of amino acids – deamination and transamination (metabolism of glutamic acid, phenyl alanine, methionine, tryptophan, isoleucine and histidine to be given emphasis). Fat metabolism – Biosynthesis and oxidation of fatty acids (beta oxidation) – biosynthesis of phospholipids sphingolipids – glycolipid and cholesterol metabolism; Nucleic acid metabolism – Biosynthesis and degradation of purines and pyrimidines

MODULE-4

Biological oxidation – electron transport system in mitochondria – redox potential – mechanism of oxidative phosphorylation – chemiosmotic coupling hypothesis.

Photosynthesis: Chloroplast as photosynthetic unit –Hill reaction–photosynthesis I and II – Calvin cycle.

References:

1. Smith E L et al., Principles of Biochemistry. Vol. I and Vol.II.
2. Lubert Stryer, Biochemistry. W H Freeman & Co.
3. Lehninger A L, Principles of Biochemistry. CBS publishers.
4. Conn and Stumpf, Concepts in Biochemistry.
5. Mahler H R & Cordes E H, Basic Biological Chemistry. Harper & Row.
6. Awapara J, Introduction to Biological Chemistry. Prentice-Hall of India.
7. Cohn E E & Stumpf P K, Outlines of Biochemistry. Wiley Eastern.
8. Wilson J & Walker K Practical Biochemistry: Principles and Techniques, Cambridge.
9. Sadasivan S & Manikam A, Biochemical methods. New Age International.
10. Patabhiraman T N Laboratory Manual in Biochemistry. All India Publishers.
11. Nelson David L, Principles of Biochemistry. McMillan.
12. Chatterji M N & Rana Shindo, Text Book of Medical Biochemistry. J P Brothers.
13. Das Debjyoti , Biochemistry. Academic Publishers.
14. Voet Donald & Voet Judith, Biochemistry.
15. Garrot Reginald H, Biochemistry, Thomson Publishers.
16. Elliot Willim H & Eliot C Daphne, Biochemistry and Molecular Biology.
17. Camphell Peter N, Biochemistry Illustrated. Churchill Living Stone.
18. Kamal Ritu, Biochemistry of Biomolecules. Paragon International.
19. Metzier David E, Biochemistry: the chemical reactions of living cells. Academic Press.
20. McKee Trudy, Biochemistry: the molecular basis of life. McGraw Hill.
21. Sheehan. Physical Biochemistry. Willy Blackwell.
22. Perasena. Enzymology. Oxford.
23. Heldt et al. Plans Biochemistry. Academic press.

MSMOB01DSE01: Biophysics and Bioinstrumentation

45 Hours **3 Credits**

Course Objectives:
The objective of this course is to offer knowledge on Biophysics, an interdisciplinary science that employs and develops theories and methods of the physical sciences for the investigation of biological systems. Currently, protein physics is one of the fastest growing physics research areas that is vital to many other fields, including medicine, bioengineering, and biology.

Course Learning Outcomes:
Upon completion of this course, students will be able to

- describe how various chromatographic methods can be used to separate various macromolecules
- appraise the importance of various biophysical techniques
- understand the biophysical principles of interaction of light with living systems and their significance in biosphere sustenance.
- understand various kinds of radiations in the environment and their sources, the effects of various radiations on living systems etc.

MODULE-1

Principles and applications of Biophysical Methods: microscopy- light, phase contrast, fluorescence, Confocal, FRET, Atomic force, Scanning and transmission electron microscopy
Spectroscopy- UV- visible, fluorescence, Atomic absorption, Plasma emission spectroscopy
Cytophotometry – flow cytometry , FACS
Centrifugation – sedimentation coefficient- Svedberg unit, gradient and differential – ultracentrifugation- analytical centrifugation

MODULE-2

Biomolecular Separation and Structure Determination Methods:
Chromatography: Basic principles- plate and rate theory , resolution of the peak, Types of chromatography- gel filtration- Ion exchange and affinity chromatography – thin layer chromatography – high pressure liquid chromatography (HPLC) , FPLC and Gas Chromatography
Electrophoresis: Principles-Native and reducing PAGE, agarose, IEF- ampholytes, 2D; Gel shift assay, Pulsed field electrophoresis
X-ray Crystallography**:** Crystals; Types of lattices and crystal symmetry, Scattering by atoms and molecules; Scattering in terms of Fourier transforms, Interference from sets of atoms and Bragg's Law, Electron density calculations and phase problem; Model building and Refinement.
ORD/CD spectroscopy, ESR , NMR, Mass spectroscopy- MALDI-TOF, LCMS

MODULE-3

Biomolecular structure, folding and interactions:
Thermodynamics of helix-coil transition, thermodynamics and kinetics of DNA- Cot Curve,
Thermodynamics of biomolecular interactions.

Protein tertiary structure; domains, folds and motifs, protein folding and cooperativity, quaternary structure and allosteric interactions. Protein-protein and protein-nucleic acid interaction
Nucleosome and chromatin model; supercoiled DNA; RNA quaternary structure; tRNA structure and folding.

MODULE-4

Applied biophysical methods:
Radiation Biology: Sources of ionizing radiations- radioisotopes- Principles and applications of tracer techniques in biology – radiation dosimetry. Measurement of radioactivity: autoradiography – Gamma counter-G M Counter- liquid scintillation counter
Laser- types of Laser; its application as a tool in surgery and therapy.
physical basis of sound – infra, sub sonic sounds and ultrasonic sounds; Doppler ultrasonography – lithotripsy-echolocation, echocardiography
Bioelectricity and bioluminescence.

References:

1. Chatwal G R, Biophysics, Himalaya Publishing House.
2. Cotterill Rodney M J Biophysics: An Introduction. John Wiley.
3. PattabhiVasantha& Gautham M, Biophysics 2nd edition,Narosa.
4. Subramanyan M A, Biophysics. MJP
5. Roy K N, A Text Book of Biophysics, New Central Book Agency.
6. Ackerman E, Biophysical Science. Prentice-Hall Inc.
7. Kane J W &Steinhein M M , Life Science Physics. John Wiley.
8. Thiravia Raj S, Biophysics. Saras Publications.
9. Glaser. Biophysics. Springer.
10. Pranab Kumar Banerjee,Introduction to biophysics,S Chand
11. Tuszynski et al.,Introduction to molecular Biophysics,CRC Press
12. Nolting,Methods in Modern Biophysics,Springer
13. Keith Wilson and John Walker,Principles And Techniques Of Biochemistry And Molecular Biology

MSMOB01DSE02: Biostatistics

45 Hours **3 Credits**

Course Objectives:
The objective of this elective course is to provide an introduction to selected important topics in biostatistical concepts and reasoning

Course Learning Outcomes:
Upon completion of this course, students will be able to
- recognize the importance of data collection and its role in determining scope of inference.
- interpret statistical results correctly, effectively, and in context.
- appreciate the power of data.

MODULE-1

Nature and scope of Biostatistics and its applications in biology: Discrete and continuous variables – collection and classification and tabulation of data frequency table – diagrammatic and graphic presentation of data – bar diagram - pie diagram – histogram – frequency polygon and frequency curve.

MODULE-2

Measures of central tendency: Arithmetic mean – median – mode. Measures of dispersion: Range – quartile deviation – mean deviation and standard deviation. Analysis of variance: ANOVA – one way and two way classification.

MODULE-3

Probability theory: Basic concepts and definition of probability – relative frequency definition – probability distributions – binomial, Poisson and normal distributions and their applications.

Testing hypothesis; level of significance – critical region , type 1 and type 11 error – tests based on normal distribution – t-test, F-test, Z-transformation and chi-square test.

MODULE-4

Correlation and regression analysis: positive correlation – negative correlation coefficient of correlation, regression equation and its application in computing X or Y. Applications of computer in biostatistics.

References:

1. Jasra P K & Raj G, Biostatistics. Krishna Prakasan Media Pvt. Ltd.
2. Dixon W J & Massey F J Jr, Introduction to Statistical Analysis.
3. Khan I A & Khanum a, Fundamentals of Biostatistics. Ukaaz Publications.
4. Sokal R R & Rohif F J, Introduction to Biostatistics. W H Freeman & Co.
5. Lewis A I, Biostatistics. Reinhold Publications.
6. Snedecor G W & Cochran W G, Statistical Methods. Oxford & IBH.
7. Zar, Jerrold H, Biostatistical Analysis. Morgan Kaufman.
8. Hannagan T J, Mastering Statistics. Mac Millan Master Series.
9. Milton Susan J, Statistical Methods in the Biology & Health Sciences. McGraw Hill.
10. Arora P N, Biostatistics. Himalaya Publishing House.

MSMOB01DSC04: Lab in Cell Biology & Microbiology

3 Credits

Course Objectives:
The objective of this practical course is to demonstrate significant cell biological and microbiological principles, quantitative and analytical approaches that enable the students to translate the theoretical foundation in cell biology and microbiology to be translated into practical understanding.

Course Learning Outcomes:
Upon completion of this practical course, students will be able to

- differentiate the cells of various living organisms and get awareness of physiological processes of cell e.g. cell divisions.
- observe and correctly identify different cell types, cellular structures using different microscopic techniques.
- attain skills in microscopy and their handling techniques and staining procedures.
- understand the basic microbial structure and microbial growth

Contents:

1. Study of meiosis in grasshopper testis squash and determination of chiasma frequency.
2. Preparation of chromosome spread from rat bone marrow and analysis of metaphase chromosome by means of G and C banding.
3. Preparation of Human karyotype from photographs of chromosome spreads – normal and abnormal.
4. Staining of buccal epithelial smear to demonstrate Barr body.
5. Preparation of human blood smears to demonstrate drumsticks in neutrophils.
6. Induction of chromosome aberration in onion root tips by a suitable clastogenic agent and its demonstration by means of root tip squashes.
7. Cell fractionation and isolation of nuclei and mitochondria from any suitable material (Rat liver).
8. Preparation and sterilization of culture media.
9. Pure culture technique: Streak plates, spread plate, and pour plate methods.
10. Staining methods: Simple, negative, Acid fast, Gram staining, spore staining, capsule staining, lactophenol cotton blue staining.
11. Measurement of growth – Direct haemocytometer count, viable count, growth curve, determination of growth rate and generation time.
12. Effect of pH, temperature and antibiotics on growth of bacteria.

