

# Centre for Human Genetics and Molecular Medicine

School of Health Sciences  
Central University of Punjab, Bathinda

## Credit Structure of M.Sc. Life Sciences with specialization in Human Genetics

Course type	Required as per CBCS system, UGC	Actual Credit distribution
Foundation	10-15% i.e.7.2 to 10.8	10
Elective	25-35% i.e.18 to 25.2	19
Core	50-65% i.e. 36 to 46.7	39
<b>Total credits (excluding Research Project)</b>		<b>68</b>

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## M.Sc. (Life Sciences with Specialization in Human Genetics) SEMISTER – I

S.No	Paper Code	Course Title	L	T	P	Cr
<b>Foundation courses</b>						
2	LSL.501	Biostatistics and Research Methodology	2	1	-	3
3	LSP.502	Biostatistics and Research Methodology	-	-	1	1
4	LSL.503	Introduction to Cell and Molecular Biology	3	1	-	4
5	LSP.504	Introduction to Cell and Molecular Biology	-	-	1	1
<b>Core courses</b>						
6	LSL.505	Basic and Clinical Biochemistry	3	1	-	4
7	LSP.506	Basic and Clinical Biochemistry	-	-	1	1
8	LSL.507	Concepts of Genetics	3	-	-	3
9	LSP.508	Concepts of Genetics	-	-	1	1
10	HGL.509	Human Cytogenetics and Biochemical Genetics	2	1	-	3
11	HGP.510	Human Cytogenetics and Biochemical Genetics	-	-	1	1
12	XXX	<b>Interdisciplinary Elective Course-1</b> <b>(choose from other Centre)</b>	2	-	-	2
		<b>Total</b>	15	4	5	24
<b>Interdisciplinary courses offered to students of other Centre</b>						
13	HGL.511	Basics of Human Genetics	2	-	-	2

**L: Lectures, T: Tutorial, P: Practical, Cr: Credit.**

Note: Students need to present one non-credit seminar each.

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## LSL.501: Biostatistics & Research Methodology

Credits Hours: 3

**Course Objectives:** This course will give a basic but significant exposure towards better understanding of biostatistics and 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 Lectures

**Overview of Biostatistics:** Difference between parametric and non-parametric statistics, Univariate and multivariate analysis, Frequency distribution, Measures of central tendency and variation.

### Unit 2 12 Lectures

**Experimental design and analysis:** Sampling techniques, Sampling theory, Various steps in sampling, Sampling distribution. Graphical representation of data, Levels of significance, Hypothesis testing.

### Unit 3 15 Lectures

**Inferential Statistics:** Chi-Square test, Student's t-test, One-way and two-way analysis of variance (ANOVA), Correlation and regression.

### Unit 4 15 Lectures

**Technical writing & Library:** Scientific writing that includes the way of writing Synopsis, research paper, poster preparation and presentation, and dissertation. Classification systems, e-Library, web-based literature search engines.

### Suggested Readings:

1. Norman, G. and Streiner, D. (2008). *Biostatistics: The Bare Essentials*. (with SPSS), 3<sup>rd</sup> Edition, Decker Inc. USA.
2. Sneath, P.H.A. and Sokal, R.R. (1973). *Numerical Taxonomy*. Freeman, San Francisco.
3. Sokal, R.R. and Rohlf, F.J. (1994). *Biometry: The Principles and Practices of Statistics in Biological Research*. W.H. Freeman publishers, USA.
4. Banerjee P.K (2014). *Introduction to Biostatistics*. S.Chand, India
5. Daniel WW (2010). *Biostatistics: A Foundation for Analysis in the Health Sciences*. John Wiley and Sons Inc.
6. Baile NTJ. *Statistical Methods in Biology*. Cambridge Univ. Press.
7. Glaser AN. *High-Yield Biostatistics*. Lippincott Williams & Wilkins.

## LSP.502: Biostatistics & Research Methodology –Practical

Credit Hours: 1

1. Experimental design and analysis.
2. Plotting different types of graphs using statistical data, using MS Excel
3. Plotting normal distribution graph
4. Frequency distribution, SD, SE calculations

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5. Chi-square tests
6. Student's t-test
7. Regression and Correlation.
8. Writing scientific abstracts and papers.

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

## LSL.503: Introduction to Cell and Molecular Biology

Credit Hours: 4

**Learning Objective:** Students will understand the structures and purposes of basic components of membranes, and organelles and their related functions. Understanding the molecular processes of DNA replication, transcription, and translation, and how they are managed in cells. Understand the basic mechanisms of cellular signal transduction and regulation of gene expression.

### Unit: 1 15 Lectures

**Introduction to the Cell:** Prokaryotic and eukaryotic cells, Single cell to multicellular organisms.

**Membrane Structure and Function:** Models of membrane structure, membranes of intracellular organelles, Membrane transport.

**Protein Secretion and Sorting:** Structure and functions of intracellular organelles, Intracellular traffic and secretory pathways, protein sorting, endocytosis and, exocytosis.

### Unit: 2 12 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, cell cycle and its regulation.

### Unit: 3 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, Refgulation of nucleosome assembly Chromatin.

**Gene and Genome organization:** Split genes, Overlapping genes, Transposons & retrotransposons, Gene clusters, Mechanism of DNA replication, DNA damage and their repair.

### Unit: 4 12 Lectures

**Transcription and mRNA Processing:** Transcription and transcription factors, Transcriptional and posttranscriptional 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.

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## Suggested Reading:

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. (2010). *Molecular Biology of the cell*. Garland publishers, Oxford.
2. Celis, J.E. (2006). *Cell biology: A laboratory handbook*, Vol 1, 2, 3. Academic Press, UK.
3. Gupta, P.K. (2008). *Cytology, Genetics and Evolution*. Rastogi publications, Meerut, India
4. Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments*. John Wiley & Sons. Inc. New Delhi, India.
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. James, D.W., Baker, T.A., Bell, S.P., Gann, A. (2009). *Molecular Biology of the Gene*. Benjamin Cummings, USA.
8. Jocelyn, E.K., Elliott, S.G., Stephen, T.K. (2009). *Lewin's Genes X*. Jones & Bartlett Publishers, 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.

## LSP.504: Introduction to Cell and Molecular Biology-Practical

Credit Hours: 1

1. Preparation of mitotic and meiotic chromosomes.
2. Study of structure of cell organelles through electron micrographs.
3. Instrumental methods for cell biology-centrifugation, chromatography.
4. Bacterial staining and identification.
5. Histochemical techniques (Fixing, Processing, Staining).
6. Basic Cell culture
7. Isolation, quantification and quality assessment of DNA and RNA
8. PCR and RFLP
9. Electrophoresis (Agarose and SDS-PAGE)

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

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LSL.505: Basic and Clinical Biochemistry

Credits Hours: 4

**Course Objectives:** The course aims to provide an advanced understanding of the core principles and topics of Biochemistry and their experimental basis.

## Unit 1 15 Lectures

**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 and metal poisoning.

## Unit 2 14 Lectures

**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 hyperthyroidism.

## Unit 3 10 Lectures

**Conformation of Biomolecules:** Ramachandran plot, 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 Lectures

**Enzymology:** Classification, Principles of catalysis, Mechanism of enzyme catalysis, Enzyme kinetics, Enzyme inhibition, Enzyme regulation, Isozymes and Clinical enzymology.

### Suggested Reading:

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.

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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

## LSP.506: Basic and Clinical Biochemistry-Practical

Credits Hours: 1

1. Preparation of solutions, buffers, pH setting etc.
2. Amino acid and carbohydrate separations by paper and 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 in plant seeds.
5. Principle and application of electrophoresis, Native, SDS PAGE.
6. Estimation of total phenolic compounds.
7. Extraction and estimation of vitamins.

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

## LSL.507: Concepts of Genetics

Credits Hours: 3

### Course Objectives:

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

### Unit 1 10 Lectures

**Basics of Inheritance:** Mendel's Laws of inheritance, Concept of segregation, independent assortment and dominance, Chromosome theory of inheritance, Alleles and multiple alleles, Locus concept, Epistasis, Crossing over and recombination, Pedigree analysis, Linkage analysis and gene mapping: Coupling and repulsion phase linkage, Application of Mendel's laws to populations, