CENTRAL UNIVERSITY OF PUNJAB

M.Sc. in Molecular Medicine

Batch - 2022

Department of Human Genetics and Molecular Medicine

Syllabus

MSc in Molecular Medicine (Batch-2022)

Graduate Attributes

Context of Society

The students of this course will understand the significant role of cell and molecular biology, Pathophysiology of common diseases and therapeutic strategies in the broader societal context. There will be an understanding of the basics of professional ethics, research ethics, biosafety issues, and the principles of professional practice.

Enterprising and Knowledgeable

The course content will develop skills in regenerative medicine, molecular biology, and bioinformatics and cutting-edge molecular techniques through the subject content across a broad range of modules among the students. The development of skills in molecular medicine will enhance employability in the field biomedical sciences and clinical practices. The emphasis is on student-centric learning where they solve the patterns of inheritance by drawing pedigrees and discuss the current therapeutic interventions to treat specific genetic disorders.

Digital and research methodology-based skills

The students will be able to study and learn the effective use of digital tools to support academic writing, reference management and independent study using digital resources and learning materials. The understanding of the principles of experimental design and methods will help the students to explore new scientific approaches in translational research.

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Course Structure of the Programme

Total Credit: 86

	Core Subjects	Elective Courses			Foundation Courses		Total Credit
		DE	ID	SB	CF	EF/VB	
Sem-I	03 (9 Cr)	01 (3 Cr)	01 (2 Cr)	03 (3 Cr)	01 (3 Cr)	--	**20**
Sem-II	04 (12 Cr)	01 (3 Cr)	--	02 (4 Cr)	01 (3 Cr)	01 (2 Cr)	**24**
SEM-III	03 (9 Cr)	01 (3 Cr)	--	01 (3 Cr) 01 (4 Cr Dissertation)	01 (2 Cr) 01 (1 Cr)	--	**22**
SEM-IV	--	--	--	01 (20 Cr Dissertation)	--	--	**20**
Credit Score	**30**	**9**	**02**	**34**	**9**	**02**	**86**

DE: Discipline Elective
ID: Interdisciplinary
SB: Skill based (Practicals); Dissertation
CF: Compulsory foundation
EF: Elective Foundation
VB: Value Based

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Course Structure of the Programme

Semester-I

Course Code	Course Title	Course Type	Hours			Credit
			L	T	P	
MME.506	Cell Biology	Core	3	0	0	3
HGE.507	Concepts of Genetics	Core	3	0	0	3
MME.508	Biomolecules and Metabolism	Core	3	0	0	3
HGE.509	Biostatistics and Research Methodology	Compulsory Foundation	3	0	0	3
HGE.510	Concepts of Genetics (Practical)	Skill Based	0	0	2	1
MME.511	Biomolecules and Metabolism (Practical)	Skill Based	0	0	2	1
HGE.512	Biostatistics and Research Methodology (Practical)	Skill Based	0	0	2	1
Discipline Elective Course-I (Any one of the following)						
HGE.515	Population Genetics and Genetic Epidemiology	DE	3	0	0	3
MME.515	Molecular and Cellular Oncology	DE	3	0	0	3
ZOL.525	Nanobiology	DE	3	0	0	3
BIM.511	Protein Engineering	DE	3	0	0	3
Inter-disciplinary Course-I (For other Departments)						
HGE.518	Introduction to Intellectual Property Rights	IDC	2	0	0	2
XXX.	Choose from IDC courses offered by other Departments	IDC	2	0	0	2
					Total Credits	**20**

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Semester-II

Course Code	Course Title	Course Type	Hours			Credit
			L	T	P	
MME.521	Molecular Endocrinology and Signal Transduction	Core	3	0	0	3
MME.522	Essentials of Immunology	Core	3	0	0	3
MME.523	Techniques in Molecular Medicine	Core	3	0	0	3
HGE.524	Human Anatomy and Physiology	Core	3	0	0	3
MME.525	Essentials of Immunology (Practical)	Skill Based	0	0	2	1
MME.526	Practical Course in Molecular Medicine	Skill Based	0	0	6	3
MME.528	Molecular Biology	Compulsory Foundation	3	0	0	3
HGE.529	Principles of Ecological Sciences	Value based	2	0	0	2
XXX	Value Added Course (From other departments)	VAC	2	0	0	2
Discipline Elective Course-II (select anyone)						
MME.527	Stem Cell and Regenerative Medicine	DE	3	0	0	3
HGE.527	Human Embryology and Developmental Genetics	DE	3	0	0	3
MIC.525	Microbial Pathogenicity	DE	3	0	0	3
ZOL.553	Vascular Biology	DE	2	1	0	3
BIM.521	Big Data Analysis in Bioinformatics and Healthcare	DE	3	0	0	3
ZOL.554	Neurobiology and Degenerative Pathophysiology	DE	3	0	0	3
Total Credits						**24**

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Semester-III

Course Code	Course Title	Course Type	Hours			Credit
			L	T	P	
MME.551	Molecular Basis of Human Diseases	Core	3	0	0	3
MME.552	Genetic Engineering and Recombinant Therapeutics	Core	3	0	0	3
MME.553	Trends in Molecular Medicine	Core	3	0	0	3
MME.554	Tools in Bioinformatics (Practical)	Skill Based	0	0	6	3
Discipline Elective Course-III (select anyone)						
MME.555	Evolution and Developmental Biology	DE	3	0	0	3
HGE.555	Biosafety, Bioethics and IPR	DE	3	0	0	3
Compulsory Foundation Course						
MME.557	Concepts of Bioinformatics	Discipline Enrichment	2	0	0	2
HGE.558	Innovation and Entrepreneurship	Compulsory Foundation	1	0	0	1
MME.600	Dissertation Part-I	Skill Based	0	0	8	4
Total						**22**

Semester-IV

Course Code	Course Title	Course Type	Hours			Credit
			L	T	P	
MME.601	Dissertation Part-II	Skill Based	0	0	40	20
Total			**0**	**0**	**40**	**20**

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Semester I

Course Code: **MME.506**
Course Title: **Cell Biology**
Total Hours: **45**

L	T	P	C
3	0	0	3

Course Learning Outcomes:

On successful completion of the course the student will be able to:
CLO1: Understanding structures and functions of various cellular organelles.
CLO2: Conceptualization of basic cellular mechanisms.
CLO3: Conceptualize the mechanisms of inter- as well as intra-cellular communications.
CLO4: Understanding the cell cycle regulation and its importance in disease biology

Unit 1 **12 Hours** Introduction to the cell: Models of membrane structure, Membrane proteins, Membrane carbohydrates, Membrane transport of small molecules, Membrane transport of macromolecules and particles. Structural organization and function of intracellular organelles: The lysosomes, Ribosomes, The peroxisomes, The Golgi apparatus, The endoplasmic reticulum, Mitochondria.	**CLO1**
Unit 2 **10 Hours** Protein secretion and sorting: Protein secretion, synthesis and targeting to mitochondria, chloroplast, peroxisomal proteins, translational modification in the ER. Intracellular traffic, vesicular traffic in the secretary pathway, protein sorting in the Golgi bodies, traffic in the endocytic pathway, exocytosis.	**CLO2**
Unit 3 **14 Hours** The cytoskeleton: The nature of cytoskeleton, Intermediate filaments, Microtubules, Actin filaments, Cilia and centrioles, Organization of the cytoskeleton. Cell communication and cell signaling: Cell adhesions, Cell junctions and the extra cellular matrix, Cell-cell adhesion and communication, Cell matrix adhesion, Collagen the fibrous protein of the matrix, Non-collagen component of the extra cellular matrix.	**CLO3**
Unit 4 **9 Hours** Cell growth and division: Overview of the cell cycle and its control, molecular mechanisms for regulating mitotic and meiotic events, Amitosis, Cell cycle control, Checkpoints in cell cycle regulation.	**CLO4**

Transactional Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.

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Internal assessment shall be through any of the following: Surprise Tests, one sentence summary, case analysis, simulated problem solving, open book techniques, classroom assignments, homework assignments, term paper, presentations, and discussions.

Suggested Reading:

1. Alberts, B., Bray, D., Lews, J., Raff, M., Roberts, K. and Watson, J.D. (2010). Molecular Biology of the cell. Garland publishers, Oxford.
2. Celis, J.E. (2006). Cell biology: A laboratory handbook, Vol 1, 2, 3. Academic Press, UK.
3. Gupta, P.K. (2008). Cytology, Genetics and Evolution. Rastogi publications, Meerut, India.
4. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. John Wiley & Sons. Inc. New Delhi, India.

Course Code: **HGE.507**
Course Title: **Concepts of Genetics**
Total Hours: **45**

L	T	P	C
3	0	0	3

Course Learning Outcomes:

On successful completion of the course the student will be able to:

CLO1: Evaluate the Mendelian and Non-Mendelian inheritance patterns. Gather knowledge about gene expression regulation and sex determination,

CLO2: Evaluate different chromosomal aberrations and ploidies

CLO3: Know about genetic system of microbes

CLO4: Know the details of extra chromosomal inheritance patterns

UNIT I **11 Hours** **Transmission Genetics**: Mendel's laws of inheritance and its applications; concept of segregation, independent assortment and dominance; pedigree analysis; epistasis; crossing over and recombination; gene linkage and genetic mapping **Sex determination**: Sex determination in Human and Drosophila; X-chromosome inactivation; dosage compensation.	**CLO1**
UNIT II **12 Hours** **Chromosomal Mutations**: Chromosomal aberrations: structural and numerical; evolutionary history of bread wheat; aneuploids–nullisomics, monosomics, and trisomics; somatic aneuploids; changes in chromosome structure; properties of chromosomes for detection of structural changes; mutations and it's types; complementation and recombination; transposable elements in Pro- and Eukaryotes. **Genes and genome dynamics**: Fine structure of gene; and analysis, Benzer's experiments.	**CLO2**

UNIT III **11 Hours** **Microbial Genetics:** Genetic systems of Viruses and Bacteria; genetic analysis and mapping in Bacteria and Bacteriophages – conjugation, transformation and transduction; recombination and gene mapping; evolution of microbial genome.	**CLO3**
UNIT IV **11** Hours **Extra-chromosomal inheritance:** Chloroplast: variegation in Four O' Clock plants; mutations in *Chlamydomonas*; mitochondrial inheritance: poky in neurospora, petites in yeast; molecular organization and gene products of chloroplast and mitochondrial DNA; infectious heredity: Kappa in *Paramecium*: Infective particles in *Drosophila*; endosymbiont theory.	**CLO4**

Transactional Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.

Internal assessment shall be through any of the following: Report on novel chromosome aberrations in human, Discussion on transposable elements in human diseases, Surprise Tests, one sentence summary, case analysis, simulated problem solving, open book techniques, classroom assignments, homework assignments, term paper, Karyotype analysis presentations and discussions.

Suggested Readings:

1. Klug WS and Cummings MR. Concepts of Genetics. Prentice-Hall.2014
2. Anthony, J.F. Miller, J.A. Suzuki, D.T., Richard, R.C., Gilbert, W.M. (1998). An introduction to Genetic Analysis. W.H. Freeman publication, USA.
3. Pierce BA. Genetics: A Conceptual approach. Freeman Publishers.
4. Hartle DL and Jones EW. Genetics: Analysis of Genes and Genomes. Jones & Bartett.
5. Atherly, A.G., Girton, J.R., Mcdonald, J.F. (1999). The Science of Genetics. Saundern College publication.
6. Snusted, D.P., Simmons, M. J. (2010). Principles of Genetics. John Wiley & Sons, New
7. Griffith AF et al. An Introduction to Genetic Analysis. John Wiley & Sons.

Course Code: **MME.508**
Course Title: **Biomolecules and Metabolism**
Total Hours: **45**

L	T	P	C
3	0	0	3

Course Learning Outcomes:

On successful completion of the course the student will be able to:

CLO1: Evaluate the basic concepts of Enzymes, Enzyme Kinetics, and its role in metabolic processes. Conceptualize the basic features of enzyme catalysis and regulation.

CLO2: Study the basic structural features of carbohydrates and its metabolism.

CLO3: Conceptualization of pathways in lipid metabolism.

CLO4: Study the structure of nucleic acids, amino acids and proteins and their metabolism.

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Unit-1 **12 Hours** Enzymes: Importance & Classifications; Properties of enzymes; Isozymes; Enzyme nomenclature; Factors affecting enzyme action, Enzyme regulation; Mechanism of enzyme action; Enzyme kinetics & enzyme inhibiters; ES complex formation; Michaelis-Menten equation; Line-weaver Burk plot; Km value and its significance; Turnover number; Enzyme inhibitors, Allosteric enzymes. Ribozymes and Abzymes.	**CLO1**
Unit-2 **11 Hours** Carbohydrates: Structure and functions of monosaccharides, disaccharides, and polysaccharides; Epimers; Anomers; mutarotation. Reactions of carbohydrates. Carbohydrate's metabolism - General scheme of metabolism. Glycolysis, TCA cycle, Gluconeogenesis, Glycogenolysis, Pentose phosphate pathway, and their regulation; Oxidative phosphorylation	**CLO2**
Unit-3 **11 Hours** Lipids: Classification - simple, compound and derived lipids with examples and their role in human body. Lipid metabolism: Beta oxidation - Pathway and regulation. Role of acyl carnitine in fatty acyl transport. Biosynthesis of cholesterol and regulation. Formation of Ketone bodies.	**CLO3**
Unit-4 **11 Hours** Amino acids: Classification and reactions of amino acids. Metabolism of Amino Acids. Proteins: Classification and biological importance of protein in human body; Secondary, Tertiary and Quaternary structure, Ramachandran plot. Oxygen binding proteins – Hemoglobin and myoglobin. Hill equation, Bohr's Effect. Nucleic Acids: Structure and functions. Metabolism of purines and pyrimidines-Salvage and de novo pathways.	**CLO4**

Transactional Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.

Internal assessment shall be through any of the following: Surprise Tests, Group discussion, one sentence summary, case analysis, simulated problem solving, open book techniques, classroom assignments, homework assignments, term paper, presentations, and discussions.

Suggested Readings:

1. Berg, J. M., Tymoczko, J. L., & Stryer, L. (2012). Biochemistry. W.H. Freeman & Company. USA.
2. Brown, T. A. (2016). Gene cloning and DNA analysis: an introduction. John Wiley & Sons.
3. Price, N. C., Price, N. C., & Stevens, L. (2003). Fundamentals of Enzymology: The Cell and Molecular Biology of Catalytic Proteins. Oxford University Press.
4. Mathews, C.K., Van Holde, K.E. & Ahern, K.G. (2000). Biochemistry. Oxford University Press Inc. New York.

5. Nelson, D. & Cox, M.M. (2008). Lehninger Principles of Biochemistry.BI publications Pvt. Ltd. Chennai, India.
6. Palmer, T., & Bonner, P. L. (2001). Enzymes: Biochemistry. Biotechnology, Clinical Chemistry. Horwood Publishing Chichester.
7. Deininger, P. (1990). Methods in enzymology, vol. 185, gene expression technology: Edited by David V. Goeddel. Academic Press, San Diego, CA.
8. Raven, P.H., Johnson, G.B. & Mason, K.A. (2007). Biology. Mcgraw-Hill. USA.
9. Shukla, A. N. (2009). Elements of enzymology. Discovery Publishing House.
10. Voet, D. & Voet, J.G. (2008). Principles of Biochemistry. CBS Publishers &Distributors. New Delhi, India.
11. R Swaminathan. (2011). Handbook of clinical biochemistry. 2 edition, World Scientific Publishing Company, New Jersey, USA

Course Code: **HGE.509**
Course Title: **Biostatistics and Research Methodology**
Total Hours: **45**

L	T	P	C
3	0	0	3

Course Learning Outcomes:
On successful completion of the course the student will be able to:
CLO1: Analyze and evaluate wide variety of statistical data
CLO2: Compose statistical data and summary statistics in graphical and tabular forms. Perform biological sampling and statistical analysis.
CLO3: Apply suitable statistical tools to analyze data
CLO4: Write and communicate scientific reports, projects, and publications.

UNIT I **11 Hours** **Overview of Biostatistics:** Basic concepts of statistical data and different types of tables; graphical representation of experimental data for publication; frequency distribution; measurement of central tendency and variation.	**CLO1**
UNIT II **11 Hours** **Experimental design and analysis:** Basics of sampling in biological studies; different types of sampling techniques; various steps in sampling; concept of data distribution in sampling; graphical representation of data; level of significance; hypothesis testing.	**CLO2**
UNIT III **11 Hours** **Inferential Statistics:** Chi-Square test: hypothesis testing, contingency, homogeneity; student's t-test: paired and unpaired, one tailed and two tailed; one-way and two-way analysis of variance (ANOVA); correlation and regression.	**CLO3**
UNIT IV **12 Hours** **Study design & Technical writing:** Best practices in research and technicality of research design; interpretation and report writing, e-Library; web-based literature search engines; evaluation-based development of scientific writing skill: synopsis, research paper, poster preparation and paper presentation and dissertation.	**CLO4**

Transactional Modes: Lecture**;** Tutorial; Problem solving; Self-learning.
Internal assessment shall be through any of the following: Surprise Tests, student generated questions, case analysis, simulated problem solving, open book techniques, classroom assignments, homework assignments, term paper.

Suggested Readings:

1. Rao, S.P.S.S. Richard, J. (2016). Introduction to biostatistics and research methods. 5th Ed. Phi Learning Pvt. Ltd. New Delhi.
2. Hoffman, J. (2015). Biostatistics for medical and biomedical practioners. 1st Ed. Academic Press, London.
3. Banerjee P.K (2014). Introduction to Biostatistics. S.Chand, New Delhi.
4. Antonisamy, B. Christopher, S. Samuel, P.P. (2011). Biostatistics: Principles and Practice. Tata McGraw Hill. New Delhi.
5. Daniel W.W (2011). Biostatistics: Basic Concepts and methodology for the health sciences. 9th Ed. John Wiley and Sons Inc, New Delhi.
6. Norman, G. and Streiner, D. (2008). Biostatistics: The Bare Essentials. (With SPSS), 3rd Edition, Decker Inc. USA.
7. Sokal, R.R. and Rohlf, F.J. (1994). Biometry: The Principles and Practices of Statistics in Biological Research. W.H. Freeman publishers, USA.

Course Code: **HGE.510**
Course Title: **Concepts of Genetics (Practical)**
Total Hours: **30**

L	T	P	C
0	0	2	1

Course Learning Outcomes:
On successful completion of the course the student will be able to:

1. Perform any experiments on Mendelian genetics and pedigree analysis
2. Perform linkage based genetic analysis
3. Design genetic experiments using common model organisms
4. Isolate genomic DNA for genetic analyses

List of Practical work:

1	Problems on Monohybrid and dihybrid ratios, Multiple alleles, Epistasis	CLO1
2	Inheritance patterns in Human– Numerical on Pedigree analysis- Autosomal patterns, X–linked patterns, Y–linked patterns	
3	Segregation analysis in Drosophila (Monohybrid, Dihybrid)	
4	Analysis on Linkage	CLO2
5	Linkage mapping	
6	Identification of inactivated X chromosome as Barr body	CLO3
7	Studies of a Model organism: *E. coli*, *C.elegans*, *D. melanogaster* and *D.*	

	rerio	
8	Isolation of genomic DNA and quality control	CLO4

Transactional Modes: Hands-on practicals; Demonstration**;** Virtual classrooms; Tutorial**;** Self-directed learning.

Evaluation criteria for practical courses:

- Continuous Assessment = **60 Marks**
  Based on performance of the students and completion of the record book (60 divided by the number of practicals)
- Final Examination = **40 Marks**
  Subjective question = **10 Marks**
  Performing experiment = 20 Marks
  Viva voce = 10 Marks

Course Code: **MME.511**
Course Title: **Biomolecules and Metabolism (Practical)**
Total Hours: **30**

L	T	P	C
0	0	4	2

Course Learning Outcomes:

Course Learning Outcomes:

On successful completion of the course the student will be able to:

CLO1: Prepare buffers and solutions with varied concentration.

CLO2: Isolation of DNA from the blood samples

CLO3: Quantitative estimation of biomolecules and their role in health and disease

CLO4: Evaluate the effect of temperature, pH and substrate concentration on enzyme activity

List of Practicals

1. Preparation of Buffers	**CLO1**
2. Extraction of DNA, and purity check by electrophoresis.	**CLO2**
3. Quantitative estimation of Glucose. 4. Quantitative estimation of Cholesterol 5. Quantitative estimation of Proteins 6. Quantitative estimation of Nucleic Acids	**CLO3**
7. Assay of enzyme activity in saliva. 8. Effect of temperature on enzyme activity. 9. Effect of pH on enzyme activity.	**CLO4**

Suggested Readings:

1. Rajendran, S., Dhiman, P. (2019) Biochemistry Practical Manual. Elsevier India.
2. Plummer, D. (2004) An Introduction to Practical Biochemistry. Tata McGraw Hill Publishers Co. Ltd., India

3. Gupta, P.P., Gupta, N. (2017) Essentials of Practical Biochemistry. Jaypee Brothers Medical Publishers Pvt. Ltd. India.
4. Hofmann, A., Clokie, S. (2018). Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press, USA
5. Murphy M.J., Srivastava R., Deans, K. (2018) Clinical Biochemistry, 6th Edition. Elsevier's USA.
6. Swaminathan, R (2011) Handbook of Clinical Biochemistry, 2nd Edition, Publisher: World Scientific

Transactional Modes: Laboratory based practical; Problem solving; Self-learning.
Internal assessment shall be through any of the following: Case analysis, Lab Performance, Open book techniques, Instruments Demonstration, and Group discussions.

