CENTRAL UNIVERSITY OF PUNJAB

Master of Science in Human Genetics

Batch: 2023-2025

Department of Human Genetics and Molecular Medicine

Syllabus
M.Sc. in Human Genetics (Batch: 2023-2025)

Graduate attributes

The graduates of the Master of Science in Human Genetics will acquire the following:

Context of Society

The students of this course will understand the significant role human genetics/genomics, human cytogenetics, epidemiology and public health research, pharmacogenomics, nutrigenomics, therapies for genetic diseases and cell and molecular biology play 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 human genetics, molecular biology, bioinformatics and translational research through the subject content across a broad range of modules among the students. The development of skills in human genetics will enhance employability in the field of human genetics on account of their inclusion in clinical practice. 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. Exposure to genetic diseases, therapies and counseling will help the students to take up the profession of a genetic counselor who helps families to understand the significance of genetic disorders in the context of cultural, personal, and familial situations.

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 human genetics relevant research areas. Geneticists are now equipped with powerful tools for genome editing. Exposure to these tools will help the graduates to explore the application of this research more broadly in both research and medicine.

Course structure of the Programme

Total Credit: 85

	Core Subjects	Elective Courses			Foundation Courses		Total Credit
		DE	ID	SB	CF	EF/VB	
Sem-I	03 (9 Cr)	01 (3 Cr)	–	03 (3 Cr)	01 (3 Cr) 01 (3 Cr)	--	**21**
Sem-II	04 (12 Cr)	01 (3 Cr)	01 (2 Cr)	02 (4 Cr)	--	– -	**21**
SEM-III	03 (9 Cr)	01 (3 Cr)	--	01 (3 Cr) 01 (4 Cr Dissertation)	02 (2 Cr)	01 (2 Cr)	**23**
SEM-IV	--	--	--	01 (20 Cr Dissertation)	--	--	**20**
Credit Score	**30**	**9**	**02**	**34**	**8**	**02**	**85**

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

Syllabus
M.Sc. in Human Genetics (Batch: 2023-2025)

Semester-I

Syllabus
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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
MME.510	Molecular Biology	Compulsory Foundation	3	0	0	3
HGE.511	Concepts of Genetics (Practical)	Skill based	0	0	2	1
MME.512	Biomolecules and Metabolism (Practical)	Skill based	0	0	2	1
HGE.513	Biostatistics and Research Methodology (Practical)	Skill based	0	0	2	1
Discipline Elective Course-I (Any one of the following)						
HGE.515	Public Health Research and Genetic Epidemiology	DE	3	0	0	3
MME.515	Molecular and Cellular Oncology	DE	3	0	0	3
ZOL.525	Nano biology	DE	3	0	0	3
BIM.511	Protein Engineering	DE	3	0	0	3
					Total Credits	**21**

Additional: 01 non-credit course (2 hour) on individualized education plan/tutorials.

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Semester-II

Syllabus
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Course Code	Course Title	Course Type	Hours			Credit
			L	T	P	
HGE.521	Human Cytogenetics and Human Biochemical Genetics	Core	3	0	0	3
MME.522	Essentials of Immunology	Core	3	0	0	3
HGE.523	Current Techniques in Molecular Genetics	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
HGE.526	Clinical Genetics (Practical)	Skill Based	0	0	6	3
Interdisciplinary Course-I (For other Departments)						
HGE. 529	Introduction to Intellectual Property Rights	IDC	2	0	0	2
XXX	Choose from IDC courses offered by other Departments	IDC	2	0	0	2
Discipline Elective Course-II (Any one of the following)						
HGE.527	Human Embryology and Developmental Genetics	DE	3	0	0	3
MME.527	Molecular Endocrinology and Signal Transduction	DE	3	0	0	3
MIC.525	Microbial Pathogenicity	DE	3	0	0	3

ZOL.553	Vascular Biology	DE	3	0	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	**21**
Additional: 01 non-credit course (2 hour) on individualized education plan/tutorials.						

Syllabus
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Semester-III

Syllabus
M.Sc. in Human Genetics (Batch: 2023-2025)

Course Code	Course Title	Course Type	Hours			Credit
			L	T	P	
HGE.551	Pharmacogenomics and Nutrigenomics	Core	3	0	0	3
HGE.552	Genetic Diseases, Therapies and Counseling	Core	3	0	0	3
HGE.553	Recombinant DNA technology and therapeutics	Core	3	0	0	3
HGE.554	Tools in Bioinformatics (Practical)	Skill Based	0	0	6	3
Discipline Elective Course-III (Any one of the following)						
HGE.555	Biosafety, Bioethics and Intellectual Property Rights	DE	3	0	0	3
MME.555	Evolution and Developmental Biology	DE	3	0	0	3
Value Added Course Courses						
HGE.556	Principles of Ecological Sciences	Value based	2	0	0	2
XXX	Value Added Course (From other departments)	VAC	2	0	0	2
Foundation Courses						

HGE.558	Innovation and Entrepreneurship	Compulsory Foundation	2	0	0	2
HGE.600	Dissertation Part-I	Skill Based	0	0	8	4
		Total Credits				**23**
Additional: 01 non-credit course (2 hour) on individualized education plan/tutorials.						

Semester-IV

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

MOOC Options: 40% credits can be obtained through MOOCs depending on availability of course with matching content.

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 secretory 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 extracellular 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 division and cell cycle: 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.

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., Heald, R., Johnson, A., Morgan, D., Raff, M. Roberts, K., and Walter, P. (2022). 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. (2018). Cytology, Genetics and Evolution. Rastogi publications, Meerut, India.
4. Karp, G. (2022). 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 **11 Hours** **Chromosomal Aberrations and Gene mutations:** Numerical aberrations: aneuploidy and polyploidy; structural chromosomal aberrations: deletion, duplication, inversion and translocation, types of mutations: point mutation, transitions and transversions, physical and chemical mutagens, Benzer experiment to elucidate fine structure of gene; Chromosomal changes and evolution of bread wheat.	**CLO2**
Unit III **11 Hours** Extra-chromosomal inheritance: Chloroplast: variegation in Four O' Clock plants; cytohets of *Chlamydomonas*; mitochondrial inheritance: poky in neurospora, petites in yeast; infectious heredity: Kappa in *Paramecium*, infective particles in *Drosophila*.	**CLO3**
Unit IV **11** Hours **Population Genetics** Population Dynamics, conditions and deviations of the Hardy-Weinberg law; selection coefficient and fitness; heterozygous advantages; inbreeding and its consequences; mutation pressure and genetic load; dynamics of migration and genetic drifts.	**CLO4**

Transactional Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning; co-learning techniques.
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 (2014). Concepts of Genetics. Prentice-Hall.
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: (2017) A Conceptual approach. 6th edition Freeman Publishers.
4. Hartle DL and Jones EW. (2009) 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, A.F., Doebley, J., Peichel C (2020). An Introduction to Genetic Analysis. 8th edition John Wiley & Sons.

		L	T	P	C
Course Code:	**MME.508**				
Course Title:	**Biomolecules and Metabolism**	**3**	**0**	**0**	**3**
Total Hours:	**45**				

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.

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 inhibitors; 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 the 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: 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: 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. Jeremy Berg, Gregory Gatto Jr., Justin Hines, John L. Tymoczko, Lubert Stryer (2023) Biochemistry. 10th Edition, Macmillan Learning, ISBN: 9781319498504
2. David L. Nelson and Michael M. Cox (2017). Lehninger Principles of Biochemistry. W. H. Freeman publisher. ISBN: 9781464126116

3. Donald Voet and Judith G. Voet (2016). Principles of Biochemistry, 5th edition. Wiley Publisher. ISBN: 9780470547847
4. Palmer, T., & Bonner, P. L. (2001). Enzymes: Biochemistry. Biotechnology, Clinical Chemistry. Horwood Publishing Chichester.
5. Christopher K. Mathews, Kensal Edward Van Holde, and Kevin G. Ahern (2000). Biochemistry. Oxford University Press Inc. New York.
6. Nicholas Price, University of Glasgow, and Lewis Stevens (1999). Fundamentals of Enzymology: The Cell and Molecular Biology of Catalytic Proteins. Oxford University Press. ISBN: 9780198502296

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, Errors.	**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. (2019). Biostatistics for medical and biomedical practioners. 2nd 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 (2013). Biostatistics: Basic Concepts and methodology for the health sciences. 10th 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: **MME.510**
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. (2021). Molecular Cell Biology. W.H. Freeman, USA.
3. Robertis, (2017). Cell and Molecular Biology. Lippincott Williams & Wilkins.
4. Karp, G. (2019). 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. (2007). Molecular Biology of the Gene Benjamin Cummings.
7. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2022). 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.
9. Cooper GM. (2019). The Cell: A Molecular Approach. 2nd edition. Sunderland (MA): Sinauer Associates

		L	T	P	C
Course Code:	**HGE.511**				
Course Title:	**Concepts of Genetics (Practical)**	**0**	**0**	**2**	**1**
Total Hours:	**30**				

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.512**
Course Title: **Biomolecules and Metabolism (Practical)**
Total Hours: **30**

L	T	P	C
0	0	4	2

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 practical's)

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

Course Code: **HGE.513**
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 literature.

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, posters 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 practical's)

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

Discipline Elective-I

Course Code:	**HGE.515**	**L**	**T**	**P**	**C**
Course Title:	**Public Health Research and Genetic Epidemiology**	**3**	**0**	**0**	**3**
Total Hours:	**45**				

Course Learning Outcomes:
On successful completion of the course the student will be able to:
CLO1: Develop applicable knowledge on global and local public health issues.
CLO2: Perform public health data management and result interpretation.
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 I **11 Hours** Principles and Practices of Public Health: Scope and concerns of public health; Determinants and measurement of health and disease; Environment and health; Health equity.	**CLO1**
Unit II **11 Hours** Public health management: Occupational health; Exposure and risk management; Health informatics; Concepts of Genomic surveillance; Clinical trials.	**CLO2**
Unit III **12 Hours** Fundamentals of epidemiological studies: Experimental and observational studies; Cohort study; Cross-sectional studies; Methods of sampling; Methods of association studies; Genome-wide association studies (GWAS). Systematic review and meta-analysis.	**CLO3**
Unit IV **11 Hours** Application of genetic variations: 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**;** Innovative ideation; Case study; Virtual classrooms; seminar presentation; Problem solving; Co-learning techniques; 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. Detela, R. Gulliford, M. Karim, Q.A. Tan, C.C. (2021). Global Public Health. Oxford University Press. 7th Ed.
2. Park, K. (2021). Preventive and Social Medicine. Bhanot Publishers. New Delhi.
3. U.S Department of Health and Human Services. (2012). Principles of Epidemiology in Public Health Practice. Updated Third Ed.

4. World Health Organization. (2001). Health Research Methodology: A guide for training in research methods. 2nd Ed.
5. Celentano, D.D. and Szklo, M. (2019) Gordis Epidemiology. Elsevier. 6th Ed.
6. Palmer LJ, Burton PR & Smith GD (2011). An introduction to genetic epidemiology (Policy Press, University of Bristol)
7. Dawn TM (2011). Genetic Epidemiology (Springer)
8. Austin M (2013). Genetic Epidemiology: Methods and Applications, 1st Edition (CABI Publishing).

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 Indian traditional medicine for cancer 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. Jacques Robert (2015) Textbook of cell signalling in cancer, Springer science, New York.
8. Weinberg, Robert A. (2023), 3rd edition, The Biology of Cancer. New York: Garland Science

Related Web links

http://www.insidecancer.org/

http://www.who.int/cancer/en/

http://www.cancer.gov/

Semester – II

		L	T	P	C
Course Code:	**HGE.521**				
Course Title:	**Human Cytogenetics and Human Biochemical Genetics**	**3**	**0**	**0**	**3**
Total Hours:	**45**				

Course Learning Outcomes:
On successful completion of the course the student will be able to:
CLO1: Know about structure of chromosomes and chromatin model,
CLO2: Apply classical cytogenetic and molecular cytogenetic techniques for the identification of individual chromosomes and various chromosomal disorders,

CLO3: Describe biochemistry and genetics of various blood group types,
CLO4: Distinguish different disorders caused due to abnormal variants of hemoglobin, lysosomal enzymes, lipids and DNA nitrogenous bases.

Unit I **11 Hours** General features of Human Chromosome and Chromosome staining: Chromatin structure; nucleosome model; constitutive and facultative heterochromatin; centromeres, Telomere and its maintenance; nuclear organization region (NOR); chromosome nomenclature; sister chromatid exchanges (SCE); mosaicism; structure of human X and Y chromosome; ring chromosomes; human artificial chromosome.	**CLO1**
Unit II **12 Hours** Cytogenetic and Molecular Cytogenetic Techniques: Methods of Chromosome preparation; chromosome banding techniques: G banding, Q banding, R banding and C banding; fluorescent in situ hybridization (FISH); different types of FISH probes: centromeric probes, chromosome specific probes and telomeric probes; reverse painting; flow cytometry; comparative genomic hybridization (CGH) mapping technique, whole chromosome painting; spectral karyotyping (SKY).	**CLO2**
Unit III **11 Hours** **Blood groups and Haemoglobinopathies:** Biochemical and genetic basis of blood group systems: ABO, Rh and MN; Haemoglobin structure, quantitative and qualitative disorders of globin chain synthesis: Sickle Cell Anaemia, Thalassemia.	**CLO3**
Unit IV **11 Hours** **Genetic and Biochemical basis of orphaned disorders:** Lysosomal storage disorders (LSDs): Tay-Sachs disease and Mucopolysaccharidoses; lipoprotein and lipid metabolism disorders: hyper lipoproteinemia; purine metabolism disorders: Lesch-Nyhan syndrome; disorders due to abnormal pyrimidine metabolism: Orotic Aciduria.	**CLO4**

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

Internal assessment shall be through any of the following: Discussion on evolution of X and Y chromosomes, In Depth interview on banding techniques; Seminar on molecular cytogenetic techniques, Assignment on Flow cytometry; Surprise Tests, one sentence summary, Practice exercise on karyotype analysis, case analysis, simulated problem solving, open book techniques, classroom assignments, homework assignments, term paper, Seminars, term papers, discussions and presentations

Suggested Readings:

1. Gillham, N. (2011). Genes, Chromosomes and Disease. Pearson
2. Griffiths, A.J.F., Wessler, S.R. and Carroll, S.B. (2012). An Introduction to Genetic Analysis. W.H. Freeman Publication, USA.
3. Hein, S. and Mitelman, F. (2009). Cancer Cytogenetics. Wiley-Blackwell.
4. Korf, B.R and Irons, M.B. (2013). Human Genetics and Genomics. Wiley-Blackwell.
5. Kumar, A. and Srivastava, M. (2012) A textbook of Molecular Cytogenetics, Narendra Publishing House, India
6. Purandare, H. and Chakravarty, A. (2000) Human Cytogenetic Techniques and Clinical Applications. Bhalani Publishing House, Mumbai, India.
7. Ram, M. (2010). Fundamental of Cytogenetics and Genetics. PHI Learning Pvt. Ltd.
8. Roy, D. (2009). Cytogenetics.Narosa Publishing House. New Delhi, India.
9. Tom, S and Read, A (2010). Human Molecular Genetics. Garland Science.
10. Shukla, A.N. (2009). Elements of enzymology. Discovery Publishing. New Delhi, India.
11. Voet, D. and Voet, J.G. (2008). Principles of Biochemistry. CBS Publishers & Distributors, New Delhi.
12. Mark, H. F. L.9 (2020). Medical Cytogenetics. CRC Press, USA.
13. Leihr, T. (2021)Cytogenomics . Elsevier Publications

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 the 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, Transplantation immunology, vaccine development.	**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. 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

		L	T	P	C
Course Code:	**HGE.523**				
Course Title:	**Current techniques in Molecular Genetics**	**3**	**0**	**0**	**3**
Total Hours:	**45**				

Course Learning Outcomes:

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

CLO1: Analyze various cellular processes using biochemical techniques.

CLO2: Learn the techniques for the visualization of a broad range of biological processes and features in cell structure.

CLO3: Learn the isolation of nucleic acids and its quantitative & qualitative analysis. Their importance for clinical molecular methods. Apply the knowledge to decipher the mechanisms of molecular and cell biology.

CLO4: Learn various immuno-techniques, Mutation analysis techniques and Cell and tissue culture techniques. Conceptualize principles of these different techniques used in life sciences.

Unit I **11 Hours** **Biochemical Techniques:** Principle, applications and sample preparation for ultra violet, infra-red and visible spectroscopy, atomic absorption spectrometry (AAS) and ICP spectrometry (ICP-MS), high-performance liquid chromatography (HPLC), gas chromatography-mass spectrometry (GC MS); centrifugation and ultracentrifugation	**CLO1**
Unit II **11 Hours** **Microscopy:** Principle, Resolution and magnification, parts of compound microscope, sample preparation, principal and applications-light microscopy, phase contrast microscopy, fluorescent microscopy; confocal microscopy and electron microscopy	**CLO2**
UNIT III **11 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 2-Dimensional gel electrophoresis; polymerase chain reaction (PCR): principle, types and applications; PCR based markers:, SNPs; blotting techniques: southern, northern, western, dot blotting and hybridization; DNA fingerprinting.	**CLO3**
UNIT IV **12 Hours** Flow Cytometry: Cell sorting; hybridoma technology: production of antibodies; histochemical and immuno technique;developing monoclonal and polyclonal antibodies; immunocytochemistry, radioimmunoassay (RIA); enzyme linked immunosorbent assay (ELISA) and autoradiography. Mutation analyses techniques: Restriction mapping, SSCP analyses, DNA sequencing-manual and automated methods. Cell and tissue culture techniques: Plants and animals.	**CLO4**

Transactional Modes: Lecture**;** Demonstration**;** Tutorial**;** Students visit to central instrument facility, Virtual classrooms; Lecture cum demonstration; Problem solving; Self-learning.

Internal assessment shall be through any of the following: Interview on various microscopic techniques; Visit to CIL and compile a report; Case studies solved by DNA fingerprinting, Assignment; In Depth interviews, Analysis of DNA sequencing data, Surprise Tests, term paper, Seminars, discussions and presentations, drawing flow charts for the techniques.

Suggested Readings:

1. Brown, T.A. (2010). 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. (2008). Kuby Immunology. 6th Edition, W. H. Freeman & Company, San Francisco.
3. Gupta, P.K. (2005). Elements of biotechnology. Rastogi Publications, Meerut.
4. Gupta, S. (2005). Research methodology and statistical techniques, Deep & Deep Publications (P) Ltd. New Delhi.
5. Kothari, C.R. (2008.) Research methodology(s). New Age International (P) Ltd., New Delhi
6. Lewin, B. (2010). Genes X, CBS Publishers & Distributors. New Delhi.
7. Mangal, S.K. (2007). DNA Markers in Plant Improvement. Daya Publishing House, New Delhi.
8. Nelson, D. and Cox, M.M. (2009). Lehninger Principles of Biochemistry. W.H. Freeman and Company, New York.
9. Primrose. S.B. and Twyman, R. (2006). Principles of Gene Manipulation and Genomics. Blackwell Publishing Professional, U.K.
10. Sambrook, J. (2006). The Condensed Protocols from Molecular Cloning: A Laboratory Manual .Cshl Press. New York.
11. Sambrook, J. and Russell, D.W. (2000). Molecular Cloning: A Laboratory Manual (3 Vol-set). 3rd Edition, CSHL Press, New York.
12. Sawhney, S.K. and Singh, R. (2005). Introductory Practical Biochemistry. Narosa Publishing House, New Delhi.
13. Slater, A., Scott, N.W., and Fowler, M.R. (2008). Plant Biotechnology: The Genetic Manipulation of Plants. Oxford University Press, USA.
14. Wilson, K. and Walker, J. (2006). Principles and Techniques of Biochemistry and Molecular biology. 6th Edition, Cambridge University Press India Pvt. Ltd., New Delhi.
15. Sue Carson Heather Miller Melissa Srougi D. Scott Witherow (2019) Molecular Biology Techniques. Academic Press, USA.
16. Masoodi, K.Z., Maqbool, S. and Rasdool, R. S.(2021). Advanced methods in molecular biology and biotechnology. Academic Press, Cambridge, Massachusetts.

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. Hill, R.W, Wyse, G. A. and Anderson, M. (2008). Animal physiology. Sinauer Associates Inc. USA.
4. Khurana. (2006). Textbook of medical physiology. Elsevier India Pvt. Ltd.

5. Murray, R.K. (2009). Harper's illustrated biochemistry. Jaypee Publishers,
6. New Delhi, India.
7. Tyagi, P. (2009). A textbook of Animal Physiology. Dominant Publishers and Distributors, New Delhi, India.
8. Silverthorne D, (2011) Human Physiology, Pearson; 6th edition.
9. Sherman V. (2013) Vander's Human Physiology. McGraw-Hill 13th edition.
10. Jain A.K. (2021). Textbook of physiology. Avichal Publishing Company-9th
11. Edition.Guyton. (2015)., 13th edition Textbook of medical physiology. 11th Edition. Elsevier India Pvt. Ltd. New Delhi.
12. CC Chatterjee's (2022), 14th Edition, Human Physiology, CBS Publishers & Distributors Pvt. Ltd.

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).

Syllabus
M.Sc. in Human Genetics (Batch: 2023-2025)

		L	T	P	C
Course Code:	**HGE.526**				
Course Title:	**Clinical Genetics (Practical)**	**0**	**0**	**6**	**3**
Total Hours:	**45**				

Course Learning Outcomes:
On successful completion of the course the student will be able to:
CLO1: Interpret how genetic factors predispose to Mendelian and adult onset diseases
CLO2: Implications of these predispositions for diagnosis, prevention, and treatment.
CLO3: Appreciate the importance of genetic counseling to assert the birth of a children affected with genetic disorders
CLO4: Assess the clinical features of common chromosomal alterations.
CLO5: Gain an insight into the cytogenetics and analysis of karyotypes
CLO6: Application of appropriate molecular biology techniques for diagnosis, disease prediction and prevention.

List of Practical work:

1	Genetic assessment and drawing pedigree.	**CLO1**
2	Genetic counseling	**CLO2, CLO3**
3	Common chromosomal disorders-case studies	**CLO4**
4	Cytogenetics and karyotype analysis	**CLO5**
5	DNA and RNA isolation, quantification, gel electrophoresis (agarose/PAGE),	**CLO6**
6	PCR-RFLP	
7	RT-PCR	
8	ELISA	

Transactional Modes: Lecture**;** Demonstration**;** Virtual classrooms; Problem solving; Self-learning, Pedigree drawing.

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 practical's)

- Final Examination = **40 Marks**

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

Suggested Readings:

1. Brooker, R.J (2017). Genetics: analysis and principles. 6th Ed. New York, NY: McGraw-Hill Education.
2. Hartwell, L. et al (2017). Genetics: from genes to genomes. 6th Ed. New Your, NY: McGraw-Hill Education.
3. Helen, M.K. 2002. ABC of clinical Genetics. 3rd Ed. BMJ Publishing Group. London.

Interdisciplinary Courses

		L	T	P	C
Course Code:	**HGE.529**				
Course Title:	**Introduction to Intellectual Property Rights**	**2**	**0**	**0**	**2**
Total Hours:	**30**				

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/)

Discipline Elective -II

		L	T	P	C
Course Code:	**HGE.527**				
Course Title:	**Human Embryology and Developmental Genetics**	**3**	**0**	**0**	**3**
Total Hours:	**45**				

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 **Gametes, fertilization and early development**: Gametogenesis; fertilization; types of cleavage; morphogenesis; gastrulation: cell movement and formation of germ layers in frog, chick and mouse; fate map; fetal membrane and placenta; potency, commitment, specification, induction, competence, determination, and differentiation.	**CLO1**
Unit: II 11 Hours **Gene expression regulation in developmen**t: Basics of gene expression regulation during early embryogenesis; homeotic genes, P granules, role of key developmental genes: Polycomb repressor complexes (PRC1 and PRC2), Sox proteins.	**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 **Genetics of pattern and organ formation**: Chromatin diminution; endoreplication cycles; gene amplification; Drosophila: formation of body axis, segmentation genes, homeotic gene function; Vertebrates: axes formation and HOX genes.	**CLO4**

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.

Course Code: **MME.527**

Course Title: **Molecular Endocrinology and Signal Transduction**

L	T	P	C
3	0	0	3

Total Hours: **45**

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 the immune system.

Unit: 1 **10 Hours** Endocrine glands, and hormones as chemical messengers, stimulus for hormone release: change in homeostasis, sensory stimulus and others.	**CLO 1**
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).	**CLO 2**
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).	**CLO 3**
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.	**CLO 4**

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. 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.
3. Ari Sitaramayya (2012) Introduction to Cellular Signal Transduction (Hormones in Health and Disease), Springer science, New York.
4. Bastien D. G., IJsbrand M. K. and Peter E.R. T. (2015), 3rd edition, Signal Transduction, Academic Press, MA, USA

Semester – III

		L	T	P	C
Course Code:	**HGE.551**				
Course Title:	**Pharmacogenomics and Nutrigenomics**	**3**	**0**	**0**	**3**
Total Hours:	**45**				

Course Learning Outcomes:
On successful completion of the course the student will be able to:
CLO1: Define pharmacogenomics and will understand its application in clinical setting. The students will be aware about the challenges in the field on account of different ethnic background.
CLO2: Have an understanding about the nutritional requirements and the role of gut microbiota in human nutrition.
CLO3: Be aware of the effect of genetic polymorphisms in variable response to micronutrients and will understand the regulation of transcription factors by the nutrients.
CLO4: Get aware of the genetic markers involved in the regulation of metabolomics and the role of these markers in health and disease.

UNIT I **12** Hours Pharmacogenomics: Pharmacokinetics and pharmacodynamics; drug-metabolizing enzymes: cytochrome P450s, VKORC1 and TPMT; personalized treatment: example of warfarin, anti-epileptic and anti-cancer drugs like methotrexate and tamoxifen, trastuzumap; heredity disorders with altered drug response: porphrriavariegata, hemoglobinopathies, Grigler-najjar syndrome; concept of pharmacogenomics;	**CLO1**
UNIT II **11** Hours Nutritional Biochemistry: Essential and non-essential nutrients; micro and macro nutrients; basal metabolic rate (BMR); malnutrition; malabsorption and interventional strategies. Concept of gut microbiota in human nutrition. Gut-brain axis in absorption; Role of Prebiotics and Probiotics in Gut brain axis	**CLO2**
UNIT III **11** Hours Nutrigenomics in determining health: Diet and gene expression; nutritional status in early life and metabolic programming; nutrients as regulators of activity and transcription factors; modulating the risk of obesity and vitamin D deficiency through nutrigenomics.	**CLO3**
UNIT IV **12** Hours Biomarkers and recent advances in Nutrigenomics: Genetic and nutritional control of lipid metabolism, metabolomics; effect of diet on epigenetic processes, concept of oral and gut microbiome and its implications in health and disease; therapeutic approaches through microbiota transplantation.	**CLO4**

Transactional Modes: Lecture**;** Demonstration**;** Tutorial**;** Virtual classrooms; Lecture cum demonstration; Problem solving; Self-learning.
Internal assessment shall be through any of the following: Literature survey on current medicines based on pharmacogenomics, In-depth interview on ADRs. Group activity to calculate BMI, Preparation of a list of essential micro and macronutrients,

Surprise Tests, case analysis, classroom assignments, homework assignments, term paper, Seminars, term papers, discussions, and presentations.

Suggested Readings:

1. Altman RB, Flockhart D and Goldstein DB (2012). Principles of Pharmacogenetics and Pharmacogenomics. Cambridge University Press.
2. Ferguson, L,R.(2013) Nutrigenomics and Nutrigenetics in Functional Foods and Personalized Nutrition. CRC Press.
3. Tollefsbol T (2011). The New Molecular and Medical Genetics. Elsevier Inc
4. Simopoulos A.P. and Ordovas J.M. (2004). Nutrigenetics and Nutrigenomics Karger Publishers
5. Rimbach, G and Fuchs, J (2005) . Nutrigenomics (Oxidative Stress and Disease). CRC press
6. Yui-Wing Francis Lam Stuart Scott (2018) Pharmacogenomics: Challenges and Opportunities in Therapeutic Implementation, Elsevier, Netherlands.
7. https://www.frontiersin.org/research-topics/22282/insights-in-pharmacogenetics-and-pharmacogenomics-2021
8. https://www.frontiersin.org/research-topics/15354/pharmacogenomics-of-adverse-drug-reactions-adrs
9. Lam,Y.W.F.and Scott, S.(2018).Pharmacogenomics Challenges and opportunities in therapeutic implementation. Science Direct

Course Code:	**HGE.552**	**L**	**T**	**P**	**C**
Course Title:	**Genetic Diseases, Therapies and Counseling**	**3**	**0**	**0**	**3**
Total Hours:	**45**				

Course Learning Outcomes:

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

CLO1: Understand the genetic causes of monogenic disorders and common multifactorial diseases

CLO2: Understand the genetic basis of Genomic imprinting. Analyze the consequences of altered epigenetic processes in causing genetic disorders

CLO3: Understanding genetic screening and counseling

CLO4: Apply the principle of genetics and biostatistics for genetic disorders risk assessment

UNIT I **11** Hours Monogenic Disorders: Cystic fibrosis; Huntington's disease; Duchenne Muscular dystrophy; X-linked rickets. Multifactorial Diseases: Diabetes type 2; Cancers; Hypertension; Obesity; Neurodegenerative diseases, Depression, IBS	**CLO1**
UNIT II **11** Hours Genomic Imprinting and Human Diseases: Uniparental disomy and genomic imprinting; Imprinting syndromes: Prader-Willi and Angelman syndrome; Beckwith-Wiedemann syndrome and Silver Russell Syndrome; Role of Imprinting in brain development and behavior.	**CLO2**
UNIT III **11** Hours Genetic Screening and Counseling: Pre symptomatic testing for genetic diseases and malignancy, carrier detection; prenatal and postnatal screening; Assisted reproductive techniques and Pre-implantation diagnosis; Genetic Counseling.	**CLO3**
UNIT IV **12** Hours Therapies for genetic disorders and multifactorial diseases: Stem cell therapies: stem cell types, cord blood cells, bone marrow transplantation; current stem cell therapies; gene therapies: methods; diseases suitable for gene therapies: hemoglobinopathies, cystic fibrosis, muscular dystrophies, cancer; challenges in gene therapy; regulatory requirements, RNA Therapies; Artificial intelligence and diagnosis of genetic disorders	**CLO4**

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, Assignment on various gene therapies in use currently, Group activity to explore regulatory requirements and prepare a report.

Suggested Readings:

1. Brown, S.M., (2009). Essentials of Medical Genomics. Wiley-Blackwell.
2. Jocelyn, E. K., Elliot, S. G., Stephen, T. K. (2009), Lewin's Gene X. Jones &Barlett.

3. Krebs, J.E., Goldstein, E.S. and Kilpatrick, S.T. (2014). Lewin's Genes XI. Jones and Bartlet India Pvt. Ltd.
4. Lodish, H., Berk, A., Chris, A. K., Krieger, M. (2008), Molecular Cell Biology. W.H. Freeman, USA.
5. Milunsky, A. (2021).Genetic disorders and the fetus diagnosis prevention and treatment 8th Edition. Wiley Blackwell.
6. Petris, G. (2021).Curing Genetic Diseases through Genome Reprogramming. Elsevier
7. https://www.rosenpublishing.com/series/Genetic-Diseases-and-Gene-Therapies

Course Code: **MME.553**

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** 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.	**CLO 1**
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	**CLO 2**
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,	**CLO 3**
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.	**CLO 4**

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.
8.

		L	T	P	C
Course Code:	**HGE.554**				
Course Title:	**Tools of Bioinformatics (Practical)**	**0**	**0**	**6**	**3**
Total Hours:	**60**				

Course Learning Outcomes:
On successful completion of the course the student will be able to:
CLO1: Analyze publicly available and experimental genomics data
CLO2: Analyze sequence alignment and generation of PCR oligos
CLO3: Perform next generation sequence and microarray data analysis and functional annotation of genetic findings.
CLO4: Perform in-silico prediction of protein structures and interactions

1.	Access to sequence databases (downloading DNA/RNA/Protein sequences).	CLO1
2.	Genomics/transcriptomics/proteomics data retrieval and analysis	
3.	Primer designing for PCR and RT-PCR	CLO2
4.	Performing sequence alignment using various tools (BLAST, MSA)	
5.	Pipeline of Next generation RNA-seq/DNA sequencing analysis.	CLO3
6.	Genome wide association study and DNA microarray-data analysis	
7.	Analysis of linkage disequilibrium plots.	
8.	Prediction of Protein structure using sequence database	CLO4
9.	Practical insights of tertiary structure prediction and comparative modeling	
10.	Protein-protein and protein-ligand docking	

Transactional Modes: Hands-on training; 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.

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:

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

		L	T	P	C
Course Code:	**HGE.555**				
Course Title:	**Biosafety, Bioethics, and Intellectual Property Rights**	**3**	**0**	**0**	**3**
Total Hours:	**45**				

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** 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.	**CLO1**
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.

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 concepts related to the origin of life.
CLO2: Develop understanding regarding molecular evolution and origin of the 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.

Value added Course

Course Code: **HGE.556**

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 the basics of ecological components
CLO2: Conceptualize the ecosystem and its components
CLO3: Contribute to for population ecology and conservation biology
CLO4: Improve student's aptitude for ecological science research and development

UNIT I **6 Hours** **Environment components:** Physical environment (Climate, atmosphere, light, soil, temperature); biotic environment; biotic and abiotic interactions. Ecological amplitude; Ecological adaptation; Ecological species concept; Ecotype & Ecads; K-selected & r-selected species; Concept of habitat and niche; character displacement.	**CLO 1**
UNIT II **8 Hours** **Ecosystem and Ecological Succession:** Ecosystem components; Productivity & energy flow; Food chain; Food web; Concepts of the trophic level, ecological pyramid and mineral cycling (C, N, P); primary production and decomposition; Kinds of ecosystems: terrestrial and aquatic; Biomes. Ecological Successions: Types; mechanisms; changes involved in succession; concept of climax.	**CLO 2**
UNIT III **8 Hours** **Population Ecology and Conservation Biology:** Characteristics of a population; Population dispersal; Population Growth; Biotic community: Ecological characteristics; Nature & Structure of community; Ecological interdependence & interaction; Biodiversity: Levels of diversity and its measurement; Components & gradients of biodiversity; Conservation of biodiversity; Project Tiger; Biogeographic classification of India.	**CLO 3**
UNIT IV **8 Hours** **Applied Ecology:** Environmental pollution; Air pollution: Pollutants, greenhouse effect, global warming, Kyoto and Montreal Protocol, ozone, acid rain. Water pollution: Biochemical oxygen demand, chemical oxygen demand, eutrophication; Soil pollution; Bioremediation, phytoremediation.	**CLO 4**

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,

Foundation Course

Course Code: **HGE.558**

Course Title: **Innovation and Entrepreneurship**

Total Hours: **15**

L	T	P	C
2	0	0	2

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: Aware about the support system and available policies

CLO4: Know the criterion for registration of different forms of IPRs and technology transfer requirements

Unit I **8 Hours** **Enterpreneurial Structure:** Nature, characteristics, functions and its role in economic development; entrepreneurial behavior and skills; role of women entrepreneurs and social enterpreneurs in society; market driven and technology driven enterpreneurship, startups	**CLO1**
Unit II **8 Hours** **Business plan and funding opportunities** Business model canvas; supply and customer chains, Business to business (B2B), Direct to customer (D2C) business types and funding opportunities: marketing and sales strategy; public funded schemes and angel funding	**CLO2**
Unit III **7 Hours** **Blending University Research and Entrepreneurship culture:** Pre Incubation and Incubation facilities, Idea hackathons, Policy to encourage entrepreneurship in students and faculty; case studies on the development and launch of products, and services in the field of biomedicine and genetic diagnosis	**CLO3**
Unit IV **7 Hours** **Intellectual Property (IP) and Technology Transfer:** Different forms of intellectual property (IP)-patent, industrial design, trademark, copyright; technology transfer requirements and process	**CLO4**

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. Hockaday, J. (2020).University Technology Transfer-What it is and How to Do it, Johns Hopkins University Press
5. Jain, P. C. (2015). Handbook of New Entrepreneurs, Oxford University Press.

6. Srivastava, S. B. (2009). A Practical Guide to Industrial Entrepreneurs, Sultan Chand & Sons.
7. Mietzner, D. and Schultz. C. (2021). New Perspectives in Technology Transfer, Springer.
8. National Innovation and startup policy for students and faculty 2019, Government Policy document http://rmkcet.ac.in/RMK/NISP%20policy.pdf

Course Title: **Dissertation Part-I**

0	**0**	**8**	**4**

Total Hours: **120**

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 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. Students 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

Semester IV

		L	T	P	C
Course Code:	**HGE.601**				
Course Title:	**Dissertation Part-II**	**0**	**0**	**40**	**20**
Total Hours:	**60**				

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 research and interpret the results
f. Write research reports and may publish research findings (if significant)

Examination pattern for 2023-25 session

Examination pattern and evaluation for Masters' students from 2023-24 session

Formative Evaluation: Internal assessment shall be 25 marks using any two or more of the given methods: tests, open book examination, assignments, term paper, etc. The Mid-semester test shall be of 25 marks including short answer and essay type. The number of questions and distribution of marks shall be decided by the teachers.

Summative Evaluation: The End semester examination (50 marks) with 70% descriptive type and 30% objective type shall be conducted at the end of the semester. The objective type shall include one-word/sentence answers, fill-in the blanks, MCQs', and matching. The descriptive type shall include short answer and essay type questions. The number of questions and distribution of marks shall be decided by the teachers. **Questions for exams and tests shall be designed to assess course learning outcomes along with focus on knowledge, understanding, application, analysis, synthesis, and evaluation.**

The evaluation for IDC, VAC and entrepreneurship, innovation and skill development courses shall include MST (50 marks) and ESE (50 marks). The pattern of examination for both MST and ESE shall be the same as ESE described above for other courses.

Evaluation of dissertation proposal in the third semester shall include 50% weightage by supervisor and 50% by HoD and senior-most faculty of the department. The evaluation of dissertation in the fourth semester shall include 50% weightage for continuous evaluation by the supervisor for regularity in work, mid-term evaluation, report of dissertation, presentation, and final viva-voce; 50% weightage based on average assessment scores by an external expert, HoD and senior-most faculty of the department. Distribution of marks is based on the report of dissertation (30%), presentation (10%), and final viva-voce (10%). The-- external expert may attend final viva-voce through offline or online mode.

Examination pattern from 2022-23 session

Core, Discipline Elective, and Compulsory Foundation Courses			IDC, VAC, and Entrepreneurship, Innovation and Skill Development Courses	
	Marks	Evaluation	Marks	Evaluation
Internal Assessment	25	Various methods	-	-
Mid-semester test (MST)	25	Descriptive	50	Descriptive (70%) Objective (30%)
End-semester exam (ESE)	50	Descriptive (70%) Objective (30%)	50	Descriptive (70%) Objective (30%)

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)

Marks for internship shall be given by the supervisor, HoD and senior-most faculty of the department.

Some Guidelines for Internal Assessment

1. The components/pattern of internal assessment/evaluation should be made clear to students during the semester.

2. The results of the internal assessment must be shown to the students.

3. The question papers and answers of internal assessment should be discussed in the class.

4. The internal assessment shall be transparent and student-friendly and free from personal bias or influence.

Syllabus
M.Sc. in Human Genetics (Batch: 2023-2025)