MSMOB01DSC05: Lab in Biochemistry & Biophysics

3 Credits

Course Objectives:
The objective of this practical course is to provide a basic familiarity with the most common techniques used in biochemistry and biophysics and their applications to challenging problems in biology.

Course Learning Outcomes:
Upon completion of this practical course, students will be able to

- critically evaluate data and design experiments to test hypothesis relevant to the practice of Biochemistry and Biophysics.
- understand the strengths and limitations of various experimental and computational approaches for studying macromolecular structure and function.

Contents:

1. Qualitative analysis of monosaccharide (glucose & fructose), disaccharide (lactose, maltose and sucrose), and polysaccharide (dextrin and starch).
2. Qualitative analysis of protein (albumin, casein, peptone and gelatin).
3. Qualitative analysis of lipids.
4. Estimation of glucose.
5. Estimation of protein.
6. Estimation of amino acid.
7. Estimation of triglycerol / phospholipids / cholesterol.
8. Enzyme kinetics – assay of alkaline phosphatase.
9. Preparation of buffer and measurement of pH (Tris, Phosphate, Acetate buffer).
10. Practical aspects of microscopy, micrometry and camera lucida.
11. Demonstration of diffusion using dialysis tubing.
12. Separation of amino acids by paper, thin layer chromatography and identification of amino acids.
13. Ion exchange chromatography and Molecular sieve chromatography.
14. Separation of proteins by polyacrylamide gel electrophoresis and determination of molecular weight of unknown protein.

SEMESTER -II

MSMOB02DSC06: Genetics & Molecular Biology

60 Hours **4 Credits**

Course Objectives:

The objective of this course is to offer knowledge in the field of Genetics and Molecular biology, which help them to understand and apply the principles and techniques helping them for further education and/or employment in teaching and/or basic research.

Course Learning Outcomes:

Upon completion of this course, students will be able to

- explain the mechanisms of DNA replication and repair, RNA synthesis and processing, and protein synthesis.
- describe how gene expression is regulated at the transcriptional and post-transcriptional level.
- apply the principles of genetics to produce a family pedigree from a family history,
- display a broad understanding of core molecular genetics concepts.

MODULE-1

Overview of Genetics – Mendelian inheritance – non-Mendelian inheritance - Linkage, crossing over and chromosome mapping – polygenic inheritance. Chromosomal aberrations – deficiency – duplication – inversion – and translocation; Ploidy – aneuploidy – euploidy; Chromosomal aberrations in human; Mutation – molecular basis of mutation – radiation induced mutation – chemically induced mutation – mutation frequency. Restriction, modification and repair of DNA: Direct and Indirect repair, excision repair pathways – error prone repair – recombination repair – SOS system.

MODULE-2

Genetic material: Experiments, which proves DNA as genetic material and RNA as genetic material in RNA viruses. Genetic transfer in bacteria - Transformation, transduction and conjugation-Temporal mapping in *E. coli*. Genetic basis of Cancer: Characteristic features of cancer cells-carcinogen- chemical and physical carcinogen; Oncogenes-viral oncogenes -cellular oncogenes-chromosome rearrangement and cancer-tumor suppressor genes-inherited cancers.

MODULE-3

Introduction to 3D structure of DNA and RNA; Synthesis of DNA – semi conservative – experiments of Meselson and Stahl – Cairn's Experiment – Replicon – Semi-discontinuous synthesis – rolling circles – D-loop model – enzymes involved in replication; Triplex DNA – Types of DNA: A, B, Z, P and G DNA.

Transcription: Biosynthesis of RNA in prokaryotes - enzymatic machinery - promoter selection and role of RNA polymerase and ancillary factors; Transcription in eukaryotes - eukaryotic RNA polymerase - promoter and enhancer – rho factor mediated termination – antitermination - inhibition of termination. Biosynthesis of ribosomal, transfer and messenger RNA - RNA splicing and processing – post transcriptional modification in transfer and messenger RNA.

MODULE-4

Protein Synthesis: Genetic code – t RNA –rRNA and r-proteins - translation in prokaryotes and eukaryotes – factors of protein synthesis and their role – inhibitors of protein synthesis – post translational modification.

Population Genetics: Gene pool-Genotypic frequency-allelic frequency-Hardy Weinberg Law-Factors affecting allelic frequency; Speciation-Allopatric and sympatric

References:

1. Rober J Brooker, Genetics: Analysis and Principles. Addison Wesley Longman
2. Klug W S & Cummings W S, Concepts of Genetics. Prentice Hall.
3. Gardnerand Simmon, Principles of Genetics. John wiley & Sons.
4. Strickberger , Genetics. Monroe w.
5. Bhasin M K & Walter H , Genetics of Castes and Tribes in India. Kamala Raj Ent.
6. Hartwell Leland H, Genetics from Genes to Genome.
7. Stent G, Molecular Genetics. Freeman.
8. Burns G W & Hottins P J, The science of Genetics.Mapwell –Macmillan.
9. Strickberger M W, Experiments in Genetics with Drosophila. John Wiley.
10. Hartl, David L, Genetics. Jones and Bartlett.
11. King William S & M R Qummings. Genetics. Prentice Hall.
12. Benjamin Lewin, Genes IX. John Wiley.
13. Benjamin Lewin , Gene Expression Vol1 -3. John Wiley.
14. Watson J D et al., Molecular Biology of the Gene. The Benjamin / Cummings.
15. Lodish H et al., Molecular Cell Biology. Scientific American Books. W H Freeman.
16. David Freidfelder, Molecular Biology. Narosa.
17. Brown T A, Genomes. Bioscientific.
18. Winnackeer Ernst L, From genes to Clones. Panima.
19. Dale J W and von Schantz, From genes Genomes. John Wiley.
20. Micklos D A et al, DNA Science. Cold Spring Harbor.
21. Weaver Robert F, Molecular Biology. Mc Graw Hill.
22. Turner P C, Molecular Biology. Viva Books.
23. Kreuzer Helen, Molecular Biology and Biotechnology: A Guide for Teachers.
24. Alber Bruce, Molecular Biology of the Cell. Garland Science.
25. Calladine, Horace Drew, Ben Luisi, Understanding DNA. Elsevier.
26. Benjamin A Pierce,Genetics A Conceptual approach,w.Freeman
27. Simmons et al., Principles of Genetics

MSMOB02DSC07: Molecular Physiology

60 Hours **4 Credits**

Course Objectives:
The objective of this course is to offer knowledge to the Physiological concepts of homeostasis and control mechanisms and to study the functions of body systems. A brief introduction to plant physiology will also be dealt in this course.

Course Learning Outcomes:
Upon completion of this course, students will be able to

- have an enhanced knowledge and appreciation of both human and plant physiology
- use physiological and anatomical knowledge to enhance their personal lives.
- synthesize ideas to make a connection between knowledge of anatomy and physiology and real-world situations, including healthy lifestyle decisions and homeostatic imbalances.
- perform, analyse and report on experiments and observations in physiology

MODULE-1

Homeostasis: Basic mechanisms – Regulation – factors regulating homeostasis. Intercellular communications and signal transduction: Extracellular signaling molecules, receptor classes, signal transduction pathways, second Messengers, Signal amplification, Regulation of inter- and intracellular signaling.

MODULE-2

Cellular and Molecular Neurobiology: General organization and function of nerve fibers and neuroglia - synaptic transmission and structure of synapse – synaptic vesicle - neurotransmitters – synaptic receptors and physiologic response.
Sensory physiology – photoreception – eyes and vision; ear and mechanism of hearing, mechanoreceptor: touch and pressure – mechanoreceptors of motion and position – proprioceptor – chemoreceptor –olfaction, gustatory receptors.

MODULE-3

Cellular and Molecular Biology of the Muscle: structure of striated muscle fibre– smooth muscle – molecular organization of contractile system – molecular mechanism of muscle contraction – energetics of muscle contraction – regulation.
Cellular and Molecular Biology of endocrine system: Cellular secretions – mammalian endocrine glands – peptide and proteins, amines and steroid hormones – synthesis, storage and secretion of hormones – cellular mechanism of hormone action – hormone receptors – endocrine disorders – pheromones and its role behaviour and reproduction – biological clocks.

MODULE-4

Plant Physiology: Intake of water and nutrients-active and passive absorption; transpiration; Hormones and growth regulators-auxins, gibberlins, cytokinins, ethylene and other compounds; Plant Microbial Interaction: Pathogenic, Symbiotic and associated interactions.

References:

1. Sherwool L, Klandorf H and Yancy P H, Animal Physiology: From Genes to Organisms Thompson Brooks/Cole.
2. David Randall, Burggren W and Frech K, Eckert Animal Physiology: Mechanisms and Adaptations. W H Freeman & Co.
3. Guyton A C. Text Book of Medical Physiology. W B Saunders Co.
4. Hancock John T, Cell Signalling. Oxford University Press.
5. DeRobertis E D P and DeRobertis E M F, Cell and Molecular Biology. Holt Saunders.
6. Taiz and Zeiger, Plant Physiology, Sinauer
7. S.Mukherji *et al*.,Plant Physiology, Central
8. Hopkins *et al*.,Introduction to plant physiology
9. Negi, Introduction to Endocrinology, PHI
10. W.F. Boron and E.L.Boulpaep, Medical Physiology (2nd edition 2009)
11. B.M.Koeppen and B.A Stanton, Physiology (6th edition 2010)
12. Murray etal, Harper's illustrated Biochemistry (29th edition 2012)

MSMOB02DSE03: Immunology

45 Hours **3 Credits**

Course Objectives:
The objective of this course is to offer knowledge in basic immunology including cellular and molecular processes that represents the human immune system. It includes studies on cells and organs of the immune system, antigen, immunoglobulins and antibody diversity, molecular mechanisms of innate and adaptive immunity, the complement system, antigen presentation, cell-mediated effector responses and techniques used in immunological studies.

Course Learning Outcomes:
Upon completion of this course, students will be able to

- conceptualize cellular and molecular basis of the immune system.
- understand how the innate and adaptive immune responses coordinate to fight against invading pathogens.
- appreciate and understand the complement system, its activation and biological consequences of complement activation.
- understand and identify the genetic defects that lead to immunodeficiency diseases

MODULE-1

Introduction to immunology – Historical Perspective - types of immunity – innate and acquired – passive and active- Humoral and cell mediated immunity – Cells in the immune system - Organs in the immune system – Hematopoiesis - Systemic Function of the Immune System – Evolutionary Comparisons of immune cells and organs.
Autoimmunity: autoimmune diseases – Hypersensitive reactions - hypersensitive immune responses. Immune Response to Infectious Diseases: Bacterial (tuberculosis), parasitic (malaria) and viral (HIV) infections, congenital and acquired immunodeficiencies. Vaccines.

MODULE-2

Antigen: Immunogenicity Versus Antigenicity- Factors That Influence Immunogenicity – Epitopes - Haptens and the Study of Antigenicity - Pattern-Recognition Receptors – Synthetic and recombinant antigens – complement activation pathways. Antibody: Structure of immunoglobulin – different classes of immunoglobulin – Antibody Mediated Effector Functions - The B-Cell Receptor - The Immunoglobulin Superfamily - Monoclonal antibodies and Polyclonal antibodies – Chimeric antibodies – applications.

MODULE-3

Regulation of immune system : Antigen Processing and Presentation – T-Cell Receptor - T-Cell Maturation, Activation, and Differentiation - B-Cell Generation, Activation, and Differentiation- Cytokines - The Complement System - Cell-Mediated Effector Responses. Immunopathology interleukin 1 –tumor necrosis factor – interleukin 6– interferon and related cytokines. Major Histocompatibility Complex: Regulation of MHC Expression - Organization and Expression of Immunoglobulin Genes. Transplantation immunology – Graft Rejection - Immunosuppressive Therapy. Cancer and the Immune System: Tumors of the Immune System - Cancer Immunotherapy.

MODULE-4

Antigen-Antibody Interactions: Principles and Applications - Strength of Antigen-Antibody Interactions - Agglutination Reactions – Radioimmunoassay- Enzyme-Linked Immunosorbent Assay - Western Blotting – Immunoprecipitation- Immunofluorescence - Flow Cytometry and Fluorescence - Alternatives to Antigen-Antibody Reactions - Immunoelectron Microscopy - Isoelectric focusing – Cytotoxic assay - Labeled antibody technique in light and electron microscopy – Immunohistochemistry – Vaccines - techniques of immunization – use of adjuvants – separation of lymphocytes – flow cytometry –ELISpot.

References:

1. Ivan Roitt, Essential Immunology, Blackwell Science.
2. Goldsby R A, Kindt T J, Osbor R A. Kuby Immunology. W H Freeman.
3. Hue Devis. Introductory Immunology. Chapman & Hall publishers.
4. Roitt J M, Brostaff J J and Male D K, Immunology C V Mosby Publisher.
5. Bellanti J A Immunology. W B Saunders Co.
6. Talwar G P and Gupta S K. A Hand Book of Practical Immunology (Vol. & 11).
7. Elgert,Immunology ,Understanding the Immune System, Wiley Blackwell
8. Tizard, Immunology an Introduction, Cengage learning.
9. Mak et al., Primer to immune response, Academic cell.

MSMOB02DSE04: Environmental Biotechnology

45 Hours **3 Credits**

Course Objectives:
The objective of this elective course is to introduce fundamental knowledge about the different types of biotechnological processes that exist in the field of environmental applications. This also introduce students to the various types of environmental pollutants and their effects

Course Learning Outcomes:
Upon completion of this course, students will be able to
- describe the scientific basis that are applied by environmental biotechnology.
- describe the properties of microorganisms with potential application to processes of environmental biotechnology.
- explain the technologies, tools and techniques in the field of environmental biotechnology.

MODULE-1
Introduction to Environmental Biotechnology – scope and importance. Biological Treatment of waste water: Aerobic – Biological process for domestic and industrial waste water treatment; aerobic systems – activated sludge processes– trickling filters – biological filters – rotating biological contractors (RBC); fluidized bed reactors (FBR), expanded bed reactor, inverse fluidized bed biofilm reactor (IFBBR); sparged reaction. Anaerobic: Contact digestion - packed column reaction-UASB reactor.

MODULE-2
Bioremediation: Introduction – constraints and priorities of bioremediation; biostimulation of naturally occurring microbial activities; bioaugmentation; solid phase bioremediation; phytoremediation – composting, bioventing, biosparging; liquid phase bioremediation. Mining and Metal Biotechnology: Microbial transformation – accumulation and concentration of metals – metal leaching – extraction and future prospects.

MODULE-3
Biofuels: Microorganisms and energy requirements of mankind. Production of non-conventional fuels. – Methane (biogas); hydrogen, alcohols, hydrocarbon, use of microorganisms in petroleum augmentation and recovery.

MODULE-4
Major pollution problems – pathogens – microbial toxins – oxygen depletion-biodeterioration - eutrophication – hazardous transformation – Management of pollution problems using microorganisms.

References:
1. Agarwal SK, Environmental Biotechnology.
2. Martin Alexander , Biodegradation and Bioremediation . Academic Press
3. Stanier R Yetal , General Microbiology. McMillan Publications
4. Foster C F. & John Ware D A, Environmental Biotechnology. Ellish Horwood Ltd.
5. Chattergy A K, Environmental Biotechnology.
6. Jogdant S N, Environmental Biotechnology, Himalaya Publications.

MSMOB02DSE05: Lifestyle Disorders

45 Hours **3 Credits**

Course Objectives:
The objective is to provide knowledge about common life style disorders with detailed insight into two major killers: Cancer and Cardiovascular diseases.

Course Learning Outcomes:
Upon completion of this course, students will
- learn about the various life style associated disorders.
- gain detailed insight into Cancer and Cardiovascular diseases with regards to the molecular mechanisms, causes, symptoms, stages, diagnosis and treatments.
- learn about alternative medicines; current research status, various ethical, social and regulatory issues.

MODULE-1
Introduction: Life style associated disorders like obesity, diabetes, chronic obstructive pulmonary diseases (COPD), cancer and cardiovascular diseases (CVDs); Causes, symptoms, complications, diagnosis, intervention and management of disease; Two major killers: Cancer and Cardiovascular diseases.

MODULE-2
Cancer: History of cancer; Characteristics of normal and transformed cells; Hallmarks of cancer; Causes and symptoms; Pathophysiology; Stages of cancer; Molecular basis of neoplastic growth and metastasis, Key oncogenic pathways; Proto-oncogenesis and Tumor suppressor genes; Cancer causing mutations; Tumor viruses, Overview of important techniques related to cancer research.

MODULE-3
Cardiovascular diseases: Definition; The origin of cardiovascular diseases (electrical, structural and circulatory) and types of CVDs; Defining the broad spectrum of ailments; Understanding the underlying factors; Stages of CVDs; Molecular basis of CVDs like hypertension, coronary heart (artery) disease, cerebrovascular disease, cardiomyopathy, cardiac hypertrophy, atherosclerosis, myocardial infarction.

MODULE-4
Diagnosis and Treatment strategies: Biochemical analysis of cancer and screening methods; Current treatment modalities and their disadvantages, major side effects; Molecular approaches to cancer treatment; Factors affecting prognosis of cancer; Challenges of treatment and disease control strategies. Diagnosis and biomarkers for CVDs; Treatment strategies and management of the condition; Drugs and their discovery; Model systems and animals for CVDs. Recent Advances: Introduction to alternative medicines; Case studies; Research status and scope; Ethical, social and regulatory issues.

References:

1. Textbook of Biochemistry with Clinical Correlations (2011) Devlin, T.M. John Wiley & Sons, Inc. (New York), ISBN: 978-0-4710-28173-4.
2. Introduction to Human Physiology (2012) 8th edition; Lauralee Sherwood. Brooks/Cole, Cengage Learning. ISBN-13: 978-1133104544 ISBN-10: 1133104541

3. The Cell: A Molecular Approach (2009) 5th ed., Cooper, G.M. and Hausman, R.E., ASM Press & Sunderland (Washington DC), Sinauer Associates, MA, ISBN:978-0-87893-300-6.
4. The World of the cell, 7th edition (2009). Lewis J. Kleinsmith, Jeff Hardin, Gr Wayne M.Becker. ISBN-13: 978-0805393934 ISBN-10: 0805393935.
5. Life style disorders, National health portal of India (https://www.nhp.gov.in/lifestyledisorder_mtl)

MSMOB02DSE06: Ecology, Biodiversity & Evolution

45 Hours **3 Credits**

Course Objectives:
The objective of this elective course is to convey the principles of ecology and the importance of biodiversity and its conservation

Course Learning Outcomes:
Upon completion of this course, students will be able to

- understand the vital connections between plants and animals and the world
- gain knowledge about the structure and function of ecosystem
- appreciate the role of ethics, values and norms in producing culturally attuned and effective conservation interventions.

MODULE-1

Concept of ecosystem: Introduction – Various components of ecosystem – functions – Concept of habitat and niche– energy in ecosystem – nutrient cycling.
Population growth – Characteristics – population growth curves- r and k selection-dispersion – dynamics – species diversity indices – species and the individual in ecosystem.

MODULE-2

Ecological Succession: Types-Mechanisms-changes involved in succession-concept of climax. Biogeography; Major terrestrial biomes-Theory of Island biogeography-biogeographical zones in India.

MODULE-3

Concept and Scope of Biodiversity – species loss – social concept – biodiversity conservation in protected area – biodiversity and agriculture – grazing – forestry – human dimension of biodiversity. Hotspots – conservation strategies – challenges to the preservation of biodiversity– conservation and management – Indian case studies on conservation (Project Tiger/Biosphere reserves).

MODULE-4

Life- origin and evolution, Concept of evolution and theories- Lamarckism, Darwinism, Neo Darwinism. Isolation, mutation, speciation, germplasm and genetic drifts. Concepts of neutral evolution, molecular divergence and molecular clocks; Molecular tools in phylogeny. Approaches and methods in study of behaviour; Proximate and ultimate causation; Altruism and evolution-Group selection, Kin selection, Reciprocal altruism.

References:

1. Eugene P Odum, Fundamentals of Ecology. 2005, W B Saunders.
2. Subramanyam N S & Sambamurthy AVSS, Ecology. 2000, Narosa.
3. Wilson E O, Biodiversity. National Academy Press.
4. Jeffrey A, McNeely & R Miller, Conserving the Worlds Biological Biodiversity.
5. Vitousek P M & DV Hooper, Biodiversity and Ecosystem Function.
6. Cain et al,. Ecology, 2011, Sinauer.
7. Dr.V.K.Gupta, Animal diversity, natural history and conservation vol.1.,Daya publications.

8. Strickberger M W, Evolution. 2014, Jones Barllett.
9. Volpe E P, Understanding Evolution. Universal Book Stall.
10. Li.W H, Molecular Evolution. Sinaur Associates
11. Masatoshi Nei and Sudhir Kumar, Molecular Evolution and Phylogenetics. Oxford University Press.

MSMOB02DSE07: Ethics, Patency & Intellectual Property rights

45 Hours 3 **Credits**

Course Objectives:
The objective of this elective course is to introduce fundamental aspects of Intellectual property Rights to students who are going to play a major role in development and management of innovative projects in industries. This course will also provide knowledge about the ethical issues and patent rights.

Course Learning Outcomes:
Upon completion of this course, students will be able to

- Understand the ethical aspects of interfering in natural process and basic concepts of patent system.
- Evaluate the patentability of microorganisms and inanimate products, different Intellectual property rights and infringement problems
- Explain the basic principles of biosafety and containment levels
- Describe the basics of rDNA research activities

MODULE-1

Ethical aspects of interfering in natural process – hidden dangers in altering genetic makeup. Objectives of the patent system, basic principles and general requirements of patent law, technological inventions and patent law, legal development, patentable subjects and protection in biotechnology, international convention for the protection of new varieties – Strasbourg convention, UPOV convention.

MODULE-2

The patentability of microorganisms – claims, characterization and repeatability – deposition in culture collections, legal protection – for plants and other higher organisms – tissue culture protocols – transfer of technology. Patentability of inanimate products of nature – vectors, FDA, FPA, patent office practice – trade secrets, copyrights, infringement problems – harmonization patent laws – IPR and Plant genetic sources, GATT and TRIPS.

MODULE-3

Biosafety: Objectives, definition, recombinant DNA safety – classification of pathogenic microorganisms – Biological containment (BC) and physical containment (PC) – biosafety levels.

MODULE-4

Guidelines for rDNA research activities: Large scale experiments, release to the environment, import and shipment, quality control of biologicals produced by rDNA technology, mechanism of implementation.

References:

1. Erice Grace, Biotechnology Unzipped: Promises and realities. 1995. Henry Press.
2. Glick B R & Pasternak J J, Molecular Biotechnology. 2010. Fourth Edition. Panima.
3. Purohit S S & Mathur S K, Biotechnology: Fundamentals and Applications. 1999. Agrobios.

4. Brown T A, Gene Cloning and DNA Analysis. 2016. Seventh Edition. Blackwell Science.
5. Reddy G B. Intellectual Property Rights and The Law. 2008. Seventh Edition. Gogia Law Agency.
6. Bouchoux Deborah E. Intellectual Property: The law of Trademarks, Copyrights, Patents and Secrets. 2013. Fourth Edition. Delmar Cengage Learning
7. Stim Richard. Intellectual Property: Patents, Trademarks and Copyrights. 2001. Second edition. Cengage Learning.

MSMOB02DSE08: Human Genetics

45 Hours **3 Credits**

Course Objectives:
The objective of this elective course is to provide an overview of basics of Human Genetics and makes familiar with the common genetic disorders.

Course Learning Outcomes:
Upon completion of this course, students will be able to

- explain the genetic mechanisms and their role in human inherited disease.
- appreciate the importance of genetic counselling and prenatal diagnosis in real life.

MODULE-1

Human chromosomes: Karyotype and different types of banding techniques and its significance. Human pedigree and various modes of inheritance: Pedigree construction, autosomal abnormalities, sex chromosomal abnormalities, autosomal recessive inheritance, X-linked inheritance, Y-linked inheritance, multifactorial inheritance.

MODULE-2

Genetics of reproduction and development: prenatal development, errors in sexual development – defects of androgen target cells, congenital adrenal hyperplasia, sex reversal; genetics of embryonic development – maternal effect genes, segmentation and pattern forming genes.

MODULE-3

Inborn errors of metabolism: Concept of metabolic diseases, detection of metabolic diseases in new born, taysachs disease, disorders of phenyl alanine metabolism, Lesh-Nyhan syndrome. Genetic diseases and gene therapy: Types of gene therapy – germ line, zygotic and somatic cell gene therapy; treatable genetic diseases – cystic fibrosis, sickle cell anemia; future of gene therapy, early detection of genetic diseases.

MODULE-4

Genetic counselling and prenatal diagnosis: Methods of genetic counseling, amniocentesis, chorionic villi sampling, fetoscopy, ultrasound sonography; prenatal sexing and legislation. Human population genetics: Genetic drift – gene flow – consanguineous marriages, inbreeding, sampling, demographic analysis.

<u>References</u>:

1. Gardner and Simmon, Principles of Genetics. John Wiley & Sons.
2. Strickberger Genetics, Monroe W.
3. Robert J Brooker, Genetics: Analysis and Principles. Addison Wesley Longman.
4. Edwin H McConkey, Human Genetics: The Molecular Evolution. Jones and Bartlett Publishers.

MSMOB02DSC08: Lab in Genetics & Molecular Biology

3 Credits

Course Objectives:

The objective of this practical course is to introduce students to most of the common techniques used in genetic analyses, with an emphasis on basic molecular biology techniques.

Course Learning Outcomes:

Upon completion of this practical course, students will be able to

- demonstrate an understanding of modern genetics by conducting studies on Drosophila
- be able to demonstrate practical knowledge of DNA technologies by extracting and estimating DNA, RNA and protein.

Contents:

1. Maintenance of *Drosophila melanogaster* culture and demonstration of sex-linked inheritance of any suitable gene by means of crosses.

2. Gene mapping of *Drosophila melanogaster*, using text book problems

3. Preparation and analysis of salivary gland chromosomes of *Drosophila.*

4. Extraction and estimation of chromosomal DNA from animal tissues (by diphenylamine test).

5. Extraction and estimation of total RNA from any suitable material (by Orcinol test).

6. Extraction and estimation of protein from any suitable material (by Lowry test).

7. Agarose gel electrophoretic separation and visualization of DNA using UV transilluminator.

8. Leucocyte culture and chromosome study.

9. Melting temperature of DNA - Tm analysis.

MSMOB02DSC09: Lab in Physiology & Immunology

3 Credits

Course Objectives:
The objective of this practical course is to develop a working knowledge of the principles and procedures of physiology and immunology.

Course Learning Outcomes:
Upon completion of this practical course, students will attain hands on training for various physiological and immunological techniques.

Contents:

1. Determination of vertebrate haemoglobin using calorimeter.
2. Enumeration of WBC, RBC; Blood grouping and Rh typing.
3. Total and differential count of WBC.
4. Determination of vertebrate serum chloride, calcium and fibrinogen.
5. Demonstration of osmotic hemolysis.
6. Preparation of antigen; immunization protocol - preparation of serum & complement.
7. Haemagglutination test.
8. Immunodiffusion test
9. Immunoelectrophoresis – preparation of immunoglobulin-lymphocyte migration inhibition test.
10. ELISA
11. Widal / VDRL tests.

MSMOB02MDC01: Drug Discovery and Development

45 Hours **2 Credits**

Course Objectives:

The main objective of the course to impart primary knowledge about the drug discovery process, various stages of drug discovery, application computers in drug discovery and various techniques associated with drug design.

Course Learning Outcomes:

Upon completion of the course, students will be able to understand the following

- Brief history and various stages drug discovery and its approval
- Definition and Properties of drug
- Drug targets and drug-receptor interaction
- Various steps in identifying drug candidates
- Application of computers in modern drug discovery process.
- Various bio-physical techniques using in drug discovery

Module -1

Introduction to drug discovery, history of drug discovery, traditional medicines- Greek, Indian, Chinese, Arabic, Various stages of drug discovery- Early Drug Discovery, Pre-Clinical Phase, Clinical Phases, and Regulatory Approval, Regulatory bodies, challenges and opportunities.

Module -2

Definition of Drug, Source of Drugs- natural and synthetic, Physicochemical Properties of Drug, off-target interactions, toxicity, pharmacokinetics, pharmacodynamics, Lipinski's rule, pharmacophore.

Drug targets, biological macromolecules, proteins, DNA, RNA, Enzymes, anti-bodies, mechanism of action, Drug receptor interaction, forces stabilizing drug interaction, Drug binding- inhibitors, effectors, activators. Small molecules, peptide and protein drugs

Module -3

Steps in drug discovery- Hit and Lead, Target identification, Target validation, lead identification, lead optimization, Formulation and development, High throughput Assays. Computer aided drug discovery- computers in drug design, structure prediction, molecular modelling, pharmacophore modelling, molecular docking, dynamics, toxicity prediction, pharmacokinetics prediction. Drug repurposing. Drug discovery softwares, drug and target databases

Module -4

Techniques associated with Drug discovery- X-ray crystallography, Fluorimetry, ITC, SPR, BLI, CD, Cryogenic electron microscopy.