Evaluation criteria:

A. Continuous Assessment = **60 Marks (**Based on performance and good lab practices of the students and completion of the record book (60 divided by the number of practicals)

B. Final Examination = **40 Marks**
   i. Subjective question = 10 Marks
   ii. Performing experiment = 20 Marks
   iii. Viva voce = 10 Marks

Course Code: **HGE.512**
Course Title: **Biostatistics and Research Methodology (Practical)**
Total Hours: **30**

L	T	P	C
0	0	2	1

Course Learning Outcomes:
On successful completion of the course the student will be able to:

CLO1: Identify statistical data type and plot graphs using conventional tools. Perform basic statistics to check the data quality
CLO2: Test correlation and regression using two or more variables
CLO3: Perform standard parametric and non-parametric statistics on simple data
CLO4: Write and communicate scientific literatures.

List of Practical work:

1	Plotting different types of graphs and statistical tables using MS excel, GraphPad and/or relevant tools	**CLO1**
2	Plotting normal distribution from data given	
3	Problems on: central tendency, measurement of variance (standard deviation, standard error etc.)	
4	Problems of correlation	**CLO2**

5	Problems of regression	
6	Chi-square test	**CLO3**
7	Student's t-test	
8	Analysis of variance (ANOVA)	
9	Different techniques of sampling	
10	Scientific writing skill development	**CLO4**
11	Practice writing research reports, synopsis, poster etc.	

Transactional Modes: Laboratory based practicals; demonstration, Problem solving; Self-learning.

Evaluation criteria for practical courses:

- Continuous Assessment = **60 Marks**

Based on performance and good lab practices of the students and completion of the record book (60 divided by the number of practicals)

- Final Examination = **40 Marks**
  - i. Subjective question = 10 Marks
  - ii. Performing experiment = 20 Marks
  - iii. Viva voce = 10 Marks

Discipline Elective Courses (Select one)

Course Code: **HGE.515**
Course Title: **Population Genetics and Genetic Epidemiology**
Total Hours: **45**

L	T	P	C
3	0	0	3

Course Learning Outcomes:

On successful completion of the course the student will be able to:

CLO1: Conceptualize the basic concepts in population genetics and apply statistics relevant to the study of genomic diversity

CLO2: Examine the major genetic and ecological processes underlying evolution and explain the process driving speciation

CLO3: Perform different epidemiological studies to identify the cause-effect relationship in variety of human traits/diseases

CLO4: Design genetic studies and perform association and linkage analysis on any relevant data.

Unit 1 **15 Hours** Population dynamics and Fundamental of Epidemiology: Dynamics and conditions of the Hardy-Weinberg law; Selection coefficient and fitness; Heterozygous advantages, Inbreeding and its consequences; Mutation pressure and estimation of rates, Genetic load, Selection coefficient and Fitness, Dynamics of migration and genetic drifts	**CLO1**
Unit: 2 **15 Hours**	**CLO2**

Introduction of different types of epidemiological studies: Experimental and observational; Cohort studies; Association studies, genome-wide association studies (GWAS), general approaches to access the genetic basis of disease; heritability; basic parameters of epidemiology: frequency, occurrence, prevalence, Incidence; Association; variation.	
Unit: 3 **15 Hours** Fundamentals of epidemiological studies: Different types of Experimental and observational studies; basic parameters of epidemiology: frequency, occurrence, prevalence, incidence; association; causation, variation; Association studies: candidate gene association and genome-wide association studies (GWAS); systematic review and meta-analysis.	**CLO3**
UNIT IV **11 Hours** Genetic variation and complex trait inheritance: Basics of genetic variations; genetic markers – SNP, CNV, Ins/dels, VNTR, STR, microsatellite; concepts of tag markers and haplotypes, linkage disequilibrium; quantitative genetic analysis; QTL and eQTL.	**CLO4**

Transactional Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.
Internal assessment shall be through any of the following: Surprise Tests, case analysis, simulated problem solving, classroom assignments, term paper, presentations, and discussions.

Suggested Reading:

1. Bhasker, H.V., & Kumar S. (2008). Genetics. Campus Books International, New Delhi, India.
2. Cavalli-Sforza, L. L., & Bodmer, W. F. (2013). The genetics of human populations. Courier Corporation.
3. Hamilton M.B. (2009). Population Genetics. Wiley-Blackwell, UK.
4. Hedrick P.W. (2011). Genetics of Populations. Jones and Bartlett Publishers, Massachusetts.
5. Jobling, M., Hollox, E., Hurles, M., Kivisild, T., & Tyler-Smith, C. (2013). Human Evolutionary Genetics. Garland Science.
6. Knight, J.C. (2009). Human Genetic Diversity –Functional consequences for Health and Disease. Oxford University Press, USA.
7. Krebs, J.E, Goldstein, E.S., & Kilpatrick, S.T. (2013). Lewin's Essential Genes. Jones and Bartlett learning, USA.
8. Nielsen, R., & Slatkin, M. (2013). An Introduction to Population Genetics: Theory and Applications. Sinauer Associates, Inc.
9. Relethford, J.H. (2012). Human Population Genetics. John Wiley & Sons.
10. Snusted, D.P., & Simmons, M. J. (2010). Principles of Genetics. John Wiley & Sons, New York.

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Course Code: **MME.515**
Course Title: **Molecular and Cellular Oncology**
Total Hours: **45**

L	T	P	C
3	0	0	3

Course Learning Outcomes:

On successful completion of the course the student will be able to:

CLO1: Understand fundamentals of cancer.

CLO2: Gain knowledge about genetics and signal transduction involved in tumorigenesis.

CLO3: Learn about various tools used for diagnostic purposes.

CLO4: Understand basics principles of anticancer therapeutics as well as about recent developments of the field.

Unit: 1 **13 Hours** Fundamentals and Genetics of Cancer: Hallmarks of cancer, cancer classification, Mutagens, carcinogens and gene mutations, Chromosomal aberrations, tumor viruses and discovery of oncogenes, tumor suppressors and oncogenes, familial cancer syndromes, telomere regulation in cancer.	**CLO1**
Unit: 2 **11 Hours** Signal Transduction in Cancer Progression: Deregulation of Cell cycle in cancer. Cell signaling in cancer; cancer metabolism; hypoxia and metastasis, angiogenesis, tumor microenvironment. DNA damage and repair defects and their relation to cancer, cancer stem cells	**CLO2**
Unit: 3 **11 Hours** Cancer Detection: General and organ specific symptoms associated with cancer, techniques for cancer detection, biomarkers for cancer detection of various stages of cancer, In-vitro assays to detect angiogenesis, metastasis, cell proliferation, mice models to study cancer (transgenic, knock-out, knock-in, xenografts and patient derived xenografts), genomic and proteomic approaches to develop better cancer markers.	**CLO3**
Unit: 4 **10 Hours** Cancer Therapies and Recent Advances in Cancer Research: Traditional Chemotherapies, radiotherapy, Onco-surgery, Bone marrow transplantation, stem cell therapies, Immunotherapy, combinational therapies, natural products as therapeutics, cancer vaccines, gene therapies, targeted anticancer therapies, CAR T and other new anticancer therapies.	**CLO4**

Transactional Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.

Internal assessment shall be through any of the following: Surprise Tests, case analysis, simulated problem solving, classroom assignments, term paper, presentations and discussions.

Suggested Reading:

1. DeVita, V. T., Rosenberg, S. A., & Lawrence, T. S. (2018). DeVita, Hellman, and Rosenberg's cancer. Lippincott Williams & Wilkins.
2. Enders, G. H. (2010). Cell cycle deregulation in cancer. Humana Press, Springer science, New York.
3. Gusev, Y. (2019). Micro RNA Profiling in Cancer. Pan Standford publishing pvt.Ltd., Singapore.
4. Hiem, S., & Mitelman, F. (2019). Cancer Cytogenetics. IIIrd edition. Willey-Blackwell publishing, New Jersey.
5. Jocelyn, E. K., Elliot, S. G., Stephen, T. K. (2018). Lewin's Gene X. Jones &Barlett.
6. Wang, E. (2018). Cancer systems biology. CRC press, Taylor & Francis group, New York.
7. Weinberg, Robert A. (2015). The Biology of Cancer. New York: Garland Science

Related Weblink

http://www.insidecancer.org/
http://www.who.int/cancer/en/
http://www.cancer.gov/
http://www.icmr.nic.in/ncrp/cancer_reg.htm

Interdisciplinary Courses

Course Code: **HGE.518**
Course Title: **Introduction to Intellectual Property Rights**
Total Hours: **30**

L	T	P	C
2	0	0	2

Course Learning Outcomes:

On successful completion of the course the student will be able to:
CLO1: Understand the concept and genesis of IP
CLO2: Differentiate between plagiarism and fair use of copyright material
CLO3: Understand the Patent regime of India
CLO4: Conceptualize the other forms of IP namely Trademark, Industrial Design, Trade Secret, New varieties of plant

UNIT I **8 Hours** Brief history, current status and career opportunities in IP Introduction to IP, Genesis and development of concept of IPR; WIPO administered Treaties: Paris Convention, 1883, the Berne Convention, 1886, the TRIPS Agreement, 1994; the WIPO Convention, 1967; National Innovation and Startup Policy for Students and Faculty 2019, Career Opportunities in IP.	**CLO1**
UNIT II **6 Hours** Copyright and Layout Design Protection Copyright and related rights; Plagiarism; Fair Use of copyright material; Layout Design Protection.	**CLO2**

UNIT III **8 Hours** Patent Regime in India: Patents, patentability of inventions; non-patentable subject matter, Patent registration procedure in India; Protection of Traditional Knowledge, Assignment and license of patented technology; Patent filing routes for other countries: Convention Application and Patent Cooperation Treaty (PCT) application.	**CLO3**
UNIT IV **8 Hours** Other forms of IP Concept, Registration and term of protection: Trademark, Industrial Design, Trade Secret, Protection of New varieties of plant, Geographical Indications	**CLO4**

Transactional Modes: Lecture**;** Demonstration**;** Tutorial**;** Virtual classrooms; Lecture cum demonstration; Problem solving; Self-learning, Class activity based

Internal assessment shall be through any of the following: Surprise Tests, one sentence summary, case analysis, simulated problem solving, open book techniques, classroom assignments, term paper, Seminars.

