CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

M.Sc. Molecular Medicine

Session - 2020-22

Department of Human Genetics and Molecular Medicine

Programme Outcomes

M.Sc. Molecular Medicine students will be able to:

- Integrate multidisciplinary approaches for translational research and focus on designing molecular approaches for better understanding of human diseases.
- Target to perform molecular and translational techniques for health research and compete at national and global level to pursue research and teaching in any field of life sciences

Semester-I

Course Code	Course Title	Course Type	Hours			Credit
			L	T	P	
LHG.506	Biostatistics and Research Methodology	Compulsory Foundation	4	0	0	4
LHG.507	Biostatistics and Research Methodology (Practical)	Skill based	0	0	2	1
LMM.508	Cellular and Molecular Biology	Core	4	0	0	4
LMM.509	Cellular and Molecular Biology (Practical)	Skill based	0	0	2	1
LMM.510	Biochemistry	Core	4	0	0	4
LHG.511	Biochemistry (Practical)	Skill based	0	0	2	1
LHG.512	Concepts of Genetics	Core	4	0	0	4
LHG.513	Concepts of Genetics (Practical)	Skill based	0	0	2	1
xxxx	IDC from other department	Interdisciplinary Elective	2	0	0	2
Total			**18**	0	**8**	**22**
Inter-disciplinary Course-I (For other Departments)						
LMM.515	Introduction to Human Cancers	IDC-I	2	0	0	2

Semester-II

Course Code	Course Title	Course Type	Hours			Credit
			L	T	P	
LMM.521	Human Physiology	Core	4	0	0	4
LHG.522	Human Physiology (Practical)	Skill Based	0	0	2	1
LMM.523	Essentials of Immunology	Core	4	0	0	4
LMM.524	Techniques in Molecular Medicine	Core	4	0	0	4
Elective Course-I (select anyone)						
LMM.525	Regenerative Medicine	Elective	4	0	0	4
LHG.525	Human Embryology and Developmental Genetics	Elective	4	0	0	4
LMM.514	Trends in Molecular Medicine	Core Course	4	0	0	4
LMM.542	Seminar-I	Skill Based	1	0	0	1
xxx.xxx	IDC from other department	Interdisciplinary Elective	2	0	0	2
LMM.515	Introduction to Human Cancers	IDC for students of other departments	2	0	0	2
Total			**23**	**0**	**2**	**24**

Semester-III

Course Code	Course Title	Course Type	Hours			Credit
			L	T	P	
LMM.551	Molecular Basis of Human Diseases	Core	4	0	0	4
LMM.554	Bioinformatics and Computational Biology	Core	4	0	0	4
LMM.552	Evolutionary and Developmental Biology	Core	4	0	0	4
Elective Course-II/MOOC (select anyone)						
LHG.526	Population Genetics and Genetic Epidemiology	Elective	4	0	0	4
LMM.526	Molecular and Cellular Oncology	Elective	4	0	0	4
Value added course offered by the Department						
LHG.504	Clinical Genetics (Practical)	Value Added	0	0	2	1
LHG.599	Project –I	Skill Based	0	0	12	6
Total			**16**	0	**14**	**23**

Semester-IV

Course Code	Course Title	Course Type	Hours			Credit
			L	T	P	
LMM.571	Genetic Engineering and Recombinant Therapeutics	Core	4	0	0	4
LMM.553	Molecular Endocrinology and Signal Transduction	Core	4	0	0	4
LHG.573	Practice in Life Sciences-I	Discipline Enrichment	2	0	0	2
LHG.574	Practice in Life Sciences-II	Discipline Enrichment	2	0	0	2
LHG.505	Principles of Ecological Science(for students of other deptts also)	Value based	1	0	0	1
LMM.544	Seminar-II	Skill Based	0	0	0	2
LMM.599	Project -II	Skill Based	0	0	0	6
Total			**13**	**0**	**0**	**21**

Total Credit: 90 (22+24+23+21)

Evaluation Criteria for Theory Courses

A. Continuous Assessment: [25 Marks]
   i. Surprise Test (minimum three) - Based on Objective Type Tests (10 Marks)
   ii. Term paper (10 Marks)
   iii. Assignment(s) (5 Marks)

B. Mid Semester Test: Based on Subjective Type Test [25 Marks]

C. End-Term Exam: Based on Subjective Type Test [25Marks]
   Based on Objective Type Tests [25 Marks]

Semester I

LHG.506: Biostatistics and Research Methodology

L	T	P	Cr
4	0	0	4

Credit Hours: 4

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

- Analyze and evaluate wide variety of statistical data
- Represent statistical data and summary statistics in graphical and tabular forms
- Apply suitable statistical tools to analyze data
- Write and communicate scientific reports, projects and publications

Unit – I **15 Lectures**

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; statistical errors.

Unit – II **15 Lectures**

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; multiple corrections; hypothesis testing.

Unit – III **15 Lectures**

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.

Unit – IV **15 Lectures**

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.

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

Suggested Readings:

1. Rao, P. S., & Richard, J. (2012). *Introduction to biostatistics and research methods*. PHI Learning Pvt. Ltd.

2. Hoffman, J. I. (2015). *Biostatistics for medical and biomedical practitioners*. Academic Press.
3. Banerjee, P. K. (2014). *Introduction to Bio-Statistics*. S. Chand Publishing.
4. Antonisamy, B. Christopher, S., & Samuel, P.P. (2011). *Biostatistics: Principles and Practice*. Tata McGraw Hill. New Delhi.
5. Daniel, W. W., & Cross, C. L. (2010). *Biostatistics: basic concepts and methodology for the health sciences* (pp. 410-412). New York: John Wiley & Sons
6. Norman, G. R., & Streiner, D. L. (2008). *Biostatistics: the bare essentials*. PMPH USA.

LHG.507: Biostatistics and Research Methodology (Practical)
Credit Hours: 1

L	T	P	Cr
0	0	2	1

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

- Apply suitable statistical equations to analyze data
- Perform data stratification and representation
- Write and communicate scientific reports, projects and publications

1. Plotting different types of graphs using statistical data, using MS Excel.
2. Plotting normal distribution graph
3. Frequency distribution, SD, SE calculations
4. Chi-square tests
5. Student's t-test
6. ANOVA
7. Regression and Correlation.
8. Scientific writing skill development.

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

Transactional Modes: Laboratory based practical; Problem solving; 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

LMM.508: Cellular and Molecular Biology
Credit Hours: 4

L	T	P	Cr
4	0	0	4

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

- Conceptualization of basic cellular and molecular mechanisms.
- Understanding structures and functions of various cellular organelles.
- Understanding the molecular processes of DNA replication, transcription, and translation

Unit – I **15 Lectures**

Membranes of intracellular organelles, Membrane transport, Structure and functions of intracellular organelles, Intracellular traffic and secretory pathways, endocytosis and exocytosis.

Unit – II **15 Lectures**

The Cytoskeleton: cell cytoskeleton and its organization including extracellular matrix, adhesions and junctions.

Cell-cell communication and cell growth: Overview of cell signaling, cell surface receptors and second messengers.

Unit – III **15 Lectures**

Chemical structure and functions of Nucleic acids: Chemical structure of DNA and RNA, Watson-Crick model, Different forms of DNA and RNA, Organelle DNA, nucleosome assembly.

Gene and Genome organization: Eukaryotic gene organization, transposition, Mechanism of DNA replication, DNA damage and their repair.

Unit – IV **15 Lectures**

Transcription: transcription and transcription factors, Transcriptional and post-transcriptional gene silencing, mRNA processing: Capping, Polyadenylation, Splicing, editing, mRNA stability.

Translation: Genetic code, the translation machinery, mechanisms of chain initiation, elongation and termination, regulation of translation, post-translational modifications of proteins.

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

Suggested Reading:

1. Sambrook, J., Fritsch, E. F., & Maniatis, T. (2015). Molecular cloning: a laboratory manual. Cold Spring Harbor Laboratory Pressn New York.
2. Lodish, H.,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.

L	T	P	Cr
0	0	2	1

LMM.509: Cellular and Molecular Biology (Practical)
Credit Hours: 1

Learning Outcomes:

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

- Visual analysis of cellular processes like mitosis, localization of proteins by immunofluorescence.
- Apply the knowledge for the research related to cell biology.

1. DNA isolation and Agarose gel electrophoresis
2. RNA isolation and denaturing gel electrophoresis
3. Instrumental methods for cell biology-centrifugation, chromatography.
4. Immunofluorescence and fluorescent probes.
5. Basics of mammalian cell culture
6. Histochemical techniques (Fixing, Processing, Staining).
7. Epifluoresence and Confocal Microscopy.

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

Transactional Modes: Laboratory based practical; Problem solving; 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

LMM.510: Biochemistry
Credits Hours: 4

L	T	P	Cr
4	0	0	4

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

- Understand the importance of maintenance of pH, role of vitamins and minerals in metabolic processes
- Compare the basic structural features of biomolecules namely amino acids, carbohydrates, lipids, and proteins.
- Study the metabolism of carbohydrates, lipids and proteins.
- Understand the structure of nucleic acids and their metabolism
- Conceptualize the basic features of enzyme catalysis and regulation.

Unit-I **15 Lectures**

Enzymes: Introductions, Importance & Classifications; Isozymes; Properties of enzymes; Enzyme nomenclature; Factors affecting enzyme action, Enzyme regulation; Mechanism of enzyme action; Enzyme kinetics & enzyme inhibiters; ES complex formation; Steady state kinetics; Michaelis-Menten equation; Km value and its significance; Turnover number; Enzyme inhibitors, Allosteric enzymes. Ribozymes and Abzymes.

Unit-II **15 Lectures**

Carbohydrates: Definition, classification and functions; Structures of monosaccharides, disaccharides, and polysaccharides; Epimers; Anomers; mutarotation. Reactions of carbohydrates; General scheme of metabolism.
Carbohydrates metabolism - Glycolysis, TCA cycle, Gluconeogenesis, Glycogenolysis, Pentose phosphate pathway, and their regulation; Oxidative phosphorylation.

Unit-III **15 Lectures**

Lipids: Definition, 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. Ketone bodies- Formation and utilization.
Amino acids: Introduction, classification and reactions of amino acids.

Unit-IV **15 Lectures**

Proteins: Definition, classification, structure and biological importance of protein in human body; Secondary, Tertiary and Quaternary structure, super secondary structures, Ramachandran plot. Oxygen binding proteins – Hemoglobin and myoglobin. Hill equation, Bohr's Effect.

Nucleic Acids: Structure and functions, Nucleosides and nucleotides. Metabolism of purines and pyrimidines- Salvage and *de novo* pathways.

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

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 Swaminathann. (2011). Handbook of clinical biochemistry. 2 edition, World Scientific Publishing Company, New Jersey, USA

LMM.511: Biochemistry (Practical)
Credit Hours: 1

L	T	P	Cr
0	0	2	1

Learning Outcomes:

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

- Appreciate the importance of chemical safety and precautions in the biochemistry laboratory.
- Prepare buffers and solutions with varied concentration.
- Quantitative estimation of biomolecules.
- Separation of biomolecules using electrophoresis and chromatography.

Practicals:

1. Preparation of solutions, buffers, pH setting etc.
2. Quantitative estimation of glucose.
3. Quantitation estimation of Cholesterol.
4. Estimation of proteins using Lowry's methods.
5. Extraction of DNA from blood/saliva.
6. Assay of amylase activity in saliva.
7. Effect of temperature/pH on enzyme activity.
8. Quantitative and qualitative estimation of DNA.
9. Principle and applications of electrophoresis

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

Transactional Modes: Laboratory based practical; Problem solving; 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**
   iv. Subjective question = 10 Marks
   v. Performing experiment = 20 Marks
   vi. Viva voce = 10 Marks

LHG.512: Concepts of Genetics
Credits Hours: 4

L	T	P	Cr
4	0	0	4

Learning Outcomes:

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

- Evaluate the Mendelian and Non-Mendelian inheritance patterns
- Gather knowledge about gene expression regulation and sex determination
- Evaluate different chromosomal aberrations and ploidies
- Know the details of extra chromosomal inheritance patterns

Unit: I **15 Lectures**

Transmission Genetics: Mendel's laws of inheritance and it's applications; concept of segregation, independent assortment and dominance; pedigree analysis; epistasis; crossing over and recombination; two and three point gene mapping.

Sex determination: Sex determination in Human and Drosophila; X-chromosome inactivation; dosage compensation.

Unit: II **16 Lectures**

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

Unit: III **16 Lectures**

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.

Unit: IV **13 Lectures**

Extra-chromosomal inheritance: Chloroplast: variegation in Four O' Clock plants; mutations in *Chlamydomonas*; mitochondrial inheritance: poky in neurspora, petites in yeast; molecular organization and gene products of chloroplast and mitochondrial DNA; infectious heredity: Kappa in *Paramecium*: Infective particles in *Drosophila*; endosymbiont theory.

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

Suggested Reading:

1. Korf, B.R. (2014). *Human Genetics and Genomics*. Wiley-Blackwell
2. Atherly, A.G., Girton, J.R., & Mcdonald, J.F. (1999). *The science of Genetics*. Saundern College publication.
3. Snusted, D.P. & Simmons, M. J. (2018). *Principles of Genetics*. John Wiley & Sons, New York.
4. Gupta, P.K. (2019). *Genetics*. RastogiPublications, Meerut, India.
5. Gupta, P.K (2018). *Cytology, Genetics and Evolution.*RastogiPublications, Meerut, India.
6. Jocelyn, E.K., Elliott, S.G., & Stephen, T.K. (2009). *Lewin's Genes X*. Jones and Bartlett Publishers, USA.
7. Schaum, W.D. (2016). *Theory & problems in Genetics by* Stansfield, outline series McGrahill, USA.
8. Tamarin, R.H. (2017). *Principles of Genetics, International edtn.* McGrawhill, USA.

L	T	P	Cr
0	0	2	1

LHG.513: Concepts of Genetics (Practical)
Credit Hours: 1

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

- Analyze genetic linkage and epistasis
- Evaluate different mutants of *Drosophila*
- Demonstrate X inactivation in females

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

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

Transactional Modes: Hands-on practical; 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**
   vii. Subjective question = 10 Marks
   viii. Performing experiment = 20 Marks
   ix. Viva voce = 10 Marks

L	T	P	Cr
2	0	0	2

Interdisciplinary Courses for Semester-I
Credit Hours: 2.

(To be offered by faculties from other centres)

Course Code: Code shall be brought from the department whose course is undertaken by the student.

Interdisciplinary Courses offered by Faculty of Molecular Medicine

L	T	P	Cr
2	0	0	2

LMM. 515: Introduction to Human Cancers
Credits Hours: 2

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

- Know basics of cancer biology.
- Understand various concepts and issues of cancer disease.
- Gain knowledge about deregulation of cellular processes in cancer.
- Learn about anticancer therapies in practice.

Unit: I **7 Lectures**
Classifications of human cancers, common symptoms.

Unit: II **7 Lectures**
Tumor suppressor and oncogenes, metastasis, angiogenesis.

Unit: III **8 Lectures**
Cancer hallmarks.

Unit: IV **8 Lectures**
Standard cancer therapies.

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

Suggested Reading:

1. Airley, R. (2017). *Cancer Chemotherapy: basics to clinic.* Willey-Blackwell publishing, New Jersey.
2. DeVita, V. T., Hellman, S., & Rosenberg, S. A. (2018). *Cancer: principles and practice of oncology*. Lippincot Williams and Wilkins Publishers, Philadelphia.
3. Enders, G. H. (2018). *Cell cycle deregulation in cancer.* Humana Press, Springer science, New York.
4. Weinberg, Robert A. (2012). *The Biology of Cancer*. New York: Garland Science.

Semester II

L	T	P	Cr
4	0	0	4

LMM.521: Human Physiology
Credit Hours: 4

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

- Know about the physiological functions of body systems.
- Evaluate the interrelationships between organ systems of the human body.
- Understand the principle of homeostasis and control mechanisms of physiological systems in the human body.
- Make a connection between knowledge of physiology and real-world situations, including healthy lifestyle decisions

Unit: I **15 Lectures**

Cardiovascular System: Heart, Cardiac cycle, blood constituents and groups, Blood pressure and its neural and chemical regulation. **Excretory System:** Kidneys, Urine formation and concentration, Micturition, Regulation of water balance, Electrolytes and acid-base balance.

Unit: II **15 Lectures**

Digestive System: Digestion, absorption, energy balance, BMR, Epithelial Barrier Function, Regulation of Swallowing and Gastric Emptying and small/ Large Bowel. Gastro-intestinal Secretions and accessory glands **Muscle Physiology:** Types of muscles: Skeletal, cardiac and smooth muscles, Properties; Contractile force.

Unit: III **17 Lectures**

Nervous System: Neurons, action potential, Central and peripheral nervous system, Neural control of muscle tone and posture, Vision, hearing and tactile response. **Thermoregulation and Stress Adaptation:** Comfort zone, Body temperature – physical, chemical, Neural regulation, Acclimatization.

Unit: IV **13 Lectures**

Respiratory System: Transport of gases, Exchange of gases, Neural and chemical regulation of respiration. Alveolar Ventilation, Diffusion across alveoli, respiration under Stress: Altitude, Hypoxia. **Reproduction:** Males and female reproductive system.

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

Suggested Reading:

1. Sherman V. (2018) *Vander's Human Physiology*. McGraw-Hill.
2. Guyton. (2017). *Textbook of Medical Physiology*. Elsevier India Pvt. Ltd.
3. Khurana. (2018). *Textbook of Medical Physiology*. Elsevier India Pvt. Ltd.
4. Murray, R.K. (2016). *Harper's Illustrated Biochemistry*. Jaypee Publishers.

5. Silverthorn D, (2018) *Human Physiology*, Pearson.

LHG.522: Human Physiology (Practical)
Credit Hours: 1

L	T	P	Cr
0	0	2	1

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

- Perform key hands-on experiments related to human physiology.
- Get practical familiarity with the basic principles of physiology.

1. Equipment in the laboratory - maintenance and use.
2. Determination of hemoglobin in the blood by various methods.
3. Isolation and estimation of DNA
4. Isolation and estimation of RNA
5. Isolation and estimation of proteins
6. Blood group determination.
7. Analysis of various cell types in human blood.

*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**
   x. Subjective question = 10 Marks
   xi. Performing experiment = 20 Marks
   xii. Viva voce = 10 Marks

LMM.523: Essentials of Immunology
Credit Hours: 4

L	T	P	Cr
4	0	0	4

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

- Evaluate basic concepts of immune system.
- Gain knowledge about various key processes related to development of immune system.
- Understand the concept of immune-based diseases as either a deficiency of components or excess activity as hypersensitivity.

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

Unit: I **15 Lectures**

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.

Unit: II **15 Lectures**

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.

Unit: III **15 Lectures**

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.

Unit: IV **15 Lectures**

Immune System in Health and Diseases: Inflammation, hypersensitivity and autoimmunity, AIDS and immunodeficiencies, vaccine development.

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

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

LMM.524: Techniques in Molecular Medicine
Credit Hours: 4

L	T	P	Cr
4	0	0	4

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

- Understand technical aspects of various tools used during experiments.
- Conceptualize principles of different techniques used in life sciences.
- Gain conceptual knowledge about various advanced techniques related to the field.
- Apply this knowledge learn how molecules control a cell's activities and growth.

Unit I **14 Lectures**

Microscopy: Light microscopy, phase contrast microscopy, fluorescent microscopy, scanning electron microscopy (SEM/FESEM), transmission electron microscopy (TEM), Atomic force microscopy, CLSM, Histochemistry.

Unit:II **18 Lectures**

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. Blotting techniques: Southern, Northern, Western, Dot blotting and hybridization, DNA fingerprinting.

Unit:III **14 Lectures**

RNA and Proteins: high throughput techniques: microarray, NGS, real time qPCR, Western blotting**,** mass spec, Enzyme Linked Immunosorbent Assay (ELISA), 2D gel electrophoresis.

Unit:IV **14 Lectures**

Cell culture and Related Techniques: Sterile culture practices, 3D culture, Flow cytometry, Cell sorting, Developing Monoclonal and Polyclonal antibodies.

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

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.

Elective Course-I **Credit Hours: 4**

Students has to choose 1 out of 2 elective course

Option-I

LMM.525: Regenerative Medicine
Credit Hours: 4

L	T	P	Cr
4	0	0	4

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

- Understand basics of cell culture
- Understand basic stem cell biology.
- Gain conceptual knowledge about requirements for tissue engineering.
- Know regenerative medicine and its potential applications.

Unit: I **15 Lectures**

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.

Unit: II **15 Lectures**

Stem Cells: Stem cells and their properties, classification of stem cells, *in-vitro* culture techniques, isolation, identification and characterization of stem cells, stem cells in various organs and in disease conditions.

Unit: III **15 Lectures**

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.

Unit: IV **15 Lectures**

Regenerative Medicine: Modes of tissue and organ delivery, tissue Engineering and transplantation techniques, immunoisolation techniques, regeneration of bone

and cartilage, Islet cell transplantation and bio-artificial pancreas, lung regeneration

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

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.

Option II

LHG.525: Human Embryology and Developmental Genetics

Credit Hours: 4

L	T	P	Cr
4	0	0	4

Learning Outcomes:

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

- Understand basics of developmental biology and embryology.
- Gain knowledge about reproductive physiology.
- Understand various processes involved in regulation of organ development.
- Know degenerative processes like aging.

Unit: I **15 Lectures**

Reproductive Physiology: Structure and Functions of Adult Human Reproductive organs, Reproductive Endocrinology, Gametogenesis: Formation of male and female gametes, Embryogenesis: Fertilization, Gastrulation and Implantation of Embryo, Lactation.

Unit: II **15 Lectures**

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 cytoplamic determinants; imprinting; mutants and transgenics in analysis of development.

Unit: III **15 Lectures**

Regulation of Organ Development: Genetic and molecular control of development of limbs, Gastrointestinal system and cardiovascular system; Genetics of sex determination in humans and development of urogenital system; Programmed cell death and role of cell death in formation of digits and joints, Genetic and molecular control of development of head and neck region, Formation of nervous system.

Unit: IV **15 Lectures**

Post-natal Development, Aging and Senescence: Environmental and genetic factors during maturations, Sex linked changes, Deciduous *and p*rimary teeth, Cognitive development ageing: its causes and regulation; Clinical death.

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

Suggested Reading:

1. Green, D. R. & Reed J. C. (2010). *Apoptosis: Physiology and Pathology*. Cambridge press, UK
2. Milunsky, J. & Milunsky, A. (2010). *Genetic Disorders and the Fetus: Diagnosis, Prevention & Treatment*. Willey Blackwell India, New Delhi.
3. Nussbaun, R., Roderick, R. M. & Huntington, F.W. (2007). *Genetics in Medicine*. Saunders Elsevier Philadelphia.
4. Prakash, G. (2007). *Reproductive Biology*. Narosa Publication House Pvt. Ltd., New Delhi.
5. Sadler, T. W. (2011). *Langman's medical embryology*. Lippincott Williams & Wilkins.
6. Schaefer, G. B., & Thompson, J. N. (2013). *Medical Genetics*. McGraw Hill Professional.
7. Tyagi R. (2011). *Understanding Evolutionary Biology*. Discovery Publication House Pvt. Ltd., New Delhi.

L	T	P	Cr
4	0	0	4

LMM.514: Trends in Molecular Medicine
Credits Hours: 4

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

- Know about background of Molecular Medicine.
- Know about development of therapeutics.
- Understand cellular microenvironment and problems of drug resistance.
- Develop knowledge about translational research.

Unit: I **15 Lectures**
Introduction to Molecular Medicine, contribution of genomics, transcriptomics and proteomics in human diseases

Unit: II **15 Lectures**
Molecular Medicine Therapeutics: Gene therapy and recombinant molecules in medicine and therapeutic development, pharmacogenomics.

Unit: III **15 Lectures**
Signal Transduction and its Role in Human Diseases: cell signaling and human diseases, Cellular and tissue microenvironment in diseases, drug resistance with convention chemotherapies.

Unit: IV **15 Lectures**
Advances in translational research: nano-biotechnology and its applications in molecular medicine, Developing novel biomarkers and therapies using high throughput technologies.

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

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.

Interdisciplinary Courses for Semester-II **Credit Hours: 2**
(To be offered by faculties from other centres)

Course Code: Code shall be brought from the department whose course is undertaken by the student.

L	T	P	Cr
1	0	0	1

LMM.542: Seminar-I
Credit Hours: 1

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

- Improve communication aptitude
- Learn presenting paper or data in scientific forum

Evaluation criteria:

A. The performance of the students will be continuously evaluated based on the choice of the topic, preparation of the topic, referring new research in the area and also discussing the future perspective = **50 marks**
B. Final presentation and report writing = **50 marks**

Semester-III

LMM.551: Molecular Basis of Human Diseases
Credit Hours: 4

L	T	P	Cr
4	0	0	4

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

- Acquire knowledge on basic mechanisms of common human diseases.
- Understand classical genetic disorders.
- Gain knowledge about molecular mechanisms underlying the pathogenesis of each disease.
- Know modern therapeutic approaches in development/clinical practice.

Unit: I **15 Lectures**

Molecular basis of the diseases, cardiomyopathies, Molecular and genetic basis of Diabetes, Dementia, Schizophrenia, Cancer, Coronary Artery diseases, Hypertension and neuronal disorders such as Autism, Alzheimer's and Parkinson. Mental Retardation.

Unit: II **14 Lectures**

Genetic disorders: various 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, Thalassemias and Haemophilias and Haematopoietic Malignancies. Muscular Dystrophy.