Reference

1. Drug Discovery and Development From Targets and Molecules to Medicines; Ramarao Poduri, Springer Singapore, https://doi.org/10.1007/978-981-15-5534-3.
2. Textbook of Pharmacology, Prasan R. Bhandari, Thieme Publishers Delhi
3. Drug Design and Discovery, Seetharama D. Satyanarayanajois, Humana Totowa, NJ, Springer Protocols , https://doi.org/10.1007/978-1-61779-012-6
4. Drug Discovery and Development, 3rd Edition, James J. O'Donnell, John Somberg, Vincent Idemyor, James T. O'Donnell. Taylor & Francis Ltd. ISBN 9781032084244.

MSMOB02MDC02: Protein Purification Strategies

30 Hours **2 credits**

Course Objectives:

This course provides an in-depth exploration of various strategies and techniques employed in the purification of proteins. Students will learn the principles behind protein purification, different purification methods, and their applications in research and biotechnology.

Course Learning Outcomes:

Upon completion of this course, students will be able to:

- Explain the fundamental principles of protein purification.
- Identify and select appropriate protein purification methods based on protein characteristics and research goals.
- Design and execute protein protocols effectively.
- Analyse and interpret protein purification data to assess purity and yield.
- Critically evaluate the efficiency, specificity and scalability of different protein purification strategies.

MODULE-I

Introduction to protein purification: Overview of protein purification techniques-classical and modern protein purification methods, Importance of protein purification in various fields (research, biotechnology, pharmaceuticals). Protein characteristics influencing purification strategies-molecular weight, charge, solubility, stability etc. Factors affecting protein stability and solubility-pH, temperature, salt concentration, presence of additives (detergents, chaotropic agents etc.). Considerations for protein purification design-selection of appropriate purification methods based on properties and research goals, designing purification protocols for optimal yield and purity.

MODULE-2

Protein Extraction and Fractionation: Sample preparation techniques-cell lysis methods (mechanical, chemical and enzymatic)-extraction buffers and reagents. Fractionation methods-centrifugation techniques (differential, density gradient). Precipitation methods (ammonium sulfate, organic solvent). Membrane protein extraction strategies (detergent based, solubilisation using chaotrpic agents, lipids etc.)

MODULE-3

Chromatographic Techniques in Protein Purification: Principles of chromatography-adsorption/desorption kinetics, separation mechanisms (size exclusion, affifnity, ion exchange etc). *Ion exchange chromatography*-principles and mechanisms, selection of ion exchange resins, elution strategies (slat gradient, pH gradient). *Affinity chromatography*-principles and applications, Ligand selection and immobilisation, elution strategies. *Size exclusion chromatography*-principles of molecular sieving, column packing and equilibration, elution strategies and applications. *Hydrophobic interaction chromatography*-principles and mechanisms, selection of hydrophobic resins and ligands, elution strategies and applications.

MODULE-4

Advanced Protein Purification Techniques: High-performance liquid chromatography (HPLC)-principles and instrumentation, column selection and equilibration, elution strategies and applications. Protein refolding techniques-principles of protein denaturation and refolding, refolding buffer composition and optimisation, refolding methods (dilution, dialysis, on-column refolding). Ultrafiltration and diafiltration-principles of membrane-based separation, membrane selection and optimisation, applications in protein concentration and buffer exchange. Protein crystallisation and purification for structural studies-principles of protein crystallization, crystallization screening methods, optimisation of crystallisation conditions, purification strategies for crystallography applications.

References:

1. Protein Purification Protocols 2nd Edition. In Methods in Molecular Biology Vol 244. Ed. Paul Cutler, 2004.
2. High Throughput Protein Expression And Purification Ed Sharon A Doyle. Springer Protocols 2009.
3. Methods in Enzymology: Guide to Protein Purification Eds Burgess and Deutscher. Vol 463.
4. Protein Purification: Principles, High Resolution Methods, and Applications, 3rd Edition Ed Jan-Christer Janson, 2011.

SEMESTER -III

MSMOB03DSC10: Advanced Molecular Biology

60 Hours **4 Credits**

Course Objectives:
The objective of this course is to introduce the student to the advanced concepts in molecular biology. Students will gain an understanding of molecular mechanisms involved in recombination, gene regulation in prokaryotic and eukaryotic organisms. They will also study the techniques and experiments used to understand these mechanisms.

Course Learning Outcomes:
Upon completion of this course, students will be able to

- understand the structural and functional organization of genome.
- acquire knowledge on various molecular mechanism involved in the regulation of gene expression in prokaryotes and eukaryotes.
- describe molecular mechanism involved in recombination and transposition.
- design and implement experimental procedures using advanced molecular biology techniques.
- interpret the outcome of various molecular biology experiments.

MODULE-1

Molecular mechanisms involved in recombination of DNA: Holliday intermediate – Reciprocal recombination-patch recombination-heteroduplex DNA – gene conversion – Rec A protein ant its role in recombination.
Eukaryotic genome: C-value paradox –Gene numbers– unique, moderately repetitive and highly repetitive DNA sequences – reassociation kinetics – Cot value and complexity of genome-Interrupted genes – satellite – Rot value.

MODULE-2

Regulation of gene expression in Prokaryotes: various models - operon - details of lac operon-negative and positive control lac operon – catabolite repression-basic features of tryptophan, arabinose, and galactose operon. Gene regulation in bacteriophage.
Regulation gene expression in eukaryotes: Regulation of transcription-regulation of RNA processing and translation.

MODULE-3

Developmental Genetics: Induction and competence – maternal effects of genes – homeotic genes. Transposon in bacteria and eukaryotes: retroviruses and transposition – phage Mu as transposable elements. Microarray and gene expression analysis.

MODULE-4

DNA sequencing: Maxam Gilbert chemical method - Sanger's enzymatic chain termination method- foot printing. Molecular probes – cDNA probes – RNA probes – nick translated probes; Restriction mapping – RFLP. Blotting techniques: Northern blotting – western blotting – dot blots- Southern blotting. PCR technology – gene amplification – primer designing – variation in PCR – real time PCR, RACE, inverse, nested etc-Applications of PCR

References:

1. Walker J M and Gringold EB, Molecular Biology and Biotechnology. 2002, Panima.
2. Benjamin Lewin.Genes 1X. 2007, John Wiley.
3. Sambrook J, Fritsch E F and Maniatis T, Molecular cloning: A laboratory Manual. 2011, Cold Spring Harbor Laboratory.
4. Hartwell L H et al., Genetics: From Genes to Genome. 2004, Mc Graw Hill.
5. Watson J D et al., Molecular Biology of the Gene. 1987, The Benjamin / Cummings.
6. Lodish H et al., Molecular Cell Biology. 7th edition, 2013, Scientific American Books. W H Freeman.
7. David Freidfelder, Molecular Biology. 1985, Narosa.
8. Adrin J Harwood, Methods in Molecular Biology,Vol.58, Basic DNA and RNA protocols. Humana Press.
9. Chris R Calladine et al., Understanding DNA. Elsevier.
10. Micklos D A et al., DNA Science. Cold Spring Harbour.
11. Cox et al, Molecular Biology, Principles and Practice, 2012, Freeman
12. Tropp, Molecular Biology, Genes to proteins, 2012, Jones and Bartlett
13. Allison, Fundamental Molecular Biology, 2012Wiley.
14. Ernst L Winnacker, From genes to clones, 2003, Panima.
15. Lewin et. al., Genes X. 10th edition, 2011, Jones and Bartlett Pub Inc.
16. David Clark and Nanette K Pazdernik, Molecular Biology, 2nd edition,2013, Academic press
17. Lewin et. al., Genes XI. 11th edition, 2014, Jones and Bartlett Pub Inc.

MSMOB03DSC11: Genetic Engineering & Applied Biotechnology

60 Hours **4 Credits**

Course Objectives:
The objective of this course is to introduce the student to the advanced concepts in genetic engineering and biotechnology. It encompasses ways to analyze, alter and recombine virtually any DNA sequences. The student will also study the techniques and experiments used in genetic engineering and biotechnology.

Course Learning Outcomes:
Upon completion of this course, students will be able to

- be able to learn the basics of gene cloning, construction of various libraries and gene identification.
- be able to familiarize with the various techniques to engineer and express recombinant proteins.
- be able to appreciate the importance and application of recombinant DNA technology in biology.

MODULE-1

Fundamentals of biotechnology: History – emergence of molecular biotechnology; Genetic Engineering tools and techniques: (a) Enzymes in genetic engineering – restriction enzymes type I, II & III, ligases, enzymes to modify the ends of DNA molecules; alkaline phosphatase, polynucleotide kinase, terminal transferase, polymerases, reverse transcriptase etc. (b) Gene cloning vectors: plasmids – pBR 322, pUC, Ti plasmids Ri – bacteriophages – lambda phage, M13, – cosmids – phagemids – BAC, PAC - special vectors – shuttle vectors, expression vectors, yeast artificial chromosomes, MAC etc. (c)Host systems for r-DNA technology- bacterial and Yeast system (d) Gene isolation, identification and synthesis; Construction of chimeric DNA – cohesive end ligation – use of linkers – blunt end ligation; construction of cDNA and genomic libraries

MODULE-2

Screening recombinant clones-colony hybridization – plaque hybridization – chromosome walking, chromosome jumping, subtractive cDNA hybridization, differential mRNA display; Studying cloned gene expression and function.

Gene transfer in animals and plants: Gene transfer method (transfection) – direct gene transfer – Ti plasmid – electroporation – uptake by protoplast –microinjection – liposome mediated DNA delivery –.Gene Knockout, RNAi and gene silencing; gene targeting. Protein engineering

MODULE-3

Protoplast fusion – techniques of protoplast fusion – enzymes involved in cell wall digestion – factors effecting protoplast fusion – fate of products of protoplast fusion.