Suggested Readings:

1. Dutfield G. (2003). Intellectual Property Rights and the Life Science Industries: A Twentieth Century History (Globalization and Law). Routledge.
2. Mahop, M.T. (2010). Intellectual Property, Community Rights and Human Rights: The Biological and Genetic Resources of Developing Countries. Routledge.
3. Khor M. (2002). Intellectual Property, Biodiversity and Sustainable Development: Resolving the Difficult Issues. Zed Books limited.
4. Ahuja, V.K. (2017). Law relating to Intellectual Property Rights. LexisNexis, India. 3rd Edition.
5. Mahop, M.T. (2010). Intellectual Property, Community Rights and Human Rights: The Biological and Genetic Resources of Developing Countries. Routledge, USA.
6. Neeraj, P. and Khusdeep, D. (2014). Intellectual Property Rights. India, IN: PHI learning Private Limited.
7. Nithyananda, K V. (2019). Intellectual Property Rights: Protection and Management. India, IN: Cengage Learning India Private Limited.

Weblinks:

1. World Intellectual Property Organization (https://www.wipo.int/about-ip/en/)
2. Office of the Controller General of Patents, Designs & Trademarks (http://www.ipindia.nic.in/)

Syllabus

MSc in Molecular Medicine (Batch-2022)

Semester-II

Course Code: **MME.521**
Course Title: **Molecular Endocrinology and Signal Transduction**
Total Hours: **45**

L	T	P	C
3	0	0	3

Course Learning Outcomes:
On successful completion of the course the student will be able to:
CLO1: Know endocrine system and signal transduction at physiological levels
CLO2: Conceptualize and understand the endocrine cellular signaling
CLO2: Understand various human hormones.
CLO3: Develop understanding regarding disorders of immune system.

Unit: 1 **10 Hours** Endocrine glands, and hormones as chemical messengers, stimulus for hormone release: change in homeostasis, sensory stimulus and others.	**CLO1**
Unit: 2 **15 Hours** Cell Signaling and Mechanism of Hormone Action: G protein linked receptor family; Signal transduction pathways involving G-proteins, Adenylcyclases, Ca+2, Phosphoinositides, PI-3 Kinase, DAG, cAMP, cGMP, NO, Protein kinases (A,B,C,G), Phosphoprotein phosphatases & Phosphodiesterases. Receptor tyrosine kinase family-EGF receptor family, Insulin receptor family, & Cytokine/erythropoietin receptor family associated with non-receptor Tyrosine kinase (Signal transduction pathways involving: SH2 proteins, Ras, IRS-1, Raf, MEK, MAP kinase, JAK-STAT pathway).	**CLO2**
Unit: 3 **10 Hours** Hormones: Structures, Receptor type, Regulation of biosynthesis and release (including feedback mechanism), Physiological and Biochemical actions, Pathophysiology (hyper & hypo secretion). Hypothalamic Hormones: CRH, TRH, GnRH, PRL/PRIH, GHRH/GHRIH. Pituitary Hormones - Anterior Pituitary hormones- Growth hormone, Prolactin, POMC peptide family, LH, FSH, TSH; Posterior Pituitary: Vasopressin, Oxytocin, reproductive hormones, Other organs with endocrine function: Heart (ANP), Kidney (erythropoietin), Liver (Angiotensinogen, IGF-1), Adipose tissue (Leptin, adiponectin).	**CLO3**
Unit: 4 **10 Hours** Endocrine disorders: Gigantism, Acromegaly, dwarfs, pigmies; Pathophysiology: Diabetes insipidus. Thyroid Hormone (include biosynthesis) Goiter, Graves' disease, Cretinism, Myxedema, Hashimoto's disease. Pancreatic Hormones: Insulin, Glucagon, Diabetes type I & II. Hormones associated with obesity: Ghrelin, Leptin.	**CLO4**

Transactional Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.

Syllabus

MSc in Molecular Medicine (Batch-2022)

Internal assessment shall be through any of the following: Surprise Tests, case analysis, simulated problem solving, classroom assignments, term paper, presentations and discussions.

Suggested Reading:

1. Norris, D.O., & Carr, J.A. (2017). Vertebrate Endocrinology. Academic Press.
2. Widmaier, E.P., Raff, H., & Strang, K.T. (2013). Vander's Human Physiology. McGraw-Hill Higher Education.

Course Code: **MME.522**
Course Title: **Essentials of Immunology**
Total Hours: **45**

L	T	P	C
3	0	0	3

Course Learning Outcomes:

On successful completion of the course the student will be able to:

CLO1: Evaluate basic concepts of immune system.

CLO2: Gain knowledge about various key processes related to development of immune system.

CLO3: Understand the concept of immune-based diseases as either a deficiency of components or excess activity as hypersensitivity.

CLO4: Apply the knowledge how immune system is involved in diseases caused by internal or external factors.

Unit: 1 **12 Hours** Immune System: The cells and organs of immune system, humoral immunity-immunoglobulin, basic structure, classes and subclasses, structural and functional relationships, nature of antigen, antigen-antibody reaction, antibody diversity, class switching, B and T cell development.	**CLO1**
Unit: 2 **11 Hours** Immune Effectors: Complement system, their structure, functions and mechanisms of activation by classical, alternative and lectin pathway. Th1 and Th2 response, various effector cells of immune system: DC, NK, Monocytes etc.	**CLO2**
Unit: 3 **12 Hours** Mechanisms of Immune System Diversity: Structure and functions of Major Histocompatibility Complex (MHC) and Human Leukocyte Antigen (HLA) system, polymorphism, distribution, variation and their functions.	**CLO3**
Unit: 4 **10 Hours** Immune System in Health and Diseases: Inflammation, hypersensitivity and autoimmunity, AIDS and immunodeficiencies, vaccine development.	**CLO4**

Transactional Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.

Syllabus

MSc in Molecular Medicine (Batch-2022)

Internal assessment shall be through any of the following: Surprise Tests, one sentence summary, case analysis, simulated problem solving, open book techniques, classroom assignments, homework assignments, term paper, presentations and discussions.

Suggested Reading:

1. Kindt, T.J., Osborne, B.A. and Goldsby, R.A. (2018). Kuby Immunology. W.H. Freeman, USA.
2. Abbas. (2018). Cellular and Molecular Immunology.CBS Publishers & Distributors, India.
3. Charles, A. and Janeway, J.R. (2001). Immunobiology: The immune system in health and disease Blackwell Publishing, USA.
4. Delves, P.J., Roitt, I.M. and Seamus, J.M. (2016). Roitt's Essential Immunology (Series–Essentials). Blackwell Publishers, USA.
5. Elgert, K.D. (2015). Immunology: Understanding the immune system. Wiley-Blackwell, USA.
6. Tizard. (2018). Immunology: An Introduction. Cengage Learning, Thompson, USA.
7. Owen, Judith A; Punt, Jenni, Stranford, Sharon A. Kuby's Immunology (2013), W.H. Freeman and Company: New York, 2013

Course Code: **MME.523**
Course Title: **Techniques in Molecular Medicine**
Total Hours: **45**

L	T	P	C
3	0	0	3

Course Learning Outcomes:

On successful completion of the course the student will be able to:
CLO1: Understand technical aspects of various tools used during experiments.
CLO2: Conceptualize principles of different techniques used in life sciences.
CLO3: Gain conceptual knowledge about various advanced techniques related to the field.
CLO4: Apply this knowledge learn how molecules control a cell's activities and growth.

Unit 1 **10 Hours** Microscopy: Light microscopy, phase contrast microscopy, fluorescent microscopy, scanning electron microscopy (SEM/FESEM), transmission electron microscopy (TEM), Atomic force microscopy, CLSM, Histochemistry.	**CLO1**
Unit:2 **12 Hours** Nucleic Acids: Isolation, purification and analysis of nucleic acids. Electrophoresis: Principle of gel electrophoresis, polyacrylamide gel electrophoresis (PAGE and SDS-PAGE), agarose gel electrophoresis, pulse field gel electrophoresis (PFGE) and Two-Dimensional gel electrophoresis. Polymerase chain reaction (PCR): Principle, types and applications, PCR based markers: RAPDs, SSRs, SNPs, ISSRs, and SCARs etc.	**CLO2**

Blotting techniques: Southern, Northern, Western, Dot blotting and hybridization, DNA fingerprinting.	
Unit:3 **10 Hours** RNA and Proteins: high throughput techniques: microarray, NGS, real time qPCR, Western blotting, Mass Spec, Enzyme Linked Immunosorbent Assay (ELISA), 2D gel electrophoresis	**CLO3**
Unit:4 **13 Hours** Cell culture and Related Techniques: Sterile culture practices, 3D culture, Flow cytometry, Cell sorting, Developing Monoclonal and Polyclonal antibodies.	**CLO4**

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Transactional Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.
Internal assessment shall be through any of the following: Surprise Tests, case analysis, simulated problem solving, classroom assignments, term paper, presentations and discussions.

Suggested Reading:

1. Brown, T.A. (2016). Gene cloning and DNA analysis: An Introduction. 6th Edition, Wiley-Blackwell Publisher, New York.
2. Goldsby, R.A., Kindt, T.J. and Osborne, B.A. (2018). Kuby Immunology. 6th Edition, W. H. Freeman & Company, San Francisco.
3. Sue Carson Heather Miller Melissa Srougi D. Scott Witherow (2019). Molecular Biology Techniques. Academic Press, USA
6. Nelson, D. and Cox, M.M. (2016). Lehninger Principles of Biochemistry. W.H. Freeman and Company, New York.
7. Primrose. S.B. and Twyman, R. (2016). Principles of Gene Manipulation and Genomics.Blackwell Publishing Professional, U.K.
8. Sambrook, J. (2015). The Condensed Protocols from Molecular Cloning: A Laboratory Manual.Cshl Press. New York.
9. Sambrook, J., Fritish, E.F., & Maniatis, T. (2017). Molecular cloning: A laboratory manual. Cold Spring Harbor Laboratory Press, New York.

Course Code: **HGE.524**
Course Title: **Human Anatomy and Physiology**
Total Hours: **45**

L	T	P	C
3	0	0	3

Learning outcome
CLO1: Understand anatomical and physiological functions of various tissues.
CLO2: Understand the clinical scenarios and be able to interpret physiological function.
CLO3: Recognize the cell structure and function, histology, gross anatomy and physiology of several organ systems.

CLO4: Understand and predict the body response to stimuli. Recognize the principle of homeostasis and control mechanisms

UNIT I **11 Hours** Muscular System: Structure and organization of muscles: skeletal, cardiac and smooth muscles; neuromuscular junction. Cardiovascular System: Physiological anatomy of Heart; cardiac muscle, cardiac cycle; blood constituents; hematopoiesis; cardiovascular regulation.	**CLO1**
UNIT II **12 Hours** Digestive System: Anatomy of Gastrointestinal tract, physiology of salivary secretion, mouth and esophagus, epithelial barrier function; digestion and absorption in GIT; GIT secretions and accessory glands; BMR. Urinary System: Physiological anatomy Kidney; urine formation; regulation of volume and concentration of body fluids, KFT.	**CLO2**
UNIT III **11 Hours** Nervous System: Organization of nervous system, synapse, generation of action potential; vision; hearing and tactile response, degeneration and regeneration of peripheral nerves. Thermoregulation and stress adaptation: Comfort zone; body temperature – physical, chemical and neural regulation; acclimatization.	**CLO3**
UNIT IV **11 Hours** **Respiratory System**: Anatomical considerations; mechanism of respiration; neural and chemical regulation of respiration; Physiology of high altitude, hypoxia, PFT. **Reproduction**: Physiology of reproductive system (male, female), pregnancy, physiology of fetus.	**CLO4**

Transactional Modes: Lecture**;** Seminar**;** Tutorial**;** Virtual classrooms; Problem solving; Self-learning; group discussion.

Internal assessment shall be through any of the following: Assignment; In Depth interviews, Surprise Tests, term paper, Seminars, discussions, and presentations.

Suggested Readings:

1. Brody, T. (1998). Nutritional biochemistry. Academic Press, USA.
2. Devlin, T.M. (2005). Textbook of Biochemistry with clinical correlations. John
2. Wiley & Sons Inc. USA.
3. Guyton. (2007). Textbook of medical physiology. 11th Edition. Elsevier India Pvt. Ltd. New Delhi.
4. Hill, R.W, Wyse, G. A. and Anderson, M. (2008). Animal physiology. Sinauer Associates Inc. USA.
5. Khurana. (2006). Textbook of medical physiology. Elsevier India Pvt. Ltd.
6. Murray, R.K. (2009). Harper's illustrated biochemistry. Jaypee Publishers,
7. New Delhi, India.
8. Tyagi, P. (2009). A textbook of Animal Physiology. Dominant Publishers and
9. distributors, New Delhi, India.
10. Silverthorne D, (2011) Human Physiology, Pearson; 6th edition.

11. Sherman V. (2013) Vander's Human Physiology. McGraw-Hill 13th edition.
12. Jain A.K. (2021). Textbook of physiology. Avichal Publishing Company-9th Edition.

Course Code: **MME.525**
Course Title: **Essentials of Immunology (Practical)**
Total Hours: **30**

L	T	P	C
0	0	2	1

Course Learning Outcomes:
On successful completion of the course the student will be able to:

CLO1: Understand the basic concepts in handling of blood samples.
CLO2: Identification of different cells in blood
CLO3: Conceptualize and understand the Immunologic techniques
CLO4: Develop understanding regarding purification of antibodies

Practicals

1.	Separation of Plasma and Serum from the blood samples.	CLO1
2.	Blood film preparation and identification of cells	CLO2
3.	Separation of mononuclear cells	
4.	Lymphoid organs and their microscopic organization	
5.	Double diffusion and immuno-electrophoresis	CLO3
6.	ELISA	
7.	Radial immuno diffusion	
8.	Purification of IgG from serum	CLO4

*Practical can be modified depending upon the available faculty/facility.

Transactional Modes: Hands-on Practicals; Demonstration**;** Tutorial**;** Self-learning.

Evaluation criteria:
A. Continuous Assessment = **60 Marks**
Based on performance and good lab practices of the students and completion of the record book (60 divided by the number of practicals)
B. Final Examination = **40 Marks**
i. Subjective question = 10 Marks
ii. Performing experiment = 20 Marks
iii. Viva voce = 10 Marks

Suggested Reading:
1. Practical immunology (2002) by F.C. Hay and O.M.R. Westwood, P.N. Nelson, L. Hudson (Wiley-Blackwell).

2. Clinical immunology and serology: A laboratory perspective (1997) by Stevens C.D (FA Davis Company, Philadelphia).

Course Code: **MME.526**
Course Title: **Practical Course in Molecular Medicine**
Total Hours: **60**

L	T	P	C
0	0	6	3

Course Learning Outcomes:
At the completion of this course, the students will learn:
CLO1 To evaluate biological experiments using the principles of molecular biology and its applied aspect.

CLO2 To analyze the experimental results based on variety of techniques to prove biological hypothesis.

CLO3 To apply the gained knowledge in diagnosis and therapeutics practically.

CLO4 . To acquire hands on practice in cell culture and its applications in tissue engineering.

Practicals

1.	Agarose Gel Electrophoresis	CLO1
2.	Polymerase Chain Reaction for SNP Analysis	
3.	RNA extraction and cDNA synthesis	CLO2
4.	Real-Time PCR	
5.	Western Blotting	
6.	Genome Wide Association studies	CLO3
7.	Transcriptomic studies	
8.	Next Generation Sequencing	
9.	Epigenomic Studies	
10.	Cell Culturing	CLO4

Transactional Modes: Lecture**;** Demonstration**;** Virtual classrooms; Problem solving; Self-learning; YouTube demonstrations; Lab performances.

Evaluation criteria for practical courses:

- Continuous Assessment = **60 Marks**

Based on performance and good lab practices of the students and completion of the record book (60 divided by the number of practicals)

- Final Examination = **40 Marks**

Subjective question = 10 Marks
Performing experiment = 20 Marks
Viva voce = 10 Marks

Syllabus

MSc in Molecular Medicine (Batch-2022)

Course Code: **MME.528**
Course Title: **Molecular Biology**
Total Hours: **45**

L	T	P	C
3	0	0	3

Course Learning Outcomes:
On successful completion of the course the student will be able to:
CLO1: Conceptualization of molecular mechanisms involved in cellular functioning.
CLO2: Understanding the molecular processes of DNA replication
CLO3: Study the process of transcription in prokaryotes and eukaryotes.
CLO4: Understand the concept of Genetic code, process of translation and post translational modifications

Unit: 1 **12 Hours** Nucleic acids, Genes and Genome organization: Chemical structure of DNA and base composition, Watson-Crick model, mitochondrial DNA, Chromosome Structure, Chromatin and the Nucleosome, Chromatin structure: euchromatin, heterochromatin, Constitutive and facultative heterochromatin, Regulation of chromatin structure and nucleosome assembly, typical structure of a eukaryotic genes including various regulatory elements.	**CLO1**
Unit:2 **12 Hours** DNA replication and repair: Mechanisms of DNA replication in eukaryotes, Enzymes and accessory proteins involved in DNA replication, Replication errors and proofreading, telomeres, DNA damage and repair mechanisms.	**CLO2**
Unit: 3 **11 Hours** Transcription and mRNA processing: Different forms of RNA: mRNA, tRNA, rRNA and other Types of RNA Eukaryotic transcription: Initiation, Elongation & Termination, general and specific transcription factors, Regulatory elements and mechanisms of transcription regulation, RNA processing and editing, post transcriptional gene regulation.	**CLO3**
Unit: 4 **10 Hours** Translation: Genetic code, eukaryotic translation, the translation machinery, mechanisms of chain initiation, elongation and termination, regulation of translation, co-and post- translational modifications of proteins.	**CLO4**

Transactional Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.
Internal assessment shall be through any of the following: Surprise Tests, one sentence summary, case analysis, simulated problem solving, open book techniques, classroom assignments, homework assignments, term paper, presentations and discussions.

Suggested Reading:

1. Sambrook, J., Fritsch, E. F., & Maniatis, T. (2015). Molecular cloning: a laboratory manual. Cold Spring Harbor Laboratory Pressn New York.
2. Berk, A. Chris, A.K. & Krieger, M. (2011). Molecular Cell Biology. W.H. Freeman, USA.

3. Robertis, (2011). Cell and Molecular Biology. Lippincott Williams & Wilkins.
4. Karp, G. (2010). Cell and molecular biology: concepts and experiments. John Wiley & Sons.
5. Krebs, J. E., Goldstein, E. S., & Kilpatrick, S. T. (2017). Lewin's Genes XII. Jones & Bartlett Learning.
6. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., & Levine, M. (2003). Molecular Biology of the Gene Benjamin Cummings.
7. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2007). Molecular biology of the cell. Garland Science. New York, 1392.
8. Fasman, G.D. (1989). Practical Handbook of Biochemistry and Molecular Biology. CRC Press, Taylor and Francis Group, UK.

Course Code: **HGE.529**
Course Title: **Principles of Ecological Science**
Total Hours: **30**

L	T	P	C
2	0	0	2

Course Learning Outcomes:
On successful completion of the course the student will be able to:

CLO1: Improve their knowledgebase about basics of ecological science
CLO2: Conceptualize and contribute in environmental studies
CLO3: Improve student's aptitude for research and development on ecological succession and dynamics
CLO4: Contribute to conservation science

UNIT I **6 Hours** **Environmental components:** Physical environment; biotic environment; biotic and abiotic interactions. Concept of habitat and niche; resource partitioning; character displacement. Major terrestrial biomes; theory of island biogeography; biogeographical zones of India.	**CLO1**
UNIT II **8 Hours** **Biological components of environment:** Characteristics of a population; life history strategies (r and K selection); concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations; Species Interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis; Community Ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.	**CLO2**
UNIT III **8 Hours** **Ecosystem and Ecological Succession:** Ecosystem: structure and function; energy flow and mineral cycling (C, N, P); primary production and decomposition; structure and function of some Indian ecosystems: terrestrial and aquatic. Ecological Successions: Types; mechanisms; changes involved in succession; concept of climax.	**CLO3**
UNIT IV **8 Hours**	**CLO4**

Applied Ecology and Conservation Biology: Environmental pollution; biodiversity: status, monitoring and documentation; biodiversity management approaches; Principles of conservation and its management; Indian case studies on conservation/management strategy: Project Tiger, Biosphere reserves.	

Transactional Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning; MCQ practice.
Internal assessment shall be through any of the following: Surprise Tests, one sentence summary, case analysis, simulated problem solving, open book techniques, classroom assignments, homework assignments, term paper, Seminars, term papers, discussions, and presentations.

Suggested Readings:

1. Smith, Robert Leo, et al. "Elements of ecology." (2015): E9.
2. Recknagel F. 2002 Ecological Informatics: Understanding Ecology by Biologically-Inspired Computation, Springer, New York.
3. Odum E.P. 1983 Basic Ecology. Saunders International Edition, Japan
4. Michael Begon, 2020 Ecology: From Individuals to Ecosystems 5th Edition,

Discipline Elective-II

Course Code: **MME.527**
Course Title: **Stem Cell and Regenerative Medicine**
Total Hours: **45**

L	T	P	C
3	0	0	3

Course Learning Outcomes:
On successful completion of the course the student will be able to:
CLO1: Understand basics of cell culture
CLO2: Understand basic stem cell biology.
CLO3: Gain conceptual knowledge about requirements for tissue engineering.
CLO4: Know regenerative medicine and its potential applications.

Unit: 1 **11 Hours** Basics of cell culture and media, Culturing primary cells and cell lines, suspension and adherent cultures, cell growth, growth inhibition and apoptotic studies, Embryo culture, transplantation and teratogens, teratomas, stem cell culture, organ culture.	**CLO1**
Unit: 2 **12 Hours** **Stem Cells:** Stem cells and their properties, classification of stem cells, in-vitro	**CLO2**

culture techniques, isolation, identification and characterization of stem cells, stem cells in various organs and in disease conditions.	
Unit: 3 **11 Hours** **Tissue Engineering:** Principles of tissue culture, tissue and organ culture, extracellular matrices, bioreactors, ethical issues related to stem cell therapies, stem cell banks, bone marrow transplantation.	**CLO3**
Unit: 4 **11 Hours** **Regenerative Medicine:** Modes of tissue and organ delivery, tissue Engineering and transplantation techniques, immuno isolation techniques, regeneration of bone and cartilage, Islet cell transplantation and bio-artificial pancreas, lung regeneration	**CLO4**

Transactional Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.
Internal assessment shall be through any of the following: Group discussions, Surprise Tests, case analysis, simulated problem solving, classroom assignments, term paper, presentations and discussions.

Suggested Reading:

1. Lanza, R., Gearhart,J. (2016). Essential of Stem Cell Biology. Elsevier Academic Press.
2. Lanza, R., Klimanskaya, I. (2018). Essential Stem Cells Methods. Academic Press.
3. Mao, J. J. & (2017). Translational approaches in tissue engineering and regenerative medicine. Artech House.
4. Lanza, R. (2017). Principles of Tissue Engineering, 3rd Edition. Academic Press
5. Stein, G. S., Borowski, M., Luong, M. X., Shi, M. J., Smith, K. P., & Vazquez, P. (Eds.). (2011). Human stem cell technology and biology: A research guide and laboratory manual. John Wiley & Sons.
6. Lanza, R., Blau, H., Gearhart, J., Hogan, B., Melton, D., Moore, M., ... & Weissman, I. (Eds.). (2014). Handbook of Stem Cells, Two-Volume Set: Volume 1-Embryonic Stem Cells; Volume 2-Adult & Fetal Stem Cells. Elsevier.

Course Code: **HGE.527**
Course Title: **Human Embryology and Developmental Genetics**
Total Hours: **45**

L	T	P	C
3	0	0	3

Course Learning Outcomes:
On successful completion of the course the student will be able to:
CLO1: Conceptualize basics of reproductive physiology
CLO2: Correlate genetic regulation in different embryonic developmental stages

CLO3: Evaluate the role of biomolecules in embryonic development
CLO4: Know different genetic and environmental triggers for post-natal development, ageing and senescence

UNIT I **12 Hours** Basic concepts of development: Gametogenesis; fertilization; embryogenesis: gastrulation and implantation of embryo; fetal membrane and placenta; potency, commitment, specification, induction, competence, determination, and differentiation. Role of Sry, Sox9 and WNT4 and DAX1 in early gonad differentiation	**CLO1**
UNIT II **11 Hours** Gene expression regulation in development: Basics of gene expression regulation during early embryogenesis; homeotic genes, P granules, role of key developmental genes: polycomb gene, SOX, HOX.	**CLO2**
UNIT III **11 Hours** Stem Cell and Organogenesis: Stem cell: embryonic and adult; cell-cell communication; neural crest cells and axonal specificity; vertebrate eye and central nervous system development; hematopoiesis.	**CLO3**
UNIT IV **11 Hours** Post-natal Development, Aging and senescence: Environmental and genetic factors during maturations, Sex linked changes, Deciduous and primary teeth, Clinical death. Teratology: Teratogens, introduction to toxicogenomic	**CLO4**

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Transactional Modes: Lecture**;** Demonstration**;** Tutorial**;** Virtual classrooms; Lecture cum demonstration; Problem solving; Self-learning.

Internal assessment shall be through any of the following: Surprise Tests, one sentence summary, case analysis, simulated problem solving, open book techniques, classroom assignments, homework assignments, term paper, Seminars, term papers, discussions and presentations

Suggested Readings:

1. Gilbert, S.F. (2013). Developmental Biology. Tenth Edition.
2. Slack, J.M.W. (2012). Essentiel Developmental Biology. Third Edition.
3. Moody, A.A. (2014). Principles of Developmental Genetics. Second Edition.
4. Slack, J.M.W. (2018). The Science of Stem Cells. First Edition.
5. Milunsky, J. & Milunsky, A. (2010). Genetic Disorders and the Fetus: Diagnosis, Prevention & Treatment. Willey Blackwell India, New Delhi.
6. Prakash, G. (2007). Reproductive Biology. Narosa Publication House Pvt. Ltd., New Delhi.
7. Sadler, T.W., Tosney, K., Chescheir, N.,C., Imseis, H., Leland, J. and Sadler-Redmond, S.,L. (2011).Langman's Medical Embryology (Longmans Medical Embryolgy). Lippincott Williams and Wilkins.

8. Keith L. Moore BA ., T. V. N. Persaud MD.,Mark G. Torchia (2019 The Developing Human Clinically Oriented Embryology, Elsevier, Netherlands

Semester-III

Course Code: **MME.551**
Course Title: **Molecular Basis of Human Diseases**
Total Hours: **45**

L	T	P	C
3	0	0	3

Course Learning Outcomes:
On successful completion of the course the student will be able to:
CLO1: Acquire knowledge on basic mechanisms of common human diseases.
CLO2: Understand classical genetic disorders.
CLO3: Gain knowledge about molecular mechanisms underlying the pathogenesis of each disease.
CLO4: Know modern therapeutic approaches in development/clinical practice.

Unit: 1 **11 Hours** Non-Communicable Diseases: Molecular basis of Diabetes, Coronary Artery diseases, Cardiomyopathies, Hypertension, Cancer, and neuronal disorders such as Autism, Alzheimer's and Parkinson. Schizophrenia, Mental Retardation	**CLO1**
Unit: 2 **12 Hours** Genetic disorders: Classifications of genetic disorders, Intersex Disorders: Male Pseudo-hermaphrodite (MPH), Female Pseudo-hermaphrodite (FPH), True Hermaphrodites (TH), Mixed gonadal dysgenesis (MGD) & Dysgenetic male pseudohermaphrodite (DMP) and Persistent Mullerian duct syndrome (PMDS), Sickle cell anemia, Thalassemia's and Hemophilia's and Hematopoietic Malignancies. Muscular Dystrophy. Glycogen Storage Diseases (Pompe disease, Tay Sach disease, Niemann-Pick disease)	**CLO2**
Unit: 3 **12 Hours** Communicable Diseases: Mechanisms of Infection and Therapeutic Interventions: Protein and DNA secreting systems and Pathogenicity Island. Molecular basis of antimicrobial resistance and its detection. Molecular approaches in clinical microbiology, antimicrobial agents; Sulfa drugs; Antibiotics: Penicillin and Cephalosporins; Broad-spectrum antibiotics; Antibiotics from prokaryotes; Antifungal antibiotics.	**CLO3**
Unit: 4 **10 Hours** Novel therapies for diseases: Tyrosine kinase inhibitor, Monoclonal antibody, Chemo & Radio, Gene Therapies, Small peptides. Limitations, ethical and biosafety issues in gene therapies.	**CLO4**

Transactional Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.
Internal assessment shall be through any of the following: Surprise Tests, case analysis, simulated problem solving, classroom assignments, term paper, presentations, and discussions.

Suggested Reading:

1. Patch, H. S. C. (2017). Genetics for the Health Sciences. Scion Publishing Ltd., UK.
2. Brown, S. M., (2018). Essentials of Medical Genomics.Wiley-Blackwell.
3. Jocelyn, E. K., Elliot, S. G., & Stephen, T. K. (2018), Lewin's Gene X. Jones & Barlett Publishers.
4. Milunsky, A., & Milunsky, J. (2015). Genetic Disorders and the Fetus: Diagnosis, Prevention and Treatment, 6th Edition. Wiley-Blackwell publishers.
5. Trent, R. J. (2017). Molecular Medicine: Genomics to Personalized Healthcare. Academic Press.
6. Trent, R. J. (2015). Molecular Medicine: An Introductory Text. Academic Press.
7. Elles, R., & Mountford, R. (2012). Molecular Diagnosis of Genetic Diseases Series: Methods in Molecular Medicine.
8. Coleman, W. B., & Tsongalis, G. J. (2019). The Molecular Basis of Human Disease. Academic Press.
9. Nussbaum, R.L., McInnes, R. Mc., & Willard, H.F. (2017). Genetics in Medicine. Elsevier Inc., Philadelphia.
10. Read, A., & Donnai D. (2017). New clinical Genetics. Scion Publishing Lmt., Oxfordshire, UK.