Unit: III **17 Lectures**

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: Penicillins and Cephalosporins; Broad-spectrum antibiotics; Antibiotics from prokaryotes; Antifungal antibiotics.

Unit: IV **14 Lectures**

Novel therapies for diseases: Tyrosine kinase inhibitor, Monoclonal antibody, Chemo & Radio, Gene Therapies, limitations, ethical and biosafety issues in gene therapies.

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

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.

LMM.554: Bioinformatics and Computational Biology
Credit Hours: 4

L	T	P	Cr
4	0	0	4

Learning Outcomes:

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

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

UNIT I **15 Lectures**

Biological databases: Nucleotide Sequence Databases, GenBank, DDBJ, EMBL, Sequence Flatfile and submission process, Protein sequence databases, UniProt in detail, Mapping databases, Genomic databases, Data mining.

UNIT II **15 Lectures**

Sequence analysis: Gene Prediction methods and programs, 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. **Analysis for protein sequences:** Predicting features of individual

residues, Predicting function, Neural networks, Protein structure prediction, Protein structure databases, PDB in detail, 3D visualization softwares, Pathway and molecular interaction databases.

UNIT III **15 Lectures**

Inferring relationships: 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, Multiple structural alignments, Shotgun sequencing, Sequence assembly and finishing.

UNIT IV **15 Lectures**

Modelling and structure: From protein sequence to structure, theoretical and practical aspects of protein sequence alignments, secondary, tertiary structure prediction, comparative modeling, Docking, protein-protein and protein-ligand docking. Techniques for 3-D structure determination like X-ray, NMR, MS/MS analysis. **Computational drug designing:** Structure-based drug design, virtual screening, quantitative structure activity relations, Cheminformatics and pharmacophore mapping in therapeutic development.

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

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

LMM.552: Evolutionary and Developmental Biology
Credit Hours: 4

L	T	P	Cr
4	0	0	4

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

- Gain knowledge on concept related to origin of life.
- Develop understanding regarding molecular evolution and original of first cell.
- Know about concepts related to developmental processes.
- Understand pathology related to mechanisms of development and differentiation.

Unit: I **16 Lectures**

Origin of Life: Lamarckism, Darwinism, Concepts of variation, adaptation, struggle, Mendelism, Spontaneity of mutations, Theories of phyletic gradualism vs. punctuated equilibria, Modern evolutionary synthesis. Origin of basic biological molecules, Abiotic synthesis of organic monomers and polymers, Concept of Oparin and Haldane, Experiment of Miller (1953), The first cell, Evolution of prokaryotes, Origin of eukaryotic cells, Evolution of unicellular eukaryotes, Anaerobic metabolism, Photosynthesis and aerobic metabolism.

Unit: II **14 Lectures**

Paleontology and Molecular Evolution: The evolutionary time scale, Eras, periods and epoch, Major events in the evolutionary time scale, Origins of unicellular and multicellular organisms, Stages in primate evolution including *Homo sapiens*. Concepts of neutral evolution, Molecular divergence and molecular clocks, Molecular tools in phylogeny, Classification and identification; Origin of new genes and proteins; Gene duplication and divergence.

Unit: III **16 Lectures**

Basic Concepts of Development: Totipotency, 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.

Unit: IV **14 Lectures**

Gametogenesis, Fertilization and embryology: Production of gametes, Cell surface molecules in sperm-egg recognition; embryonic development and formation of germ layers in humans, fetal development.

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

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). *Strickberger'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.

Elective Course-II **Credit Hours: 4**

Students has to choose 1 out of 3 elective course

Option I

LMM.526: Molecular and Cellular Oncology

Credit Hours: 4

L	T	P	Cr
4	0	0	4

Learning Outcomes:

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

- Understand fundamentals of cancer.
- Gain knowledge about genetics and signal transduction involved in tumorigenesis.
- Learn about various tools used for diagnostic purposes.
- Understand basics principles of anticancer therapeutics as well as about recent developments of the field.

Unit: I **13 Lectures**

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.

Unit: II **16 Lectures**

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.

Unit: III **16 Lectures**

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.

Unit: IV **15 Lectures**

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.

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

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

Option II

LHG. 526: Population Genetics and Genetic Epidemiology

Credit Hours: 4

L	T	P	Cr
4	0	0	4

Learning Outcomes:

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

- Conceptualize the basic concepts in population genetics and apply statistics relevant to the study of genomic diversity
- Examine the major genetic and ecological processes underlying evolution and explain the process driving speciation
- Perform different epidemiological studies to identify the cause-effect relationship in variety of human traits/diseases
- Design genetic studies and perform association and linkage analysis on any relevant data.

Unit I **15 Lectures**

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.

Unit: II **15 Lectures**

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: III **15 Lectures**

Population and Speciation: Adaptive radiation; Isolating mechanisms; Speciation; Allopatricity and Sympatricity; convergent evolution; sexual selection; co-evolution.

Unit: IV **15 Lectures**

Genetic Variation and Inheritance of Complex Traits: Basics of genetic variation, Genetic markers – SNP, CNV, Indels, VNTR, STR, Microsatellite. Tag markers and Haplotypes, Linkage disequilibrium, Fixation index; Quantitative Genetic analysis; Broad-Sense Heritability and Narrow-Sense Heritability.

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

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.

Option III

MOOC course
Credit Hours: 4

L	T	P	Cr
4	0	0	4

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

- Acquire knowledge on specific topics and will be able to apply it to real data or experiments.
- Develop self-learning practices.

MOOC course can be selected from the list provided by UGC through course coordinator.

LMM.599: Project-I
Credit Hours: 4.

L	T	P	Cr
0	0	12	6

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

- Learn to develop a scientific question.
- Get hands-on training on relevant techniques.
- Learn study designing and report writing.
- Improve 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.

Evaluation criteria:
The 2-point assessment is **satisfactory** or **not satisfactory** based on the following parameters:

A. Daily assessment by the mentor based on the performance of the student = **50 marks**
B. Final presentation with written report = **50 marks**

Value Added Course I

LHG.504: Clinical Genetics
Credit Hours: 1

L	T	P	Cr
0	0	2	1

Learning Outcomes:
On successful completion of the course the student will be able to:
• Take a family history and construct and interpret a pedigree Have an understanding about the nutritional requirements and the role of gut microbiota in human nutrition.
• Communicate the concept risk in a manner that can be understood by the patients Get aware of the genetic markers involved in the regulation of metablomics and the role of these markers in health and disease.
• aware of the type of clinical features suggesting common chromosomal disorders and role of teratogens in human congenital disorders.

UNIT I **Hours: 3**
Genetic assessment and drawing pedigree

UNIT II **Hours: 4**
Genetic counseling

UNIT III **Hours: 4**
Common chromosomal disorders-case studies

UNIT IV **Hours: 4**
Teratogens and dysmorphology

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

Suggested Readings:

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

Semester-IV

LML.571: Genetic Engineering and Recombinant Therapeutics
Credit Hours: 4

L	T	P	Cr
4	0	0	4

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

- Know about genetic engineering and its applications.
- Gain knowledge about various cloning, expression vectors and their importance in research.
- Understand concept of artificial chromosomes and their potential applications.
- Learn therapeutics aspect of recombinant DNA technologies

Unit: I **15 Lectures**

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 and clone confirmation, expression opimization, *in-silico* methods of design.

Unit: II **13 Lectures**

Gene Cloning Vectors: Plasmids, bacteriophages, cloning in M13 mp Vectors, phagemids, Lamda vectors; insertion and replacement vectors, EMBL, λ DASH, λ gt10/11, λZAP etc. Cosmid vectors, Site directed mutagenesis.

Unit: III **17 Lectures**

Expression Vectors: Artificial chromosome vectors (YACs, BACs), Animal virus derived vectors-Sv-40, caccinal/bacculo& retroviral vectors. Expression vectors;pMal, GST, PET – based vectors. Protein purification; His-tag, GST-tag, MBP-tag.Restriction proteases, intein-based vectors. Inclusion bodies methodologies to reduce formation of inclusion bodies, *baculovirus* and pichia vectors system.Site Directed Mutagenesis.

Unit: IV **15 Lectures**

Techniques and Applications of recombinant DNA technology: Isolation and Detection of DNA, RNA and proteins by Southern blotting, Northern blotting, Western blotting and *in situ* hybridization, Yeast two hybrid system, phage display, characterization of expressed proteins through various biophysical, biochemical methods, applications rDNA in diagnosis of pathogens and abnormal genes, transgenic animals for production of proteins and pharmaceuticals, Biosafety and Ethical considerations in genetic engineering.

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

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.

Related Weblinks:

1. http://www.genengnews.com/ontheweb.asp
2. http://www.ige-india.com/

LMM.553: Molecular Endocrinology and Signal Transduction
Credit Hours: 4

L	T	P	Cr
4	0	0	4

Learning Outcomes:

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

- Know endocrine system and signal transduction at physiological levels.
- Understand various human hormones.
- Develop understanding regarding disorders of immune system.

Unit: I **15 Lectures**

History, endocrine glands, and hormones as chemical messengers, stimulus for hormone release: change in homeostasis, sensory stimulus and others.

Unit: II **15 Lectures**

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).

Unit: III **15 Lectures**

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).

Unit: IV **15 Lectures**

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.

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

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.

LMM.573. Practice in Life Sciences-I
Credit Hours: 2

L	T	P	Cr
2	0	0	2

Learning Outcomes:

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

- Improve their knowledgebase required for competitive examinations
- Improve student's aptitude for research and development
- Revise several key topics of life sciences

Unit: I **Credit Hours: 7**

Molecules and their interaction relavent to biology: Structure of atoms, molecules and chemical bonds, composition, structure and function of biomolecules, stablizing interactions, principles of biophysical chemistry, bioenergetics, glycolysis, oxidative phosphorylation, coupled reaction, group transfer, biological energy transducers, principles of catalysis, enzymes and enzyme kinetics, enzyme regulation, mechanism of enzyme catalysis, isozymes, conformation of proteins (ramachandran plot, secondary structure, domains, motif and folds), conformation of nucleic acids stability of proteins and nucleic acids, metabolism of carbohydrates, lipids, amino acids nucleotides and vitamins.

Unit: II **Credit Hours: 10**

Cellular organization: Membrane structure and function, structural organization and fu nction of intracellular organelles, organization of genes and chromosomes,

cell division and cell cycle, dna replication, repair and recombination, rna synthesis and processing, protein synthesis and processing, control of gene expression at transcription and translation level, cell communication and cell signaling.

Unit: III **Credit Hours: 8**

Innate and adaptive immune system: cells and molecules involved in innate and adaptive immunity, antigens, antigenicity and immunogenicity. B and t cell epitopes, structure and function of antibody molecules, MHC molecules, antigen processing and presentation, activation and differentiation of B and T cellshumoral and cell - mediated immune responses, primary and secondary immune modulation, the complement system, toll - like receptors, cell - mediated effector functions, inflammation, hypersensitivity and autoimmunity, immune response during bacterial (tuberculosis), parasitic (malaria) and viral (HIV) infections, congenital and acquired immunodeficiencies, vaccines.

Unit: IV **Credit Hours: 5**

Developmental biology: Basic concepts of development, gametogenesis, fertilization and early development, programmed cell death, aging and senescence

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

LMM.574. Practice in Life Sciences-II
Credit Hours: 2

L	T	P	Cr
2	0	0	2

Learning Outcomes:

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

- Improve their knowledgebase required for competitive examinations
- Improve student's aptitude for research and development
- Revise several key topics of life sciences

Unit: I **Credit Hours: 8**

System physiology – animal: Blood and circulation, cardiovascular system, respira tory system, nervous system, sense organs, excretory system, thermoregulation, stress and adaptation, digestive system, endocrinology and reproduction

Unit: II **Credit Hours: 5**

Inheritance biology: Mendelian genetics, concept of gene, extensions of mendelian principles, gene mapping methods, extra chromosomal inheritance, microbial genetics, human genetics, quantitative genetics, mutation, structural and numerical alterations of chromosomes, recombination.

Unit: III **Credit Hours: 8**

Evolution and behaviour: Emergence of evolutionary thoughts- lamarck; darwin, origin of cells and unicellular evolution, origin of basic biological molecules; abiotic synthesis of organic monomers and polymers; concept of oparin and haldane; experiement of miller (1953); the first cell; evol ution of prokaryotes; origin of eukaryotic cells; evolution of unicellular eukaryotes; anaerobic metaboli sm, photosynthesis and aerobic metabolism, paleontology and evolutionary history, molecular evolution, mechanisms of evolution, population genetics, brain, behavior and evolution.

Unit: IV **Credit Hours: 9**

Applied biology: Application of immunological principles, vaccines, diagnostics. Tissue and cell culture methods for plants and animals, transgenic animals, molecular approaches to diagnosis, genomics and its application to health, molecular biology and recombinant dna methods, histochemical and immunotechniques, biophysical method, statisitcal methods, radiolabeling techniques, microscopic techniques, electrophysiological methods, methods in field biology.

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

LMM.544: Seminar-II
Credit Hours: 2.

L	T	P	Cr
0	0	0	2

Learning Outcomes:

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

- Improve communication aptitude
- Learn presenting paper or data in scientific forum

Evaluation criteria: the detailed assessment criteria are as per university policy. The students will be assessed based on presentation and report submitted on the topics assigned by seminar coordinator.

Evaluation criteria for Seminar:

A. The performance of the students will be continuously evaluated based on the choice of the topic, preparation of the topic, referring new research in the area and also discussing the future perspective = **50 marks**
B. Final presentation and report writing = **50 marks**

LMD.599: Project-II
Credit Hours: 6.

L	T	P	Cr
0	0	0	6

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

- Get hands-on training on several genetic and genomics techniques
- Learn study designing and report writing
- Interpretation of results and discussion
- Improve communication skills

Evaluation criteria for Project:
The 2-point assessment is **satisfactory** or **not satisfactory** based on the following parameters:

A. Daily assessment by the mentor based on the performance of the student = **50 marks**
B. Final presentation with written report = **50 marks**

Value Added Course II

LHG.505: Principles of Ecological Sciences
Credit Hours: 1

L	T	P	Cr
1	0	0	1

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

- Improve their knowledgebase about basics of ecological science
- Improve student's aptitude for research and development on ecological succession and dynamics
- Contribute in conservation science

UNIT I **Hours: 3**

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.

UNIT II **Hours: 4**

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.

UNIT III **Hours: 4**

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.

UNIT IV **Hours: 4**

Applied Ecology and Conservation Biology: Environmental pollution; biodiversity: status, monitoring and documentation; biodiversity management approaches; Principles of conservation and it's 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.

Suggested Readings:

1. Alberts, B. Bray, D. Lews, J., Raff, M., Roberts, K. and Watson, J.D. (2018). Molecular
Biology of the Cell. Garland publishers, Oxford.
2. Celis, J.E. (2016). Cell biology: A laboratory handbook, Vol 1, 2, 3. Academic Press, UK.
3. Karp, G. (2017). Cell and Molecular Biology: Concepts and Experiments. John Wiley &
Sons. Inc., New Delhi, India
4. Alimoghaddam, K. (2019). Stem Cell Biology in Normal Life and Diseases. INTECH publications.
5. *Lanza R., Gearhart,J., Hogan,B.,Melton,D., Pedersen, R., Thomas ,E.D., Thomson, J., Wilmut, I. (2013).*Essentials of Stem Cell Biology (Second Edition).