Tissue culture: Plant tissue culture – principle and methodology – callus culture – tissue and organ culture – whole embryo culture; Animal tissue culture: primary, secondary and established cell lines.

Transgenic animals and plants- flavour saver tomato-round up seeds-golden rice-Terminator genes, animal pharming.

MODULE-4

DNA finger printing – Variable number of tandem repeats (VNTR) – applications; Gene therapy – somatic and germ line gene therapy- embryonic stem cell transformation– *ex-vivo* and *in-vivo* gene therapy – antisense therapy – application of gene therapy in the correction of adenosine deaminase (ADA) – future prospects of gene therapy; nanoparticles for labelling and delivery of drugs, DNA and RNA.

References:

1. Brown T A, Gene Cloning and DNA Analysis Blackwell Science.
2. B R Glick and Pasternack J J, Molecular Biotechnology: Principles and Applications of Recombinant DNA. Panima.(1994)
3. James D Watson et al., Recombinant DNA: A Short Course. Scientific American Books, W H Freeman & Co.(2007)
4. Primrose S B and R.M.Twyman, Principles of Gene Manipulation and Genomics. Black Well Publishing (2014)
5. Winnaker E L, From Genes to Clones: Introduction to Gene Technology. VCH Publications.(2003)
6. Purohit S S& Mathur S K, Biotechnology: Fundamentals and Applications. Agrobios.
7. Eric Grace, Biotechnology Unzipped: Promises and Realities. University Press.
8. Fumento Michael, Biotechnology: How it is changing our Life. Jaico Publishing.
9. Bourgaize David, Biotechnology demystifying the concepts.
10. Meyers Robert A, Molecular Biology Biotechnology. John Wiley.
11. Sambrook J, Fritsch E F and Maniatis T, Molecular cloning: A laboratory Manual. Cold Spring Harbor Laboratory.
12. Howe, Gene cloning and Manipulation, Cambridge
13. Lodge *et al,* Gene cloning, Taylor and Francis.
14. Rastogi, Genetic Engineering, Oxford.
15. Satyanarayana, Biotechnology (2017)

MSMOB03DSE09: Genomics & Bioinformatics

45 Hours **3 Credits**

Course Objectives:

The objective of this course is to teach genomics and bioinformatics, with a brief introduction to transcriptomics, proteomics and metabolomics. The course will cover recent developments in genomics- genome mapping, pharmacogenomics, human genome project and its future etc. This course will outline the brief historical context of sequencing, provide an introduction to what bioinformatics is and why it is important, along with an overview of the application areas of bioinformatics,

Course Learning Outcomes:

Upon completion of this course, students will be able to

- be able to describe recent advances in genomics, transcriptomics, proteomics and metabolomics.
- be able to explain some of the current genomics technologies and illustrate how these can be used to study gene function.
- be exposed to available bioinformatics tools and databases
- get trained in the application of programs used for database searching, protein and DNA sequence analysis, and prediction of protein structures.
- be able to locate and evaluate current scientific literature and discuss the important findings of these publications in writing.

MODULE-1

The Human genome: Organization of genes and related sequences – pseudo genes and microsatellites. Organellar genomes: Special features of yeast mitochondria and human mitochondrial genome – petite mutants of yeast. Mapping genomes: Genetic mapping – physical mapping – restriction mapping – Fluorescent *in situ* hybridization (FISH) – sequence tagged site (STS) mapping.

MODULE-2

Sequencing genomes: pyrosequencing-Next generation sequencing- assembly of contiguous DNA sequence – sequence assembly by shot gun approach – sequence assembly by clone contig approach – whole genome shot gun sequence – Human genome project – sequencing the human genome – future of the human genome project (hapmap, 1000 genome project). Understanding a genome sequence: Locating the genes in a genome sequence – determining the function of individual genes – computer analysis of gene function – assigning gene function by experimental analysis.

MODULE-3

Pharmacogenomics and its applications: Historical perspectives and current status – Genetic polymorphism – SNPs – personalized medicine. Genome evolution and phylogenetics: Origin of genome – acquisition of new genes – non coding DNA – genome evolution -phylogenetic tree as a tool in the study of human prehistory – origin and migration of modern human.

MODULE-4

Bioinformatics: Introduction – genomics – transcriptomic – proteomic-metabolomics. Biological databases: Generalized and specialized databases – DNA, protein and carbohydrate databases – nucleic acid sequence databases – premier institutes for databases

– nucleic acid codes used in database formats; Collection and down loading of information from databases – literature search. Sequence alignment and its evolutionary basis: Simple alignment and multiple sequence alignment - searching the database for sequence similarity – search programmes with special reference to FASTA, BLAST, CLUSTAL W. Application of bioinformatics in phylogenetic analysis.

References:

1. Dale J W and Schantz M V, From Genes to Genome. Wiley.
2. Brown T A, Gene Cloning and DNA Analysis. Blackwell Science.
3. Winnacker E L, From Genes to Clones: Introduction to Gene Technology. Panima.
4. Benjamin Lewin, Genes IX. Jones and Bartlett.
5. Daniel L Hartl and Elizabath W Jones, Gentics: Analysis of Genes and Genome. Jones and Bartlett
6. Young, Computerized Data Acquisition and Analysis For Life Sciences. Cambridge University Press.
7. Xiong, Essential Bioinformatics. Cambridge University Press.
8. Marketa J Zvelebil, Understanding Bioinformatics. Garland Science.
9. Shui Quing Ye, Bioinformatics: A practical Approach.
10. Anna Tramontano, Introduction to Bioinformatics
11. David W Mount, Bioinformatics. CBS
12. Mani K and Vijayaraj N, Bioinformatics. Kalaikathir Achchagam.
13. Augen Jeff, Bioinformatics in the post genomic era. Addison Wesley.
14. Cohen Nadine, Pharmacogenomics and personalized medicine
15. Lesk, Introduction to Genomics, Oxford
16. Ruvinsky et al., Mammalian Genomics, Oxford
17. Faridi, Genetics and Genomics, Pearson
18. Bosu et al, Bioinformatics, Oxford
19. Rastogi et al,. Bioinformatics, Oxford.

MSMOB03DSE10: Molecular Neurobiology

45 Hours **3 Credits**

Course Objectives:

Main objective of the Molecular Neurobiology Course is to develop an in-depth knowledge about the Molecular level organization of nervous system and functioning. It will also deal with the molecular basis of some of the important neuronal disorders.

Course Learning Outcomes:

Upon completion of this course, students will be able to

- Understand the structure and function of nervous system organization
- Describe molecular structure of different types of neuronal cells
- Understand about functioning of neuronal circuits and how it controls normal body functioning
- Comprehend the molecular pathology of the important neurological disorders including neurodegenerative disorder and neurodevelopmental disorder.

MODULE-1

Organization of the nervous system- Structure and anatomy of Nervous system- Central and Peripheral nervous system. Types of cells in the nervous systems: sensory neurons, motor neurons, or interneurons, Neuroglia – CNS Synapses: Types and anatomy.

MODULE-2

Overview of neuronal activities- Resting potential, Transmembrane potential, Action potential- Neuronal membrane: passive forces and active forces in the membrane- Changes in the transmembrane potential, Propagation of transmembrane potential- Synapse: General properties, chemical electrical- Cholinergic neuro-transmission: events, Synaptic Delay, Synaptic Fatigue- Neurotransmitters and neuromodulators: types and functions.

MODULE-3

An introduction to brain and Spinal cord- Major brain and spinal cord regions and its functions: Cranial and spinal meninges, Cerebrospinal fluid, blood-brain barrier, spinal nerves- Spinal reflexes: reflex arc, classification- An introduction to neuronal integration: overview, neuronal receptors and functions- Molecular structure and functions of sensory organs: Vision, taste, somatosensation and olfaction- Circadian rhythm- Memory and learning- Synaptic plasticity.

MODULE-4

Methods in neurobiology-Animal models in neurobiology, Genetic and molecular techniques in neurobiology, Recording and manipulating neuronal activity.

Neuronal disorders- Types and its pathological features. Molecular pathology of important Neuro degenerative disorders- Alzheimer’s disease, Parkinson’s disease, amyotrophic lateral sclerosis (ALS)-Neurodevelopmental Disorders-Psychiatric disorders.

References:

1. Principles of Neurobiology, Luo Liqun, (2015), Taylor & Francis Inc.
2. Fundamental Neuroscience, Squire et al., (2008), Academic Press and Elsevier.
3. Neurobiology, Gordon M. Shepherd, (1994), Oxford University Press.
4. Basic Neurochemistry: Principles of molecular, cellular and medical neurobiology, Brady ST et al., (2012) 8th Edn, Academic Press, USA.

5. Elements of molecular neurobiology, Smith CUM, (2002) John Wiley & Sons Ltd, England.
6. Fundamental Neuroscience for Basic and Clinical Applications, 5th Edn, by Duane E. Haines and Gregory A. Mihailoff (2018), Elsevier.
7. Handbook of Neurochemistry and Molecular Neurobiology, Abel Lajtha, Maarten E. A. Reith, (2020), Springer.
8. Neuropsychiatry and Behavioral Neurology: Principles and Practice 1st Edn by David S, Laura T. S., Kirk R. D. (2021), McGraw Hill.
9. Neurobiology, (2011), Parasher, Y.K Campus Books International, India.

MSMOB03DSE11: Forensic Biology & DNA Profiling

45 Hours **3 Credits**

Course Objectives:

The objective of this course is to discuss the principles of serology and immunology and to explain the bloodstains investigations techniques. It also aims at informing the students about various protected and endangered species of animals and plants and introduction of wildlife (protection) act 1972. The student would be able to understand the forensic DNA profiling and its application in criminal and civil investigations.

Course Learning Outcome

Upon completion of this course, students will be able to

- to learn about various serological techniques used to analyse blood samples for criminal investigation.
- be able to analyse microscopic and macroscopic examination of biological samples like plant, hair recovered from crime scene.
- learn the techniques used in DNA Profiling.
- understand the Concept of gene and sequence variation.

MODULE-1

Cell structure and functions. Structure and function of carbohydrates, fats and proteins, serum proteins, haemoglobin and its variants, haptoglobins, HLA, polymorphic enzymes, blood groups-history, biochemistry and genetics of ABO, Rh, Mn and other systems, Methods of ABO blood grouping from fresh blood and biological stains, body fluids, determination of secretor status, polymorphic enzyme typing, serogenetic markers, determination of origin of species, immunology, immune response, antigens, haptens and antibodies, function and rising of antisera, lectins. Bloodstains investigations: Blood pattern analysis, ageing of bloodstains, difference between human and animal bloodstains, spectroscopic analysis.

MODULE-2

General plant classification schemes. Sub specialisation of forensic botany- plant morphology, plant anatomy, plant systematic, palynology, plant ecology. Wood and timber analysis. Diatoms and their forensic importance. Study and identification of various diatoms. Paper and pulp identification. Introduction and importance of wild life. Protected and endangered species of animals and plants. Sanctuaries and their importance. Introduction to Wildlife (Protection) Act 1972 and CITES, Relevant provision of wild life and environmental act. Types of wildlife crimes, different methods of killing and poaching of wildlife animals. Collection and preservation of hair samples. Morphological and microscopic examination of human and animal hair. Hair growth and development, determination of origin, race, sex, site from hair. Comparison between human and non-human hair. Macroscopic and microscopic features of hair.

MODULE-3

Double helical structure of DNA, alternate forms of DNA double helix, denaturation and renaturation of DNA, DNA binding proteins, factors affecting DNA stability, types and structure of RNA. Chemical nature of DNA and RNA. Nature and structure of human genome and its diversity.mt-DNA, Y-Chromosomes and the peopling, migration, of modern humans, Forensic DNA profiling and its application in criminal and civil investigations.

MODULE-4

Concept of gene – Conventional and modern views. Concept of sequence variation - VNTRs, STRs, Mini STRs , SNPs. Detection techniques - RFLP, PCR amplifications, Amp-FLP, sequence polymorphism, Y-STR, Mitochondrial DNA. Disputed paternity cases. Missing person identity, population genetics and legal admissibility of DNA evidence. Concepts of length and sequence DNA polymorphism, DNA markers (VNTRs, Stars, SNPs, Y-STRs, mt DNA)- their importance and detection. DNA extraction, it's qualitative and quantitative assessment, Polymerase chain reaction (PCR), Generation and assessment of DNA profiles, Statistical interpretation of DNA profiles, evaluation and presentation of DNA evidence, Kinship testing and lineage markers DNA databanks and their utility in various criminal investigations.

References:

1. Brown, T; Gene cloning and DNA analysis: An Introduction , 5th ed. Blackwellpublishing, London, 2006 .
2. Butler, J; Advanced Topics in Forensic DNA Typing: Methodology, 1st Ed., Academic Press, London, 2009.
3. Easteal, S. McLeod, N. & Reed, K; DNA Profiling: Principles, Pitfalls and Potential, Harwood Academic Publishers, New Jersey, 1991.
4. Primorac, D.&Schanfield, M; Forensic DNA Applications: An Interdisciplinary Perspective, CRC Press, New York, 2014.
5. Rudin, N. & Inman, K; An Introduction to Forensic DNA Analysis, Second Ed.,CRC press, New York, 2001.
6. Spencer, C; Genetic testimony: a guide to forensic DNA profiling, Pearson, New Delhi, 2004.

MSMOB03DSE12: Developmental Biology

45 Hours **3 Credits**

Course Objectives:
The objective of this elective course is to provide a comprehensive understanding of the concepts of early development in animals and plants.

Course Learning Outcomes:
Upon completion of this course, students will be able to
- Understand the basic concepts of development
- Explain Gametogenesis, fertilization and early development
- Describe Morphogenesis and organogenesis in animals
- Describe Morphogenesis and organogenesis in plants

MODULE-1
Basic concepts of development: Potency-commitment, specification, induction-competence-determination and differentiation-morphogenetic gradients-cell fate and cell lineages-stem cells.

MODULE-2
Gametogenesis, fertilization and early development: Production of gametes-cell surface molecules in sperm egg recognition in animals-Embryo sac development and double fertilization in plants-zygote formation-cleavage-blastula formation-embryonic fields-gastrulation and formation of germ layers in animals-Embryogenesis.

MODULE-3
Morphogenesis and organogenesis in animals: Cell aggregation and differentiation in Dictyostelium-Axes and pattern formation in Amphibia and chick-vulva formation in *Caenorhabditis elegans*, eye lens induction, limb development and regeneration in vertebrates - Post embryonic development - larval formation – metamorphosis - sex determination

MODULE-4
Morphogenesis and organogenesis in plants: Organization of shoot and root apical meristem-Shoot and root development-leaf development and phyllotaxy-Transition to flowering.

<u>**References**</u>:

1. Scott F Gilbert, Developmental Biology, 2016, Eleventh Edition Sinauer Associates, Inc.,Sunderland.
2. B.I.Balinsky & B.C.Fabian, An Introduction to Embryology. 1981. Fifth Edition. Cengage Learning India.
3. Abhilash Jain, Advanced Developmental Biology. 2010. Campus Books International
4. Geoffrey M Cooper, Robert E Hausman, The cell-A molecular Approach. 2016. Seventh Edition. Sinauer Associates
5. Elena Notarianni, Martin J Evans, Embryonic stem cells- A Practical Approach, 2007. OUP Oxford
6. Twyman R M. Developmental Biology. 2001. Viva Books Private Ltd.
7. Slack J. M. W. Essential Developmental Biology. 2013. Third edition. Wiley Blackwell.

MSMOB04DSE13: Bioprocess Technology

45 Hours **3 Credits**

Course Objectives:
The objective of this elective course is to provide a comprehensive overview on the instruments used in bioprocess and methods to improve modern biotechnology.

Course Learning Outcomes:
Upon completion of this course, students will be able to
- be able to understand the need for sustainable innovation and how biotechnology and biobased production can contribute to this.
- be able to integrate scientific and technological knowledge on the use of bioprocesses for industrial products on the cell and process level.

MODULE-1
Introduction to Bioprocess-Fermentation Types – surface, submerged, solid state, adhesive, batch, continuous, fed batch, immobilized and anaerobic. Media for industrial fermentation, media optimization, Sterilization-heat sterilization-filter sterilization; development of inoculum;

MODULE-2
Bioreactor – ideal reactors; aeration agitation, foam control, process control equipments; Packed bed, fluidized bed and airlift reactors; Microbial batch and continuous growth Kinetics - chemostat and turbidostat mode of operation; mass transfer, heat transfer and mass balance.

MODULE-3
Bioproduct technology: Assay of fermentation products and use of biosensors. Downstream processing- cell disruption methods-precipitation-filtration-concentration-purification and finishing
Fermentation economics, market potential, process cost, recovery cost and future of bioprocess technology
Bioproduct processing : production of microbial biomass, enzymes, vaccines, vitamins, microbial transformation of steroid,

MODULE-4
Bioproduct processing –Anaerobic fermentation - Wine, beer, industrial alcohol, acetone-butanol, lactic acid and glycerol production. Aerobic fermentation–vinegar, citric acid, gluconic acid, fermanic acid, Kojic acid, amino acids and antibiotics (Penicillin and streptomycin) production.

References:

1. Michael J Waites, et al., Industrial Microbiology: An introduction. Blackwell Science.
2. EI-Mansi, E.M.T and Bryce, C.F.A. Fermentation Microbiology and Biotechnology.
3. L.E. Casida, J.R Industrial Microbiology. New international (p) Ltd. Publishers. (2012)
4. Kavita, Industrial Biotechnology, AITBS publishers
5. Demain and Davies, Manual of industrial Microbiology and Biotechnology,

Panima.(2nd edition 1999)
6. P.F.Stanburry, Principles of fermentation technology. (2nd edition 2008)
7. M.L Shuler and F.Kargi, Bioprocess engineering basic concepts (2nd edition 2002)
8. Pauline M Doran, Bioprocess Engineering principles

MSMOB03DSE14: Molecular Evolution

45 Hours **3 Credits**

Course Objectives:
The objective of this elective course is to provide a comprehensive overview of the concepts of evolution at molecular level. This will also provide adequate knowledge about microevolution, origin of life and evolution of man.

Course Learning Outcomes:
Upon completion of this course, students will be able to
- understand the concepts of molecular evolution
- learn most of the essential aspects of evolution in detail, which will help them in acquiring better understanding of the subject.

MODULE-1
Molecules and Origin of life: Origin of basic biomolecules - origin of organized structures (coacervates, microspheres); RNA world, evolution of protein synthesis, evolution of genetic code, prokaryotes and eukaryotes - evolution of eukaryotic organelle, genetic constancy and variability – chromosomal variation – gene mutation - gene duplication- evolutionary history of haemoglobin, cytochrome C, pseudogene, genetic polymorphism, evolutionary clock.

MODULE-2
Speciation: Isolating mechanisms – Founder principle – bottleneck effect – genetic drift – and gene flow.

MODULE-3
Microevolution – Macroevolution and punctuated equilibrium – anagenesis and cladogenesis.

MODULE-4
Culture and human evolution; learning, society and culture – cultural and biological evolution – Social Darwinism, sociobiology, biological limitations, deleterious genes, eugenics.

References:

1. Strickberger M W, Evolution. Jones Barllett.
2. Volpe E P, Understanding Evolution. Universal Book Stall.
3. Li.W H, Molecular Evolution. Sinaur Associates.
4. Edwin H McConkey, Human Genetics: The Molecular Evolution. Jones and Bartlette.
5. Masatoshi Nei and Sudhir Kumar, Molecular Evolution and Phylogenetics. Oxford University Press.

MSMOB03DSC12: Lab in Molecular Biology, Genetic Engineering & Biotechnology

2 Credits

Course Objectives:
The objective of this practical course is to develop a working knowledge of the principles and procedures of molecular biology techniques.

Course Learning Outcomes:
Upon completion of this practical course, the students will be able to
- attain hands on training for various molecular biology techniques.
- explain the principles of cloning and genetic manipulation and their applications.

Contents:
1. Isolation of genomic DNA.

2. Isolation of plasmid DNA from *E.coli* – Separation by agarose gel electrophoresis.

3. Restriction digestion of plasmid – single, double digestion – determination of molecular weight – physical mapping.

4. Cloning of fragment in pBR 322/pUC – insertional inactivation - Bluewhite selection.

5. Re-isolation of plasmid from recombinant clone – restriction digestion and agarose gel electrophoresis – confirmation of size of insert.

6. PCR amplification of DNA, RFLP – gel electrophoresis – analysis of fragments.

7. Genomic and cDNA library construction.

8. Blotting technique – Southern, Northern and Western blotting.

9. DNA sequencing.

MSMOB03SEC01: Lab in Genomics & Bioinformatics

2 Credits

Course Objectives:
The objective of this practical course is to provide training in the application of programs used for database searching, protein and DNA sequence analysis, and prediction of protein structures.

Course Learning Outcomes:
Upon completion of this practical course, students will be able to

- acquire training in different areas of bioinformatics related to various biological databases such as protein databases, nucleic acid databases, metabolic pathway databases, etc.
- attain training in multiple sequence alignments, they will be in a position to perform in-silico experiments and will predict structures of proteins.

Contents:

1. Internet search for literature.
2. Genome Database services – Search against genes and genomes (BLAST / FASTA) – Gene annotation; DNA–Protein interactions, protein-protein interactions, similarity searches.
3. Use of software for sequence alignment (BLAST , FASTA , CLUSTAL W)
4. Phylogenetic analysis using bioinformatics software.
5. Alignment of protein sequence using Bioinformatics software

MSMOB03VAC01: Academic Scientific Writing

30 Hours **2 Credits**

Course Objectives: The objective of this course is to equip students with the necessary skills and knowledge to produce high-quality academic and scientific writing. Through a combination of theoretical learning and practical exercises, students will learn how to effectively communicate complex ideas, research findings, and arguments in various academic and scientific contexts. By the end of the course, students will have the confidence and proficiency to write clear, concise, and well-structured academic papers, reports, and articles.

Course Learning Outcomes:
Upon completion of this course, students will be able to:
- Understand the conventions and standards of academic and scientific writing.
- Identify and analyze different types of academic and scientific texts.
- Develop critical thinking and analytical skills for evaluating research literature.
- Formulate clear research questions and hypotheses.
- Structure and organize academic papers, reports, and articles effectively.

MODULE I
Introduction to Academic and Scientific Writing-Overview of the course objectives and expectations, Characteristics and conventions of academic and scientific writing. Understanding Academic Texts-Analyzing different types of academic texts (research articles, literature reviews, etc.), Identifying key components and structures of academic papers

MODULE II
Formulating Research Questions and Hypotheses-Developing clear and focused research questions, Understanding the role of hypotheses in scientific writing. Conducting Effective Research-Introduction to academic databases and search strategies, Ethical considerations in research and writing

MODULE III
Synthesizing Information-Strategies for synthesizing and integrating information from multiple sources, Paraphrasing and summarizing techniques, Avoiding plagiarism in academic writing. Structuring Academic Papers-Components of an academic paper (introduction, literature review, methodology, results, discussion, conclusion), Organizing ideas and arguments logically

MODULE IV
Language and Style in Academic Writing-Choosing appropriate language and style for academic writing, Writing clearly and concisely. Citation and Referencing-Understanding different citation styles (APA, MLA, Chicago, etc.), Incorporating citations into academic writing. Revision and Editing-Importance of revising and editing in the writing process, Techniques for revising and editing academic papers.

References:

1. Joshua Schimel (2012). Writing Science: How to Write Papers That Get Cited and Proposals That Get Funded. Oxford University Press.
2. Angelika H. Hofmann (2016) 2nd Edition. Scientific Writing and Communication: Papers, Proposals, and Presentations. Oxford University Press.

3. Michael Alley 2018 (4th Edition). The Craft of Scientific Writing. Springer.
4. Scott L. Montgomery, 2017 (2nd Edition). The Chicago Guide to Communicating Science". University of Chicago Press.
5. Heather Silyn-Roberts 2012 (2nd Edition). Writing for Science and Engineering: Papers, Presentations and Reports. Elsevier.
6. Mimi Zeiger 1999 (2nd Edition). Essentials of Writing Biomedical Research Papers. McGraw-Hill Education

MSMOB03VAC02: Advanced forensic DNA analysis and profiling

30 Hours **2 Credits**

Course Objectives:

This course provides an in-depth understanding of advanced techniques and methodologies used in forensic DNA analysis and profiling. It covers topics ranging from DNA extraction and quantification to the interpretation of complex DNA profiles. Students will gain practical knowledge through case studies (laboratory exercises, if possible). The student would be able to understand the forensic DNA profiling and its application in criminal and civil investigations.

Course Learning Outcome

Upon completion of this course, students will

- learn the techniques used in DNA Profiling.
- understand the Concept of gene and sequence variation.

Module I (6-8 hours)

Introduction to Forensic DNA analysis: Overview of forensic biology and DNA profiling-historical developments in DNA analysis-legal and ethical aspects of DNA evidence.

DNA extraction and quantification: Methods of DNA extraction from various sample types-quantitative PCR (qPCR) for DNA quantification-quality control measures in DNA extraction.

Module II (6-8 hours)

Short Tandem Repeat (STR) analysis: Introduction to STR markers-capillary electrophoresis for STR analysis-allele calling and interpretation.

Advanced DNA profiling techniques: Mitochondrial DNA analysis-Y chromosomal DNA analysis-SNP genotyping for ancestry determination.

Module III (6-8 hours)

DNA mixture analysis and interpretation: complex DNA mixtures and challenges-statistical methods for mixture interpretation-case studies (practical exercises).

Emerging trends in forensic DNA analysis: Next-generation sequencing (NGS) in forensics-DNA phenotyping and predicting physical traits-ethical considerations in emerging technologies.

DNA database and CODIS (Combined DNA Index system): CODIS and its role in forensic investigations-national and international DNA databases-legal issues and privacy concerns.

Module IV (4-6 hours)

Forensic DNA evidence in court: expert witness testimony-presentation of DNA evidence in court-cross-examination and challenges.

Case studies and practical applications: review of real-life forensic cases-ethical dilemmas in DNA analysis-group discussion and analysis.

<u>References:</u>

1. Brown, T; Gene cloning and DNA analysis: An Introduction, 5th ed. Blackwellpublishing, London, 2006 .
2. Butler, J; Advanced Topics in Forensic DNA Typing: Methodology, 1st Ed., Academic Press, London, 2009.

3. Easteal, S. McLeod, N. & Reed, K; DNA Profiling: Principles, Pitfalls and Potential, Harwood Academic Publishers, New Jersey, 1991.
4. Primorac, D.&Schanfield, M; Forensic DNA Applications: An Interdisciplinary Perspective, CRC Press, New York, 2014.
5. Rudin, N. & Inman, K; An Introduction to Forensic DNA Analysis, Second Ed.,CRC press, New York, 2001.
6. Spencer, C; Genetic testimony: a guide to forensic DNA profiling, Pearson, New Delhi, 2004.

MSMOB03MDC03: Life & Genes

60 Hours **4 Credits**

Course Objectives:
This basic course is intended for those students, who are interested to know the living world around us, their diversity and finally to know they themselves through living technology.

Course Learning Outcomes:
Upon completion of this course, students will be able to
- understand how life originated in this earth.
- appreciate the concept of genes and living cells.

MODULE-I
Life: appearance of life – experimental studies for the origin of life – spontaneous generation, Pasteur experiment, Oparin's experiment, Miller's experiment.

MODULE-II
Biodiversity: Concept and scope of biodiversity – species biodiversity, ecosystem biodiversity, genetic biodiversity – biodiversity and health.

MODULE-III
Cell: General organization – Cell architecture – Biomolecules – cell cycle. Genome: Genetic material – central dogma of modern biology – DNA, RNA– genetic code – gene expression and regulation – Human genome.

MODULE-IV
Living Technology: Biotechnology – basic steps in genetic engineering - applications – Hazards and impacts on society.

References:

1. Biology. Raven *et.al.*
2. Biodiversity: Concept, conservation and biofuture. Mandal and Nandi.
3. Ecology. Subramanyan and Sambamurthy.
4. Fundamentals of Ecology. Odum and Barrett.
5. Cell and Molecular Biology. DeRobertis and DeRobertis.
6. The thread of life. Susan Aldridge
7. Biotechnology. John.E.Smith.
8. Gene cloning and DNA Analysis. T.A.Brown
9. Molecular Biotechnology, Principles and Application of Recombinant DNA. Glick & Pasternak.
10. DNA Science. Micklos & Freger

Experts involved in Syllabus revision

External experts:

Prof. Indranil Dasgupta, Department of Plant Molecular Biology, University of Delhi, South Campus, New Delhi

Prof. Chinmay K. Mukhopadhyay, Special Centre for Molecular Medicine, Jawaharlal Nehru University, New Delhi.

Prof. Elyas K. K., Department of Biotechnology, University of Calicut, Kerala.

Internal experts:

Dr. Soorej M. Basheer, Department of Molecular Biology, Kannur University

Dr. Sreeja Chellappan, Department of Molecular Biology, Kannur University

Dr. Anupama K. P., Department of Molecular Biology, Kannur University

Dr. Arun Kumar G., Department of Molecular Biology, Kannur University

Dr. Smitha K.V., Department of Molecular Biology, Kannur University

Dr. Nimisha Vijayan P, Department of Molecular Biology, Kannur University