Course Code: **MME.552**
Course Title: **Genetic Engineering and Recombinant Therapeutics**
Total Hours: **45**

L	T	P	C
3	0	0	3

Course Learning Outcomes:
On successful completion of the course the student will be able to:
CLO1: Know about genetic engineering and its applications.
CLO2: Gain knowledge about various cloning, expression vectors and their importance in research.
CLO3: Understand concept of artificial chromosomes and their potential applications.
CLO4: Learn therapeutics aspect of recombinant DNA technologies

Unit: 1 **11 Hours**	**CLO1**
Basics of Genetic Engineering: Gene manipulation tools for molecular cloning, restriction enzymes their types, cohesive and blunt and ligation, linkers, adaptors, homopolymeric tailing, transformation, transfection: chemical and physical methods,	

sequencing methods, gene cloning, in-silico methods of design.	
Unit: 2 **11 Hours** Gene Cloning Vectors: Plasmids, bacteriophages, cloning in M13 Vectors, phagemids, Lambda vectors; insertion and replacement vectors, Cosmid vectors, Artificial chromosome vectors (YACs, BACs), Animal virus derived vectors-Sv-40, retroviral vectors, Expression vectors	**CLO2**
Unit: 3 **`11 Hours** Techniques in Genetic Engineering: Isolation and Detection of DNA, RNA and proteins by Southern blotting, Northern blotting, Western blotting and in situ hybridization, Site Directed Mutagenesis, Yeast two hybrid system, phage display, characterization of expressed proteins through various biophysical, biochemical methods,	**CLO3**
Unit: 4 **12 Hours** Applications of recombinant DNA technology: Applications of rDNA in diagnosis of pathogens and abnormal genes, Gene Editing through CRISPR/CAS system, transgenic animals for production of proteins and pharmaceuticals, Biosafety and Ethical considerations in genetic engineering.	**CLO4**

Transactional Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.
Internal assessment shall be through any of the following: Surprise Tests, case analysis, simulated problem solving, classroom assignments, term paper, presentations, and discussions.

Suggested Reading:

1. R.W. Old., & S.B. Primrose. (2017). Principles of Gene Manipulation Blackwell science.
2. Bernard R. Glick., & Jack J. Pasternak. (2018) Molecular Biotechnology ASM Press Washington.
3. James, Watson Micheal Gilman Jan Witkowsk (2017) Recombinant DNA, CSHL, New York.
4. Cokin, R., & Bjorn, C. (2016). Basic Biotechnology Cambridge University press.
5. John E. Smith. (2019). Biotechnology by Cambridge University press.
6. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losicke, R. (2017). Molecular Biology of Gene by Watson CSHL Press New York.
7. Sambrook, J & Sambrook, R. (2018). Molecular cloning, CSHL Press, New York.

Course Code: **MME.553**
Course Title: **Trends in Molecular Medicine**
Total Hours: **30**

L	T	P	C
3	0	0	3

Course Learning Outcomes:
On successful completion of the course the student will be able to:

CLO1: Know about background of Molecular Medicine.
CLO2: Know about development of therapeutics.
CLO3: Understand cellular microenvironment and problems of drug resistance.
CLO4: Develop knowledge about translational research.

Unit: 1 **10 Hours** Introduction to Molecular Medicine, contribution of genomics, transcriptomics and proteomics in human diseases, developing novel biomarkers and therapies using high throughput technologies.	**CLO1**
Unit: 2 **10 Hours** Molecular Medicine Therapeutics: Gene therapy and recombinant molecules in medicine and therapeutic development, pharmacogenomics.	**CLO2**
Unit: 3 **14 Hours** Signal Transduction and its Role in Human Diseases: cell signaling and human diseases, Cellular and tissue microenvironment in diseases, drug resistance with convention chemotherapies	**CLO3**
Unit: 4 **11 Hours** Advances in translational research: nano-biotechnology and its applications in molecular medicine, immunotherapies in human diseases, translational research and its contributions in disease therapeutics.	**CLO4**

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Transactional modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.
Internal assessment shall be through any of the following: Surprise Tests, one sentence summary, case analysis, simulated problem solving, open book techniques, classroom assignments, homework assignments, term paper, presentations and discussions.

Suggested Reading:

1. Littwack, G. (2018). Human Biochemistry and Disease. Academic Press.
2. Trent, R. J. (2016). Molecular Medicine, Fourth Edition: Genomics to Personalized Healthcare. Academic Press.
3. Trent, R. J. (2015). Molecular Medicine: An Introductory Text. Academic Press.
4. Elles, R., Mountfield, R. (2011). Molecular Diagnosis of Genetic Diseases. Springer Publication.
5. Liciniio, J., & Wong, M. L. (2018). Pharmacogenomics: The Search for Individualized Therapies. Wiley.

Course Code: **MME.554**
Course Title: **Tools in Bioinformatics (Practical)**

L	T	P	C
0	0	6	3

Syllabus

MSc in Molecular Medicine (Batch-2022)

Total Hours: 60

Course Learning Outcomes:

On successful completion of the course the student will be able to:

1. Analyze publicly available and experimental genomics data
2. Perform in-silico prediction of protein structures and interactions
3. Perform in-silico functional annotation of genetic findings
4. Demonstrate physical property of biomolecules in silico

1. Access to sequence databases (downloading DNA/RNA/Protein sequences).
2. Performing sequence alignment using various tools (BLAST, MSA)
3. Pipeline of RNA-seq analysis.
4. Submission of SRA and TSA database.
5. Genome wide association study and DNA microarray-data analysis.
6. Understanding the evolutionary relationship using molecular phylogeny analysis.
7. Prediction of Protein structure using sequence database
8. Practical insights of tertiary structure prediction and comparative modelling
9. Protein-protein and protein-ligand docking
10. Evaluation of techniques for 3-D structure determination like X-ray, NMR, MS/MS analysis using case study.
11. Structure-based drug design and virtual screening of the drug.
12. Quantitative structure activity relations, Cheminformatics and pharmacophore mapping in therapeutic development.

Transactional Modes: Hands-on training; Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.

Evaluation criteria for practical courses:

- Continuous Assessment = **60 Marks**

Based on performance and good lab practices of the students and completion of the record book (60 divided by the number of practicals)

- Final Examination = **40 Marks**

  Subjective question = 10 Marks
  Performing experiment = 20 Marks
  Viva voce = 10 Marks

Suggested Readings:

Laboratory specific modified protocols will be followed, however below mentioned reference books can be read to develop overall concepts.

1. Laboratory Protocols. Third Edition. 2005. CIMMYT Applied Molecular Genetics Laboratory.
2. Koliantz, G & Szymanski, D.B. Genetics A Laboratory Manual. Second Edition. 2009. American Society of Agronomy, Crop Science Society of America.

3. Sambrook, J & Green, M.R. Molecular Cloning: A laboratory manual. Fourth Edition. 2013. Cold Spring Harbor Laboratory Press, U.S.
4. Pazos, F & Chagoyen, M. Practical protein bioinformatics.2015. Springer International Publishing, Switserland.
5. Agostino, M. Practical Bioinformatics. 2012. Garland Science. Taylor & Francis Group. New York and London.

Discipline Elective-III

Course Code: **MME.555**
Course Title: **Evolution and Developmental Biology**
Total Hours: **45**

L	T	P	C
3	0	0	3

Course Learning Outcomes:
On successful completion of the course the student will be able to:
CLO1: Gain knowledge on concept related to origin of life.
CLO2: Develop understanding regarding molecular evolution and original of first cell.
CLO3: Know about concepts related to developmental processes.
CLO4: Understand pathology related to mechanisms of development and differentiation.

Unit: 1 **11 Hours** **Origin of Life:** History of evolutionary ideas, Modern evolution theory, Natural Selection, Adaptation, The origin of species.	**CLO1**
Unit: 2 **11 Hours** **Paleontology and Molecular Evolution:** The evolutionary time scale, Major events in the evolutionary time scale, Intimate partnership, Stages in primate evolution, Human evolution, Neutral evolution, Molecular divergence and molecular clocks, Gene duplication and divergence.	**CLO2**
Unit: 3 **12 Hours** **Basic Concepts of Development:** Potency, Commitment, Specification, Induction, Competence, Determination and Differentiation, Morphogenetic gradients, Cell fate and cell lineages, Stem cells, Genomic equivalence and the cytoplasmic determinants, Imprinting, Mutants and transgenics in analysis of development.	**CLO3**
Unit: 4 **11 Hours** **Gametogenesis, Fertilization, embryology and neurulation:** Production of gametes, Cell surface molecules in sperm-egg recognition; embryonic development and formation of germ layers in humans, fetal development, sex determination, neural tube formation.	**CLO4**

Transactional Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.

Internal assessment shall be through any of the following: Surprise Tests, one sentence summary, case analysis, simulated problem solving, open book techniques, classroom assignments, homework assignments, term paper, Seminars, term papers, discussions, and presentations.

Suggested Reading:

1. Darwin, C. (1956). The Origin of Species: By means of natural selection or the preservation of favoured races in the struggle for life (No. 575.0162). Oxford University Press.
2. Dawkins, R. (1996). The blind watchmaker: Why the evidence of evolution reveals a universe without design. WW Norton & Company.
3. Futuyma, D.J. (2017). Evolution. Sinauer Associates Inc. USA.
4. Wilt, F. H., & Hake, S. (2004). Principles of developmental biology. W.W. Norton & Company, New York, USA.
5. Hall, B.K., & Hallgrimsson, B. (2017). Strasburger's Evolution. Jones and Bartlett Publishers, India.
6. Lewin, R. (2014). Human Evolution - An Illustrated Introduction. Wiley-Blackwell, USA.
7. Scott, F., & Gilbert, S.F. (2017). Developmental Biology. Sinauer Associates, Inc. USA.
8. Slack, J.M.W. (2015). Essential Developmental Biology, Wiley-Blackwell, USA.

Course Code: **HGE.555**
Course Title: **Biosafety, Bioethics, and Intellectual Property Rights**
Total Hours: **45**

L	T	P	C
3	0	0	3

Course Learning Outcomes:

On successful completion of the course the student will be able to:

CLO1: Interpret the bioethical issues concerning biotechnological advancements like recombinant DNA technology, cloning, gene manipulation.

CLO2: Implement biosafety while carrying out research.

CLO3: Distinguish different types of Intellectual Property Rights.

CLO4: Describe the ways of protecting traditional knowledge from Biopiracy.

UNIT I **11 Hours**	**CLO1**
Biosafety: Good laboratory practices; Risk and safety assessment from genetically engineered organisms; special procedures for r-DNA based products; biological containment (BC) and physical containment (PC); CDC biosafety levels; biohazard management.	

UNIT II **11 Hours** Bioethics: Ethical considerations during research, Use of Animals for clinical research, Embryonic and adult stem cell research, assisted reproductive technologies, cloning, MTP and Euthanasia; the element of informed consent; ethical issues of the human genome project.	**CLO2**
UNIT III **11 Hours** Intellectual Property Rights (IPRs): Various forms of IP – patents, industrial designs, trademark, geographical indications, and plant breeder's right; copyright: fair use, plagiarism; protection of indigenous intellectual property.	**CLO3**
UNIT IV **12 Hours** Patent system: Patent filing procedure in India and ways of patent protection in other countries: Determination of patentability of inventions, filing a patent application in India: timeline, procedure involved in the granting of a patent, patent cooperation Treaty (PCT).	**CLO4**

Transactional Modes: Lecture**;** Demonstration**;** Virtual classrooms; Tutorial**;** Lecture cum demonstration; Problem solving; Case study; Self-learning.

Internal assessment shall be through any of the following:

Surprise Tests, one sentence summary, case analysis, simulated problem solving, open book techniques, classroom assignments, homework assignments, term paper, Seminars, term papers, discussions, and presentations.

Suggested Readings:

1. Clarke, A (2012). Genetic Counseling: Practice and Principles. Taylor & Francis
2. Fleming, D.O. and Hunt, D.L. (2006). Biological Safety: Principles and Practices. American Society for Microbiology, USA.
3. Mahop, M.T. (2010). Intellectual Property, Community Rights and Human Rights: The Biological and Genetic Resources of Developing Countries. Routledge.
4. Shannon, T.A. (2009). An Introduction to Bioethics. Paulist Press, USA.
5. Thompson J and Schaefer, B.D (2013).Medical Genetics: An Integrated Approach. McGraw Hill.
6. Vaughn, L. (2009). Bioethics: Principles, Issues, and Cases. Oxford University Press, UK.
7. WHO. (2005). Laboratory Biosafety Manual. World Health Organization.
8. Ahuja, V.K. (2017). Law relating to Intellectual Property Rights. LexisNexis, India. 3rd Edition.
9. Mahop, M.T. (2010). Intellectual Property, Community Rights and Human Rights: The Biological and Genetic Resources of Developing Countries. Routledge, USA.
10. Neeraj, P. and Khusdeep, D. (2014). Intellectual Property Rights. India, IN: PHI learning Private Limited.
11. Nithyananda, K V. (2019). Intellectual Property Rights: Protection and Management. India, IN: Cengage Learning India Private Limited.

Syllabus

MSc in Molecular Medicine (Batch-2022)

Foundation Course

Course Code: **MME.557**
Course Title: **Concepts of Bioinformatics**
Total Hours: **30**

L	T	P	C
2	0	0	2

Course Learning Outcomes:

On successful completion of the course the student will be able to:

CLO1: Analyze publicly available and experimental genomics data
CLO2: Perform in-silico prediction of protein structures and protein-protein interaction
CLO3: Perform in silico functional annotation of genetic findings
CLO4: Demonstrate the physical property of biomolecules in silico.

Unit I **6** Hours **Concept of biological databases:** Nucleotide Sequence Databases, GenBank, DDBJ, EMBL, Sequence Flat file and submission process, Protein sequence databases, UniProt in detail, Mapping databases, Genomic databases, Data mining.	**CLO1**
UNIT II **8 Hours** **Inferring relationships:** Concept of global Vs. local sequence alignments, Dotplots, Scoring matrices, Pairwise sequence alignment, BLAST, Position-Specific scoring and PSI-BLAST, MegaBLAST, BL2SEQ, BLAT, FASTA Vs BLAST, Protein multiple sequence alignments, Basics of Sequence assembly and finishing.	**CLO2**
UNIT III **8 Hours** **Sequence analysis:** Gene Prediction methods, Promoter analysis, RNA secondary structure thermodynamics, refining multiple sequence alignment based on RNA secondary structure predictions, SNP discovery methods and databases, Genotyping, International haplotype map project, 1000 genomes project.	**CLO3**
Unit IV **8 Hours** **Analysis for protein sequences:** Predicting features of individual residues, Neural networks, Theory of Protein structure prediction, Protein structure databases, PDB in detail, Pathway and molecular interaction databases.	**CLO4**

Transactional Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Case study; Self-learning.

Internal assessment shall be through any of the following: Surprise Tests, one sentence summary, case analysis, simulated problem solving, open book techniques, classroom assignments, homework assignments, term paper, Seminars, term papers, discussions, and presentations.

Suggested Readings:

1. Baxevanis, A.D. and Ouellette, B.F.F. (2005). Bioinformatics: A Practical guide to the Analysis of Genes and Proteins. Wiley-Interscience, USA.

2. Hall, B.G. (2011). Phylogenetic Trees Made Easy: A How-To Manual. Sinauer Associates, Inc. USA.
3. Lesk, A.M. (2008). Introduction to Bioinformatics. Oxford University Press, UK.
4. Zvelebil, M. and Baum, J. (2007). Understanding Bioinformatics, Garland Science, New York, USA.
5. Ramsden, J. (2010). Bioinformatics: An Introduction (Computational Biology). Springer, India.
6. Ye, S.Q. (2008). Bioinformatics: A Practical approach. Chapman & Hall/CRC, UK.
7. Mount, D. (2012). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press.
8. Graur, D., Li, W. H. (2000). Fundamentals of Molecular Evolution. Sinauer Associates.
9. Tisdall, J. (2001). Beginning Perl for Bioinformatics. O'Really Publishers.

Course Code: **HGE.558**
Course Title: **Innovation and Entrepreneurship**
Total Hours: **15**

L	T	P	C
1	0	0	1

Course Learning Outcomes:
On the completion of this course, the learners will:
CLO1: Understand the basic concepts of entrepreneur, entrepreneurship, and its importance.
CLO2: Aware of the issues, challenges, and opportunities in entrepreneurship.
CLO3: Develop capabilities of preparing proposals for starting small businesses.
CLO4: Know the availability of various institutional supports for making a new start-up.

Unit I **4 Hours** Entrepreneurial Structure; Nature, Characteristics, functions and its role in economic development Entrepreneurship- problems and prospects in India. Entrepreneurial Behavior and Skills. Entrepreneurial traits and skills; Types of entrepreneurial ventures; enterprise and society in Indian context; Importance of women entrepreneurship	**CLO1**
Unit II **4 Hours** Role of industries/entrepreneur's associations and self-help groups; Funding opportunities for start-ups. Basic start-up problems; Preliminary contracts with the vendors, suppliers, bankers, principal customers; Contents of business plan/ project proposal	**CLO2**
Unit III **4 Hours** Promotion of a venture – Why to start a small business; How to start a small business; opportunity analysis, external environmental analysis, legal requirements for establishing a new unit, raising of funds, and establishing the venture Blending University Research and Entrepreneurship culture, National Innovation and startup policy for students and faculty 2019	**CLO3**

Unit IV	4 Hours	CLO4
Opportunities and challenges associated with establishing entrepreneurship in the field of Genetics and Molecular Medicine, Success stories		

Suggested Readings:

1. Arora, Renu (2008). Entrepreneurship and Small Business, Dhanpat Rai & Sons Publications.
2. Chandra, Prasaaan (2018). Project Preparation, Appraisal, Implementation, Tata Mc-Graw Hills.
3. Desai, Vasant (2019). Management of a Small-Scale Industry, Himalaya Publishing House.
4. Jain, P. C. (2015). Handbook of New Entrepreneurs, Oxford University Press.
5. Srivastava, S. B. (2009). A Practical Guide to Industrial Entrepreneurs, Sultan Chand & Sons.
6. National Innovation and startup policy for students and faculty 2019, Government Policy document http://rmkcet.ac.in/RMK/NISP%20policy.pdf

Course Code: **MME.600**
Course Title: **Dissertation Part-I**
Total Hours: **120**

L	T	P	C
0	0	8	4

Course Learning Outcomes:

On successful completion of the course the student will be able to:

1. Apply genetic and genomics technique for research.
2. Construct study design
3. Interpret result of a genetic experiment.
4. Present oral and written scientific communication skills.

The objective of dissertation part-I would be to ensure that the student learns the nuances of the scientific writing. Herein the student shall have to write his synopsis including an extensive review of literature with simultaneous identification of scientifically sound (and achievable) objectives backed by a comprehensive and detailed methodology. Student may start working in the respective laboratory.

Students can opt for dissertation work in industry, national institutes or Universities in the top 100 NIRF ranking. Group dissertation can be opted, with a group consisting of a maximum of four students. These students may work using a single approach or multidisciplinary approach. Research projects can be taken up in collaboration with industry or in a group from within the discipline or across the discipline

Synopsis will be evaluated as per the University policy.

Evaluation criteria:

Examiner	Marks	Evaluation
Supervisor	50	Dissertation proposal and presentation
HoD and Senior-most faculty of the department	50	Dissertation proposal and presentation

Syllabus

MSc in Molecular Medicine (Batch-2022)

Semester IV

Course Code: **MME.601**
Course Title: **Dissertation Part-II**
Total Hours: **600**

L	T	P	C
0	0	40	20

Course Learning Outcomes:
On successful completion of the course the student will be able to:

1. Apply genetic and genomics technique for research
2. Design research studies and perform research following scientific and ethical guidelines
3. Interpret results of genetic and molecular experiments
4. Present oral and written scientific literatures

During the course student will perform:

a. Synthesis of research hypothesis
b. Review of literature and identify research gap
c. Formulate methodology to achieve the objective of the research idea
d. Present articles and research ideas to fellow students and in other platforms
e. Perform researh and interpret the results
f. Write research reports and may publish research findings (if significant)

Dissertation will be evaluated by the Department, as per the University policy.
Evaluation criteria

Examiner	Marks	Evaluation
Supervisor	50	Continuous assessment (regularity in work, mid-term evaluation) dissertation report, presentation, final viva-voce
External expert, HoD and senior-most faculty of the department	50	Dissertation report (30), presentation (10), final viva-voce (10)

Syllabus

MSc in Molecular Medicine (Batch-2022)

Examination pattern

Core, Discipline Elective, Compulsory Foundation, Value Added and Interdisciplinary Courses			**Discipline Enrichment Course**		**Entrepreneurship Course**	
	Marks	**Evaluation**	**Marks**	**Evaluation**	**Marks**	**Evaluation**
Internal Assessment	25	Various	-	-	-	-
Mid-semester test (MST)	25	Subjective	50	Objective	25	Objective
End-semester test (EST)	50	Subjective (70%) Objective (30%)	50	Objective	25	Subjective

Dissertation Proposal (Third Semester)			**Dissertation (Fourth Semester)**		
	Marks	**Evaluation**		**Marks**	**Evaluation**
Supervisor	50	Dissertation proposal and presentation	Supervisor	50	Continuous assessment (regularity in work, mid-term evaluation) dissertation report, presentation, final viva-voce
HoD and senior-most faculty of the department	50	Dissertation proposal and presentation	External expert, HoD and senior-most faculty of the department	50	Dissertation report (30), presentation (10), final viva-voce (10)

Evaluation pattern similar to fourth semester dissertation will apply for internship where supervisor will award 50% marks and external co-supervisor, HoD and senior-most faculty will award 50% marks.