Central University of Punjab, Bathinda

Course Scheme & Syllabus

M.Sc. Life Sciences with Specialization in Human Genetics

Batch: 2018-20

Semester-I

Sr. No.	Paper Code	Course Title	Lecture	Practical	Total Credits
Compulsory Foundation Courses					
1.	LHG.506	Biostatistics and Research Methodology	4	-	4
2.	LHG.507	Biostatistics and Research Methodology	-	1	1
Core Courses					
3.	LMM.508	Cellular and Molecular Biology	4	-	4
4.	LHG.509	Cellular and Molecular Biology - Practical	-	1	1
5.	LHG.510	Basic and Clinical Biochemistry	4	-	4
6.	LHG.511	Basic and Clinical Biochemistry - Practical	-	1	1
7.	LHG.512	Concepts of Genetics	4	-	4
8.	LHG.513	Concepts of Genetics- Practical	-	1	1
9.	LHG.514	Human Cytogenetics and Human Biochemical Genetics	4	-	4
Interdisciplinary Elective Course – I (Any one)					
10.	LHG.515	Basics of Human Genetics	2	-	2
11.	LHG.516	Intellectual Property and Life Sciences	2	-	2
		Total Credit	**22**	**4**	**26**

Transaction mode: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self learning.

Semester-II

Sr. No.	Paper Code	Course Title	Lecture	Practical	Total Credits
Core Courses					
1.	LHG.521	Human Physiology	4	-	4

2.	LHG.522	Human Physiology- Practical	-	1	1
3.	LMM.523	Essentials of Immunology	4	-	4
4.	LHG.524	Advanced Techniques in Human Genetics	4	-	4
Discipline Elective – I (Any one)					
5.	LHG.525	Human Embryology and Developmental Genetics	4	-	4
6.	LMM.525	Regenerative Medicine	4	-	4
Discipline Elective – II (Any one)					
7.	LHG.526	Population Genetics and Genetic Epidemiology	4	-	4
8.	LMM.526	Molecular and Cellular Oncology	4	-	4
Interdisciplinary Elective Course – II (Any one)					
9.	LHG.527	Prenatal Diagnosis and genetic Counseling	2	-	2
10.	LHG.528	Introduction to Population Genetics	2	-	2
Skill Based Course					
11.	LHG.542	Seminar-I	1	-	1
		Total Credit	**23**	**1**	**24**

Transaction mode: Lecture**;** Seminar**;** Tutorial**;** Case study **;** Problem solving; Self learning; group discussion.

Semester-III

Sr. No.	**Paper Code**	**Course Title**	**Lecture**	**Practical**	**Total Credits**
Compulsory Foundation					
1.		MOOC course (One course)	4	-	4
Core Courses					
2.	LHG.551	Biosafety, Bioethics and Intellectual Property Rights	4	-	4

4.	LHG.552	Genetic Disease and Therapies	4	-	4
5.	LHG.553	Pharmacogenomics and Nutrigenomics	4	-	4
Skill Based Course					
6.	LHG.599	Project	-	6	6
		Total Credit	**16**	**6**	**22**

Transaction mode: Lecture; Tutorial; Problem solving; Self learning; Brain storming; Debate; Brain storming, Case study.

Semester-IV

Sr. no.	**Paper Code**	**Course Title**	**Lecture**	**Practical**	**Total Credits**
Core Courses					
1.	LHG.571	Recombinant DNA technology and therapeutics	4	-	4
2.	LHG.572	Advanced Practical Course in Human Genetics	-	3	3
Discipline Enrichment Course					
3.	LHG.573	Practice in Life Sciences-I	2	-	2
4.	LHG.574	Practice in Life Sciences-II	2	-	2
Skill Based Course					
5.	LHG.544	Seminar-II	1	-	1
6.	LHG.599	Project	-	6	6
Elective Foundation/Value based course					
7.	Two courses need to be chosen from the list of EF/VB courses given by the University		1+1		2
		Total Credit	**11**	**9**	**20**

Transaction mode: Lecture; Tutorial; Problem solving; Group discussion; Brain storming; SOLE; Case study; Brain storming.

LHG.506. Biostatistics and Research Methodology
Credits Hours: 4

Learning objectives: This course will give a basic but significant exposure towards better understanding of implication of statistics in biologyand applicability of appropriate research methodology. Applications of biostatistical approaches are pivotal in testing hypothesis, designing experiments, analyzing experimental data and interpreting the results of biological research.

Unit – 1 **15 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; statistical errors.

Unit – 2 **15 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;multiple corrections; hypothesis testing.

Unit – 3 **15 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.

Unit – 4 **15 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.

Suggested readings

1. Norman, G. and Streiner, D. (2008). *Biostatistics: The Bare Essentials.* (with SPSS), 3rd Edition, Decker Inc. USA.
2. Sokal, R.R. and Rohlf, F.J. (1994). *Biometry: The Principles and Practices of Statistics in Biological Research*. W.H. Freeman publishers, USA.
3. Banerjee P.K (2014). *Introduction to Biostatistics*. S.Chand, India
4. Daniel WW (2010). *Biostatistics*: *A Foundation for Analysis in the Health Sciences*. John Wiley and Sons Inc.
5. Bailet NTJ. *Statistical Methods in Biology*. Cambridge Univ. Press.
6. Glaser AN. *High-Yield Biostatistics*. Lippincott Williams & Wilkins.

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

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 will be conducted depending upon the faculty/facility available.

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

Learning objectives: Students will understand the structures and functions of the basic components of membranes, and organelles and their related functions.The molecular processes of DNA replication, transcription, and translation, and how they are managed in cells will be understood. The course will give a thorough insight into basic mechanisms of cellular signal transduction and regulation of gene expression.

Unit-1 **15 hours**

Membrane Structure and Functions: Prokaryotic and eukaryotic cell; membranes of intracellular organelles; membrane transport; protein secretion and sorting: structure and functions of intracellular organelles; intracellular traffic and secretory pathways; endocytosis and exocytosis.

Unit-2 **15 hours**

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-3 **15 hours**

Chemical structure and functions of nucleic acids: Chemical structure of DNA and RNA; Watson- Crick model;different forms of DNA and RNA; organelle DNA; nucleosomeassembly.

Gene and genome organization: Eukaryotic gene organization; transposition; mechanism of DNA replication; DNA damage and their repair.

Unit-4 **15 hours**

Transcription: Transcription and transcription factors; transcriptional and post-transcriptional gene silencing; mRNA processing: capping, polyadenylation, splicing, editing, mRNA stability.

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

Suggested readings

1. Alberts, B., Bray, D., Lews, J., Raff, M., Roberts, K. and Watson, J.D. (2010). *Molecular Biology of the cell*. Garland publishers, Oxford.
2. Celis, J.E. (2006). *Cell biology: A laboratory handbook*, Vol 1, 2, 3. Academic Press, UK.
3. Gupta, P.K. (200*8). Cytology, Genetics and Evolution*. Rastogi publications, Meerut, India
4. Karp, G. (2010*). Cell and Molecular Biology: Concepts and Experiments*. John Wiley & Sons. Inc. New Delhi, India.
5. Robertis, (2011). *Cell and Molecular Biology*. Lippincott Williams & Wilkins
6. Fasman, G.D. (1989). *Practical Handbook of Biochemistry and Molecular Biology*. CRC Press, Taylor and Francis Group, UK.
7. Jocelyn, E.K., Elliott, S.G., Stephen, T.K. (2009). *Lewin's Genes X*. Jones & Bartlett Publishers, USA.
8. James, D.W.,Baker,T.A., Bell, S.P., Gann, A. (2009). *Molecular Biology of the Gene*. Benjamin Cummings, USA.
9. Johnson, A., Lewis, J., Raff, M. (2007). *Molecular Biology of the Cell*. Garland Science, USA.
10. Lodish, H.,Berk, A., Chris, A.K. and Krieger, M. (2011). *Molecular Cell Biology*. W.H. Freeman, USA.
11. Sambrook, J., Fritish, E.F., Maniatis, T. (2012). *Molecular cloning: A laboratory manual*. Cold Spring Harbor Laboratory Press, New York.

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

1. Preparation of mitotic & meiotic chromosomes.
2. Study of structure of cell organelles through electron micrographs.
3. Instrumental methods for cell biology-centrifugation, chromatography.
4. Immunofluorescence and fluorescent probes.
5. Sectioning of tissues.
6. Histochemical techniques (Fixing, Processing, Staining).
7. Epifluoresence and Confocal Microscopy.
8. Basics of bacterial/mammalian cell culture

*Practical will be conducted depending upon the faculty/facility available.

LHG.510. Basic and Clinical Biochemistry
Credits Hours: 4

Learning objectives: The course aims to provide an advanced understanding of the core principles and topics of Biochemistry and their experimental basis.This course integrates an introduction to the structure of macromolecules and a biochemical approach to cellular function. Learners will also develop problem solving and analytical skills.

Unit-1 **15 hours**

Essentials of clinical biochemistry: Molecular structure and physical properties of water; ionization of water; weak acids and weak bases; pH and buffers; interpretation of biochemical tests; clinical hematology; chemical composition of blood, urine and cerebrospinal fluids; water and sodium balance; acid-base balance disorders; potassium, calcium, magnesium and phosphate metabolism and associated diseases; vitamins and trace elements disorders.

Unit-2 **15 hours**

Biomolecules and metabolic disorders: Structure and functions of carbohydrates, lipids, amino acids, proteins, nucleic acids and vitamins; bioenergetics and thermodynamics; phosphoryl group transfer and ATP; biological oxidation-reduction reactions; glycolysis, citric acid cycle and oxidative phosphorylation;liver function test; jaundice, diabetes mellitus, hypoglycemia, hypertension, hypo- and hyper-thyroidism.

Unit: 3 **15 hours**

Conformation of Biomolecules: Ramachandran plot;protein secondary, tertiary and quaternary structure; domains, motif and folds; protein denaturation and folding; oxygen binding proteins; Hill equation; Bohr effect; nucleic acids: A-, B-, Z-DNA forms, tRNA, micro-RNA, Stability of protein and Nucleic acid structures.

Unit: 4 **15 hours**

Enzymology: Classification; Principles of catalysis; mechanism of enzyme catalysis; enzyme kinetics; enzyme inhibition; enzyme regulation; isozymes and clinical enzymology.

Suggested readings

1. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2010). *Biochemistry.* W.H. Freeman & Company. USA.
2. Brown, T.A. (2006). *Gene Cloning and DNA analysis: In Introduction*. Blackwell Publishing Professional. USA.
3. Haynie, D.T. (2007). *Biological thermodynamics*. Cambridge University. UK.
4. Mathews, C.K., Van Holde, K.E. and Ahern, K.G. (2000). *Biochemistry*.Oxford University Press Inc. New York.
5. Nelson, D. and Cox, M.M. (2008). *Lehninger Principles of Biochemistry*.BI publications Pvt. Ltd. Chennai, India.
6. Ochiai, E. (2008). *Bioinorganic Chemistry: A survey.* Academic Press. Elsevier, India.
7. Randall, D. J., Burggren, W. and French, K. (2001). *Eckert animal physiology*. W.H. Freeman & Company. USA.
8. Raven, P.H., Johnson, G.B. and Mason, K.A. (2007). *Biology*. Mcgraw-Hill. USA.
9. Shukla AN (2009). *Elements of Enzymology.* Discovery Publishing. New Delhi, India.
10. Voet, D. and 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
12. Martin A Crook et al. (2012). Clinical Biochemistry and metabolic medicine. CRC press, Taylor & Francis Group, USA

LHG.511. Basic and Clinical Biochemistry (Practical)
Credits Hours: 1

1. Preparation of solutions, buffers, pH setting etc.
2. Amino acid and carbohydrate separations by paper & thin layer chromatography.
3. Quantitative Estimation of Proteins, Sugars, total lipids and amino acids.
4. Assay and estimation of different enzymes e.g. invertase, amylases, acid and alkaline phosphatases.
5. Principle and application of electrophoresis, Native, SDS PAGE.
6. Estimation of total phenolic compounds.
7. Extraction and estimation of vitamins.
8. Basic clinical tests like Urea, lipid profiling, SGOT, SGPT etc.

*Practical will be conducted depending upon the faculty/facility availabile.

LHG.512. Concepts of Genetics
Credits Hours: 4

Learning objectives: Course on the concept of genetics would be necessary to estimate and understand the origin, existence and propagation of living organisms as a whole. Basic knowledge of genetics is also necessary in the application of various inheritance predictions based models for human welfare.

Unit-1 **15 hours**

Basics of Inheritance: Mendel's laws of inheritance; concept of segregation; independent assortment and dominance; locus concept; alleles and multiple alleles; epistasis;crossing over and recombination; application of Mendel's laws ofpopulation studies; Hardy-Weinberg principle.

Unit-2 **15 hours**

Chromosomal mutations and gene concept: Chromosomal aberrations: deletions, duplications, inversions, translocations; change in chromosome number: trisomy and polyploidy; 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: spontaneous and induced mutations; somatic vs germinal mutation; pedigree analysis.

Gene concept: Fine structure of gene; and analysis – Benzer's experiments,complementation and recombination.

Unit-3 **15 hours**

Sex determination: Sex determination and sex linked inheritance; sex determination in *Caenorhabditiselegans*, humans, *Drosophila* and other animals; sex determination in plants;sex linked genes and dosage compensation in human, *Drosophila* and *C. elegance*.

Linkage analysis and gene mapping: Monohybrid and dihybrid cross.

Unit-4 **15 hours**

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.

Suggested readings

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

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

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 will be conducted depending upon faculty/facilities availibile.

LHG.514. Human Cytogenetics and Biochemical Genetics
Credits Hours: 4

Learning objectives: The basic and specializedknowledgeand understanding the aspects of Cytogenetics and Biochemical genetics is essential to understand Human Genetics. Newer techniques have been developed since then, ranging from the initial conventional banding techniques to the currently used molecular array comparative genomic hybridisation. With a combination of these conventional and molecular techniques, cytogenetics has become an indispensable tool for the diagnosis of various genetic disorders, paving the way for possible treatment and management. This course traces the history and evolution of Cytogenetics leading up to the current state of technology

Unit-1 **15 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.

Unit-2 **15 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).

Unit-3 **15 hours**

The concept of Biochemical Polymorphism: Concept of enzyme and protein polymorphism; molecular structure; biosynthesis and genetics of the ABH antigens; Rh antigens and MN antigens; quantitative and qualitative variation of enzymes; haemoglobin variants; effects of single amino acid substitutions (Sickle cell disease).

Unit-4 **15 hours**

Disorders due to abnormal variants of lysosomal enzymes, lipids and DNA nitrogenous bases: Disorders due to abnormal lysosomal enzymes: Tay-sachs disease and Mucopolysaccharidoses; disorders of lipoprotein and lipid

metabolism: hyper lipoproteinemia; disorders of purine metabolism: Lesch Nyhan syndrome; disorders of pyrmidine metabolism: Orotic Aciduria

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. Klug, W.S., Cummings, M.R., Spencer, C.A. and Palladino, M.A. (2012). *Concepts of Genetics*. Pearson.
5. Korf, B.R and Irons, M.B. (2013). *Human Genetics and Genomics*. Wiley-Blackwell.
6. Kumar, A. and Srivastava, M. (2012) A textbook of Molecular Cytogentics, Narendra Publishing House, India
7. Purandare, H. and Chakravarty, A. (2000)*Human Cytogenetic Techniques and Clinical Applications*.Bhalani Publishing House, Mumbai, India.
8. Ram, M. (2010). *Fundamental of Cytogenetics and Genetics*. PHI Learning Pvt. Ltd.
9. Roy, D. (2009). *Cytogenetics*.Narosa Publishing House. New Delhi, India.
10. Tom, S and Read, A (2010). *Human Molecular Genetics*. Garland Science.
11. Shukla, A.N. (2009). *Elements of enzymology*. Discovery Publishing. New Delhi, India.
12. Voet, D. and Voet, J.G. (2008). *Principles of Biochemistry*. CBS Publishers & Distributors, New Delhi.
13. . Murray, R.K., Bender, D.,Botham, K., M.,Kennelly, P. J., Rodwell, V. W. and Weil, P.A. (2012). *Harpers Illustrated Biochemistry*. McGraw-Hill Medical.Nelson, D. and Cox, M.M. (2013). *Lehninger Principles of Biochemistry*. W.H. Freeman.

Interdisciplinary Elective Courses-I

LHG.515. Basics of Human Genetics

Credits Hours: 2

Learning Objectives: The course gives an overview of basics of Human Genetics and makes familiar with the common genetic disorders.The study of human DNA and genetics has plenty of practical applications. From the use of DNA in court cases to the discovery of new therapies for genetic diseases, a thorough understanding of the human genome can have important medical, social and legal impacts.

Unit-1 **7 hours**

Chromosomal analysis: Classification of human chromosomes; human chromosomes; the life cycle of a somatic cell: mitosis, meiosis, gametogenesis.

Unit-2 **8 hours**

Genetic assessment: Medical applications of chromosomes; Symbols used in a pedigree drawing of a pedigree;terminology, consanguinity**,**

Unit-3 **7 hours**

Common chromosomal disorders: Aneuploidy, Down syndrome, Edwards syndrome, Patau's syndrome and other trisomies ; structural aberration

Unit-4 **8 hours**

Patterns of inheritance: Autosomal and sex chromosomal inheritance patterns with examples; multiple , Uniparental disomy,, multifactorial disorders.

Suggested readings

1. Emery and Rimoin's, et aI., 2007. Principles and Practice of Medical Genetics. Fifth Edition.Volume - II, Churchill Livingstone Elsevier.
2. Emery and Rimoin's, Principles and Practice of Medical Genetics e-dition: 3-Volume.Set, Churchill Livingstone Elsevier
3. De Grouchy & Turleau.1984.Clinical atlas on Human Chromosomes.
4. Jankowski &Polak, 1996.*Clinical Gene Analysis and Manipulation.*
5. Robinson and Linden, Clinical Genetics Handbook. (latest edition)
6. F Vogel A.G. Motulusky. Human Genetics: Problems and Approaches. Second Completely Revised Edition, Springer-Verlag. (latest edition)
7. Golder N. Wilson, M.D., Ph.D.Clinical Genetics-A Short Course. A John Wiley and Sons, Inc., Publication. (latest edition)

LHG.516. Intellectual Property and Life Sciences
Credit hours: 2

Learning objective: Life Sciences is one of the fastest developing domains with an explosion in research and development along with the simultaneous creation of the requirement of innovation protection. The course will be helpful for the students to understand the different forms of IP which could be utilized for the protection of inventions

Unit-1 **8 hours**

Intellectual Property Rights (IPRs): Various forms of IP – patents, industrial

designs, trade secrets, geographical indications and plant breeder's right; copyright.

Unit-2 **8 hours**

Patent system in India: Patent filing in India and abroad: determination of patentability of inventions; filing a patent application in India: timeline, procedure involved in the granting of a patent; gene patent; patenting of living organisms.

Unit-3 **7 hours**

Various routes of filing international patent application: Different phased of Patent co-operation treaty (PCT) application

Unit-4 **7 hours**

Protection of indigenous intellectual property: Traditional Knowledge Digital Library (TKDL).

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. Martin Khor (2002). Intellectual Property, Biodiversity and Sustainable Development: Resolving the Difficult Issues. Zed Books limited.

LHG.521: Human Physiology

Credit Hours: 4

Learning objectives: This course is designed to provide students with an understanding of the function and regulation of the human body and physiological integration of the organ systems to maintain homeostasis. Course content includes neural & hormonal homeostatic control mechanisms, as well as the study of the musculoskeletal, circulatory, respiratory, digestive, urinary, immune, reproductive, and endocrine organ systems.

Unit-1 **15 hours**

Cardiovascular System: Heart;cardiac cycle; blood constituents; groups and hematopoiesis; blood pressure; blood pressure and its neural and chemical regulation.

Excretory System: Kidney; urine formation; urine concentration; waste elimination; micturition; regulation of water balance; electrolyte and acid-base balance.

Unit-2 **15 hours**

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-3 **15 hours**

Nervous System: Neuron; 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-4 **15 hours**

Respiratory System: Anatomical considerations;transport of gases;exchange of gases;waste elimination; neural and chemical regulation of respiration; alveolar ventilation; diffusion across alveoli; and respiration under stress: altitude, hypoxia.

Reproduction: Males and female reproductive system.

Suggested readings

1. Brody, T. (1998). *Nutritional biochemistry*. Academic Press, USA.
2. Devlin, T.M. (2005). *Textbook of Biochemistry with clinical correlations*. John Wiley & Sons Inc. USA.
3. Guyton. (2007). *Textbook of medical physiology*. 11th Edition. Elsevier India Pvt. Ltd. New Delhi.
4. Hill, R.W, Wyse, G. A. and Anderson, M. (2008). *Animal physiology*. Sinauer Associates Inc. USA.
5. Khurana. (2006). *Textbook of medical physiology*. Elsevier India Pvt. Ltd.
6. Murray, R.K. (2009). *Harper's illustrated biochemistry*.Jaypee Publishers, New Delhi, India.
7. Tyagi, P. (2009). *A textbook of Animal Physiology*.Dominant Publishers and distributors, New Delhi, India.
8. Silverthorn D, (2011) *Human Physiology*, Pearson; 6th edition.
9. Sherman V. (2013) *Vander's Human Physiology*. McGraw-Hill 13th edition.

LHG.522. Human Physiology (Practical)

Credit Hours: 1

1. Equipment in the laboratory - maintenance and use.
2. Sensory physiology practicals.
3. Determination of hemoglobin in the blood by various methods.
4. Identificaiton of formed elements in blood.
5. RBC and WBC count in whole blood.
6. Determination of blood group.
7. Measurement of Blood pressure and Pulse rate.
8. Studying characteristics of ECG.
9. Blood glucose estimation.
10. Determination of Respiratory function: Breathing rate, Breath holding capacity.
11. Distinguish different types of muscles and Observation of types of muscular contraction.
12. Urinalysis from simulated urine sample.

*Practical will be conducted depending upon the faculty/facilities available.

LMM.523. Essentials of Immunology

Credit Hours: 4

Learning objective: The objective of this course is to cover basic concepts of immune system and to understand the concept of immune-based diseases as either a deficiency of components or excess activity as hypersensitivity.

Unit: 1 **15 hours**

Immune System: The cells and organs of immune system;cells 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: 2 **15 hours**

Immune Effectors: Complement syste; their structure, functions and mechanisms of activation by classical, alternative and lectin pathway; Th1 and Th2 response; cytokines; chemokines; interferons; interlukins.

Unit: 3 **15 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.

Unit: 4 **15 hours**

Immune system in health and diseases: Inflammation; hypersensitivity and autoimmunity;immunity to microbes; immunity to tumors; AIDS and immunodeficiencies; hybridoma technology and vaccine development associated challenges for chronic and infectious diseases; immunotoxins.

Suggested readings

1. Kindt, T.J., Osborne, B.A. and Goldsby, R.A. (2007). *Kuby Immunology* .7th Edition. W.H. Freeman, USA.
2. Abbas. (2008). *Cellular and Molecular immunology*.CBS Publishers & Distributors, India.
3. Charles, A. and Janeway, J.R. (1994). *Immunobiology: The immune system in health and disease.* Blackwell Publishing, USA.
4. Delves, P.J., Roitt, I.M. and Seamus, J.M. (2006). *Roitt's essential immunology (Series–Essentials).*Blackwell Publishers, USA.
5. Elgert, K.D. (2009). *Immunology: Understanding the immune system*. Wiley-Blackwell, USA.
6. Paul, W.E. (1993). *Fundamental immunology.* Raven Press, SD, USA.
7. Sawhney, S.K. and Randhir, S. (2005). *Introductory practical biochemistry*. Alpha Science International Ltd. New Delhi, India.
8. Tizard. (2008). *Immunology: An Introduction*. Cengage Learning, Thompson, USA.

LHG.524. Advanced techniques inhuman genetics

Credit Hours: 4

Learning objectives: This course will help the students to understand safe laboratory practices and basic molecular biology techniques and specialized molecular and cell biology techniquesThese methods help the students to explore cells, their characteristics, parts, and chemical processes, to learn how molecules control a cell's activities and growth.

Unit-1 **15 hours**

Biochemical Techniques: Sterilization techniques; spectrometry; colorimetry;Mass, UV, IR, NMR and atomic absorption spectrophotometery; centrifugation: principle and applications; ultracentrifugation; chromatography: principle, procedure and applications of thin layer

chromatography (TLC), gel filtration and ion exchange, affinity chromatography, GC, GLC, HPLC, dHPLC and FPLC.

Unit-2 **15 hours**

Microscopy: Light microscopy; phase contrast microscopy; fluorescent microscopy; scanning electron microscopy (SEM/FESEM); transmission electron microscopy (TEM); micrometry and photomicrography; histochemistry; scanning-probe microscopy; atomic force microscopy; CLSM.

Unit-3 **15 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: RAPDs, SNPs; blotting techniques: southern, northern, western, dot blotting and hybridization; DNA fingerprinting.

Unit-4 **15 hours**

Flow Cytometry: Cell sorting; hybridoma technology: production of antibodies; histochemical and immunotechniques; immunochemical techniques; 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.

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.

Discipline Elective – I (choose any one)

LHG.525. Human Embryology and Developmental Genetics
Credit Hours: 4

Learning objectives: The course aims to make students familiar with the fundamental concepts in developmental genetics and embryology. It will provide a broad and multifaceted training in modern biology, ranging from traditional morphology and experimental embryology to the latest molecular approaches in genetics, cell biology, stem cell biology and biotechnology. Developmental Biology is central to the search for cures for many human genetic diseases, including cancer, and is at the forefront of recent advances in modern medicine, which includes stem cell maintenance regeneration and tissue repair.

Unit-1 **15 hours**

Reproductive Physiology: Structure and functions of adult human reproductive organs; reproductive endocrinology; gametogenesis;comparisons between female and male gametes; embryogenesis: fertilization; gastrulation and implantation of embryo; fetal membrane and placenta; lactation.

Concept of non-disjunction: Origin and cause of non-disjunction.

Unit-2 **15 hours**

Basic concepts of development: Post-zygotic cell division and cellular biology; different stages of development; potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic movements; fate map and cell lineages.

Unit-3 **15 hours**

Gene expression regulation during development: Basics of gene expression regulation during early embryogenesis;role of key developmental genes: polycomb gene, P granules, *SOX*, *BMP*, *HOX* and *PAX*.

Stem cells: An overview and its biomedical aspect; embryonic stem cells.

Unit-4 **15 hours**

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

Teratology: Teratogens, introduction to toxicogenomis.

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.

LMM.525: Regenerative Medicine

Credit Hours:4

Learning Objective: To teach students the advanced techniques in medicine in gene and molecular therapeutics. The students will understand basic stem cell biology and corresponding requirement for tissue engineering.

Unit: 1 **15 hours**

Basics of cell culture and media: Culturing primary cells and cell lines; suspension and adherent cultures; cell growth, growth inhibition and apoptotic

studies; embryo culture; transplantation and teratogens, teratomas; stem cell culture; organ culture; artificial blood; somatic cell fusion and somatic cell genetics.

Unit: 2 **15 hours**

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

Unit: 3 **15 hours**

Tissue Engineering: Principles of tissue culture; tissue and organ culture; extracellular matrices; bioreactors; ethical issues related to stem cell therapies; stem cell banks; bone marrow transplantation.

Unit: 4 **15 hours**

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**.**

Suggested readings

1. Lanza, R., Gearhart,J. (2009). *Essential of Stem Cell Biology*. Elsevier Academic Press.
2. Lanza, R., Klimanskaya, I. (2009). *Essential Stem Cells Methods*. Academic Press.
3. Mao, J. J., Vunjak-Novakovic (2008). *Translational Approaches in Tissue Engineering & Regenerative Medicine*.Artech House INC Publications.
4. Lanza, R. (2007). *Principles of Tissue Engineering, 3rd Edition*. Academic Press.
5. Stein. (2011). *Human Stem Cell Technology and Biology: A Research Guide and Laboratory Manual.* Wiley-Blackwell.
6. Lanza, R. (2004). *Handbook of Stem Cells, Two-Volume Set: Volume 1-Embryonic Stem Cells; Volume 2-Adult & Fetal Stem Cells*. Academic Press.

Related Weblinks:

1. www.stemcells.wisc.edu
2. http://stemcells.nih.gov/info/scireport/Pages/2006report.aspx
3. *stemcells.nih.gov/*
4. http://instem.res.in/

LHG.526. Population Genetics and Genetic Epidemiology
Credit Hours: 4

Learning objectives: Study of population genetics is necessary to understand the evolution. This course will be helpful to the students to conceptualize the existence of genetic variation and speciation. Further, this course will give students exposure towards understanding population health and disease susceptibility**.**

Unit-1 **15 hours**

Population dynamics and basics of epidemiology: Dynamics and conditions of the Hardy-Weinberg law; selection co-efficient and fitness; heterozygous advantages;inbreeding and its consequences; mutation pressure and estimation of rates; genetic load; selection co-efficient and fitness; dynamics of migration and genetic drifts; construction of pedigree and pedigree analysis.

Unit-2 **15 hours**

Evolution and Speciation: Emergence of evolutionary thoughts Lamarck; Darwinism – concepts of variation, adaptation, struggle, fitness and natural selection; Mendelism; spontaneity of mutations; the evolutionary synthesis.

Mechanism of evolution: Adaptive radiation; isolating mechanisms; speciation; allopatricity and sympatricity; convergent evolution; sexual selection; co-evolution.

Unit-3 **15 hours**

Fundamentals of epidemiological studies: Experimental and observationalstudies;basic parameters of epidemiology: frequency, occurrence, prevalence, incidence; association; causation, variation;Cohort studies: cross sectional and longitudinal; Association studies: candidate gene association and genome-wide association studies (GWAS);concept of heritability; systematic review and meta-analysis.

Unit-4 **15 hours**

Genetic variation and complex trait inheritance: Basics of genetic variations; genetic markers – SNP, CNV, Ins/dels, VNTR, STR, microsatellite; concepts of tag markers and haplotypes, linkage disequilibrium; quantitative genetic analysis; QTL and eQTL.

Genetic variation and complex trait inheritance: Next-generation sequencing; DNA micro -array.

Suggested readings

1. Bhasker, H.V. and Kumar S (2008). *Genetics*. Campus Books International, New Delhi, India.
2. Cavalli-Sforza, L.L. and Bodmer, W.F. (2013). *The Genetics of Human Populations.* Dover Publications.
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. and 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. and Kilpatrick, S.T. (2013) *Lewin's Essential Genes*. Jones and Bartlett learning, USA.
8. Nielsen, R. and 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.
11. Palmer LJ, Burton PR & Smith GD (2011). *An introduction to genetic epidemiology* (Policy Press, University of Bristol)
12. Dawn TM (2011). *Genetic Epidemiology* (Springer)
13. Austin M (2013). *Genetic Epidemiology: Methods and Applications*, 1st Edition (CABI Publishing)

LMM.526. Molecular and Cellular Oncology

Credit Hours: 4

Learning objectives: Cancer Biology course is designed as an elective course to equip the students of different streams of Life Sciences with a conceptual understanding and advanced comprehension to cope up with the ever-expanding role of molecular biology in basic cancer research as well as clinical oncology.

Unit-1 **15 hours**

Fundamentals and Genetics of Cancer: History, hallmarks of cancer research, cancer classification, Mutagens, carcinogens and gene mutations and genetic arrangements in progenitor cells. Chromosomal aberrations, tumor viruses and discovery of oncogenes, Mechanism of activation of oncogenes.Transcription factors as tumor suppressors and oncogenes, Familial cancer syndromes, telomere regulation in cancer, micro RNA profiling in cancer, cancer stem cells.

Unit-2 **15 hours**

Signal transduction in cancer progression: Role ofgrowth factors and receptors in carcinogenesis, Interaction of cancer cells with variety of immune cells. Deregulation of Cell cycle in cancer. Role of p53 and pRb in cell cycle, Apoptosis and tumor suppressor p53, mitochondrial signaling, RAS signaling in cancer, cancer metabolism, hypoxia and metastasis, angiogenesis, tumor microenvironment. DNA damage and repair mechanisms, DNA repair defects and their relation to cancer.

Unit-3 **15 hours**

Cancer Detection: General and organ specific symptoms associated with cancer, techniques for cancer detection, biomarkers for cancer detection of various stages of cancer, population genetics based screening methods, *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-4 **15 hours**

Cancer Therapies and Recent Advances in Cancer Research : TraditionalChemotherapies, radiotherapy, Onco-surgery, Bone marrow transplantation, stem cell therapies, Immunotherapy, combinational therapies, natural products as therapeutics, cancer vaccines, gene therapies and delivery vehicles, targeted anticancer therapies, monoclonal antibody & adjuvant therapies. System biology approaches, Application of new technologies in prevention, assessing risk, diagnostics and treatment.

Suggested readings:

1. Airley, R. (2010). *Cancer Chemotherapy: basics to clinic.* Willey-Blackwell publishing, New Jersey.
2. DeVita, V. T., Hellman, S., Rosenberg, S. A. (2011). *Cancer: principles and practice of oncology.* Lippincot Williams and Wilkins publishers, Philadelphia.
3. Enders, G. H. (2010). Cell *cycle deregulation in cancer.* Humana Press, Springer science, New York.
4. Grutzmann, R., Pilarsky, C. (2010). *Cancer gene profiling: methods and protocols*. Humana Press, Springer science, New York.
5. Gusev, Y. (2010). *Micro RNA profiling in cancer.* Pan Standford publishing pvt.Ltd, Singapore.

6. Hiem, S., Mitelman, F. (2009). *Cancer cytogenetics*. IIIrd edition. Willey-Blackwell publishing, New Jersey.
7. Jocelyn, E. K., Elliot, S. G., Stephen, T. K. (2009). *Lewin's Gene X.* Jones &Barlett.
8. Wang, E. (2010). *Cancer systems biology*. CRC press, Taylor & Francis group, New York.
9. Weinberg, Robert A. (2007). *The Biology of Cancer*. New York: Garland Science
10. Prasad, K. N. (2009). Bio-Shield, *Antioxidants against Radiological, Chemical and Biological Weapons,* Strategic Book Publishing, USA.
11. Washington, C. M. and Leaver D. T. (2009). *Principles and Practice of Radiation Therapy*, Elsevier Health Sciences, USA.

Interdisciplinary Elective Course

LHG.527. Prenatal Diagnosis and Genetic Counseling
Credit Hours: 2

Learning objectives: The course gives and overview about th e various techniques of prenatal diagnosis and the strategies to counsel the patients and their families.

Unit-1 **8 hours**

Prenatal screening & diagnosis: Indications for prenatal diagnosis; preliminaries to prenatal diagnosis; procedures for obtaining fetal tissue; ultrasonography; laboratory studies; psychosocial issues.

Unit-2 **7 hours**

Techniques used in prenatal diagnosis: Amniocentesis,Chorionic villus sampling, fetoscopy, cordocentesis, maternal serum screening.

Unit-3 **8 hours**

Genetic Counseling: History taking; examination; genetic counseling in clinical genetics; determining recurrence risks; population screening for genetic diseases; reproductive decision making.

Unit-4 **7 hours**

Indications for prenatal diagnosis: Advanced maternal age, previous child with a chromosome abnormality, family history of a chromosomal abnormality, family history of a single gene disorder, family history of neural tube defect

Suggested readings:

1. Peter Snustad and Michael J Simmons(2009). Principles of Human Genetics. Fifth Edition. John Wiley & Sons, Inc.
2. Strachan T and Read A 2010 Human Molecular Genetics, Fourth Edition. Taylor and Francis
3. Ricki Lewis (2009) Human Genetics-Concepts and Application. Ninth Edition. McGraw-Hill College Publishers

LHG.528. Introduction to Population Genetics
Credit Hours: 2

Learning objectives: The course gives an overview about the basic principles of population genetics and different evolutionary forces acting on a population.

Unit-1 **15 hours**

Hardy-Weinberg Equilibrium: Historical emergence;application and subdivisions of human population genetics;dynamics and conditions of the Hardy-Weinberg law and its application for autosomal locus with two alleles and multiple alleles; testing of Hardy-Weinberg proportion, selection co-efficient and fitness, heterozygous advantages, inbreeding and its consequences.

Unit-2 **15 hours**

Kinetics of changes of gene frequencies: Non-recurrent and recurrent mutation; mutation pressure and estimation of rates; genetic load;heterozygous advantages; equilibrium between mutation and selection; dynamics of migration and genetic drifts.

Suggested readings

1. Bhasker, H.V. and Kumar S (2008). *Genetics*. Campus Books International, New Delhi, India.
2. Cavalli-Sforza, L.L. and Bodmer, W.F. (2013). *The Genetics of Human Populations.* Dover Publications.
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. and 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. and Kilpatrick, S.T. (2013) *Lewin's Essential Genes*. Jones and Bartlett learning, USA.
8. Nielsen, R. and 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.

LHG.542 Seminar-I
Credit Hour: 1
Learning objectives: To read the recent scientific articles and prepare presentation on some recent topic of 'Human Genetics' that will be helpful to overcome the presentation related fears and blunders.

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

MOOC course
Credit Hours: 4

MOOC course of 4 credits may be chosen by a student from the list provided by Swayam to the Head of the concerned Department. The student is required to submit the pass certificate of MOOC course before the declaration of result. The link for selection of MOOC course is:

http://ugcmoocs.inflibnet.ac.in/course.php

LHG.551: Biosafety, Bioethics and Intellectual Property Rights
Credit Hours: 4
Learning objectives: The course has been designed to sensitize students about the importance of Personnel Protective Equipment (PPE), general biosafety rules and different biosafety levels. The course further aims to make students aware about the ethical issues involving biological material. The course further includes the different forms Intellectual Property, which a researcher could utilize to protect its intellectual output.

Unit-1 **15 hours**
Biosafety: Good laboratory practices; gene pollution; biological invasion; risk and safety assessment from genetically engineered organisms; special

procedures for r-DNA based products; biological containment (BC) and physical containment (PC); CDC biosafety levels;biohazard management.

Unit-2 **15 hours**

Bioethics: Ethical considerations during research;Animal testing; xenotransplantation; embryonic and adult stem cell research;assisted reproductive technologies; cloning; ethical issues of the human genome project; the element of informed consent; ethical issues in MTP and euthanasia.

Unit-3 **15 hours**

Intellectual Property Rights (IPRs): Various forms of IP – patents, industrial designs, trade secrets, geographical indications and plant breeder's right; copyright: fair use, plagiarism and open access publishing; criticism of intellectual property; protection of indigenous intellectual property.

Unit-4 **15 hours**

Patent system in India: Patent filing in India and abroad: Determination of patentability of inventions, filing a patent application in India: timeline, procedure involved in the granting of a patent, various routes of filing patent application abroad, patent co-operation Treaty (PCT);Gene patent, Patenting of Living Organisms.

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.

5.Shannon, T.A. (2009). *An Introduction to Bioethics*. Paulist Press, USA.

6.Thompson J and Schaefer, B.*D (2013).Medical Genetics: An Integrated Approach*. McGraw Hill.

7.Vaughn, L. (2009). *Bioethics: Principles, Issues, and Cases*. Oxford University Press, UK.

8.WHO. (2005). *Laboratory BiosafetyManual*. World Health Organization.

LHG. 552. Genetic Diseases and Therapies

Credit Hours: 4

Learning objectives: The students will become familiar with the various types of genetic disorders and the therapies which although are in the research stage

but may emerge as a future treatment strategies.The course will help students in understanding novel methods for the treatment of genetic disorders, including metabolic manipulation, enzyme manipulation, enzyme replacement, enzyme transplantation, and gene transfer techniques in these patients.The students will get an exposure to methods acvailablefor the prenatal diagnosis of genetic disorders using improved cytogenetic, biochemical, and nucleic acid techniques and amniotic fluid cells or chorionic villi samples.

Unit-1 **15 hours**

Monogenic Disorders: Cystic fibrosis**;**Huntington's disease; DuchenneMuscular dystrophy; X-linked rickets.

Multifactorial Diseases: Diabetes type 2;Cancers; Hypertension; Obesity; Neurodegenerative diseases.

Unit-2 **15 hours**

Genomic Imprinting and Human Diseases: Uniparental disomy& genomic imprinting:Prader-Willi & Angelman syndrome; Beckwith-Wiedeman syndrome& Silver Russell Syndrome; Imprinting and brain and behaviour; imprinting and Cancer.

Neurofibromatosis I; X/Y linked human syndromes due to numerical chromosomal anomalies.

Unit-3 **15 hours**

Genetic Screening: Risk calculations, Population screening for genetic disease-adult, Clinical utilization of presymptomatic and predispositional testing, Presymptomatic testing for genetic diseases and malignancy, carrier detection; prenatal and postnatal screening; Assisted reproductive techniques and Pre-implantation diagnosis and Genetic Counseling.

Unit-4 **15 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.

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. MilunskyA,Milunsky J (2009). *Genetic Disorders and the Fetus: Diagnosis, Prevention and Treatment*, 6th Edition. Wiley-Blackwell publishers.

LHG.553. Pharmacogenomics and Nutrigenomics
Credit Hours: 4

Learning objectives: Pharmacogenetics is the study of inherited variation in drug response. The goal of Pharmacogenetics is to develop novel ways of maximizing drug efficacy and minimizing toxicity for individual patients. Personalized medicine has the potential to allow for a patient's genetic information to predict optimal dosage for a drug with a narrow therapeutic index, to select the most appropriate pharmacological agent for a given patient and to develop cost-effective treatments. The objective of this course is to discuss the benefits of incorporating pharmacogenetics into clinical practice.
Nutrigenomics is the study of the effects of food and food constituents on gene expression, and how genetic variations affect the nutritional environment. The students will understand the interaction between nutrients and other dietary bioactives with the genome at the molecular level, and how specific nutrients or dietary regimes may affect human health.

Unit-1 **15 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; progress in understanding the genomic basis for adverse drug reactions; ethnic diversity in pharmacogenomics studies and challenges posed by ethnicity.

Unit-2 **15 hours**

Nutritional Biochemistry: Essential and non-essential nutrients; micro and macro nutrients; measurement of calorie values of foods; recommended dietary allowances; basal metabolic rate (BMR); malnutrition; malabsorption and interventional strategies.

Unit-3 **15 hours**

Nutrigenomics vsNutrigenetics: Diet and gene expression; nutrients as regulators of activity and transcription factors;nutritionalstatusin early life and metabolic programming; gene polymorphisms and differential responses to micronutrients: examples related to obesity, vitamin D deficiency and folic acid deficiency.

Unit-4 **15 hours**

Biomarkers and recent advances in Nutrigenomics: Risk/benefit biomarker; genetic and nutritional control of lipid metabolism, metabolomics; effect of diet on epigenetic processes.

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

LHG.599:Project

Credit Hours: 6

Project objectives: The objective of this course would be to ensure that the student learns the nuances of the scientific aptitude, presentation and writing. Herein the student shall have to write his/her synopsis including an extensive review of literature with simultaneous identification of scientifically sound (and achievable) objectives backed by a comprehensive and detailed methodology. Synopsis will be evaluated as per the University policy.

LHG.571: Recombinant DNA technologyand therapeutics

Credit Hours: 4

Learning objective: This course will introduce modern techniques for genetic engineering and students will learn cutting edge molecular engineering. The

Course will dealwith the basics of genetic engineering, the methodology of gene manipulation, and the implications of genetic engineering.

Unit-1 **15 hours**

Basics of Genetic Engineering: Isolation and purification of nucleic acids; gene manipulation;restriction and DNA modifying enzymes; restriction modification systems;cloning vectors: plasmids, phages, lambda vectors, cosmids, PAC, BAC, YAC; selection and screening of clones.

Unit-2 **15 hours**

Construction of DNA libraries: Genomic and cDNA libraries; screening of genomic and expression libraries.

Analysis of gene expression: Northern blotting; RT-PCR; digital PCR; EST analysis; promoter analysis; TSS mapping; cDNA and oligos array; serial analysis of gene expression (SAGE).

Unit-3 **15 hours**

Expression Vectors: 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-4 **15 hours**

Techniques and Applications of recombinant DNA technology: Sites specific mutagenesis; Gene Editing through RNA based therapeutics, CRISPR/CAS system, Genetically modified microbes (Recombinant bacteria) for the production of commercial scale production of proteins, pharmaceuticals; transgenic animals.

Suggested readings

1. R.W. Old & S.B. Primrose (2007) *Principles of Gene Manipulation* 7th Edition Blackwell science.
2. Bernard R. Glick & Jack J. Pasternak. (2010) *Molecular Biotechnology* 4th Edition ASM Press Washington.
3. James Watson, Micheal Gilman Jan Witkowsk (2007) *Recombinant DNA* 3rdedition . CSHL, New York.
4. CokinRateldge and Bjorn Christiansen, (2006) *Basic Biotechnology* 3rdEdition Cambridge University press.

5. John E. Smith. (2009) *Biotechnology* 5th Edition by Cambridge University press.
6. *Molecular Biology* of Gene 6th Edition by Watson CSHL Press New York.
7. Sambrook& Russell *Molecular cloning* , CSHL Press, New York.
8. David &Freifelder John &Barlett (2008) *Molecular biology* 2ndEdition ,Narosa publishing , New Delhi.

Related Weblinks

1. http://www.genengnews.com/ontheweb.asp
2. http://www.ige-india.com/
3. http://www.icgeb.org/~bsafesrv/
4. http://www.livescience.com/32648-whats-genetic-engineering.html

LHG.572: Advanced Practical Course in Human Genetics
Credit Hours: 3

Learning objectives: This practical course will enable the students to learn advanced cytogenetic and molecular genetic techniques.

Unit-1
Credit Hours: 15
Molecular genetic techniques: PCR and RFLP; cDNA library preparation; qPCR; analysis of qPCR data (delta CT and delta delta CT method); PBMC culture; chromosome banding: G-banding; Identification of chromosomes based on G-banding; karyotyping; fluorescence in situ hybridization (FISH).
Unit-2
Credit Hours: 15
Bioinformatics:PCR and RT-PCR primer designing; global and local sequence alignment, Sanger sequencing data analysis;data mining, comparative modeling; docking; protein-ligand; structure-based drug design; virtual screening, molecular phylogenetics.

*Practical will be conducted depending upon the faculty/facility.
Suggested readings
Laboratory specific modified protocols will be followed, however below mentioned reference books can be read to develop overall concepts.
1.Laboratory Protocols. Third Edition. 2005. CIMMYT Applied Molecular Genetics Laboratpry.
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 Enrichment Courses

LHG.573. Practice in life sciences
Credit Hours: 2
Learning Objectives: Preparatory classes will be taken to improve skill for reasoning based MCQsfor competitive examinations such as UGC CSIR-NET, GATE, ICMR and DBT-JRF examinations. Series of scheduled MCQ based test paper solving and test series will be conducted.

Unit-1 **15 hours**
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-2 **10 hours**
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-3 **8 hours**
Innate and ada ptive 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-4 **5 hours**

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

LHG.574. Practice in Life Sciences-II

Credit Hours: 2

Learning Objectives: Preparatory classes will be taken to improve skills for reasoning bases MCQ for examinations such as UGC CSIR-NET, GATE, ICMR and DBT-JRF examinations. Series of scheduled MCQ based test paper solving and test serious will be conducted.

Unit-1 **8 hours**

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-2 **5 hours**

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-3 **8 hours**

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-4 **9 hours**

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.

Skill Based Course

LHG.544. Seminar-II

Credit Hours: 1

Learning Objectives: To read the recent scientific articles and prepare presentation on some recent topic of 'Human Genetics that will be helpful to overcome the presentation related fears and blunders. The preferable topics may be related to the Research project of the student.

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.

LHG.599. Project

Credit Hours: 6

Learning objective: The objective of Research Project in SEM-IV would be to ensure that the student learns the nuances of the scientific research and/or literature review. Herein the student shall have to carry out experiments to achieve the objectives as mentioned in the synopsis. The data collected as a result of the experiments must be meticulously analyzed in light of established scientific knowledge to arrive at cogent conclusions.

The final result of the project will be on a five point scale and evaluated as **excellent, very good, good, average** and **unsatisfactory**.

Thesis will be evaluated as per the University policy.

Elective Foundation/Value based course:

Credit Hours: 1 + 1

These courses may be chosen from a pool of courses designed to provide value-based and/or skill-based knowledge and should contain both theory and

lab/hands-on/training/field work. The list of Value added courses is given below:

(i) Ethics for Science	(ii) Professional Ethics
(iii) Academic Writing	(iv) Value Education
(v) Stress Management	(vi) Personality Development through Life Skills
(vii) Physical & Mental Well Being	(viii) Pedagogical Studies
(ix) Data Analysis using spread sheet	(x) Soft Skill Training
(xi) Leadership	(xii) Personal Management
(xiii) Wealth Management	(xiv) Reasoning Ability
(xv) MS office Specialist	(xvi) Practical Taxation
(xvii) Ethical Issues & Legal Awareness	(xviii) Disaster Management
(xix) Nutrition and Specialty Foods	(xx) Shorthand & Typing
(xxi) SPSS	

* The student has to choose 2 courses in the present semester.

** The list is subject to addition/deletion/modifications at University level.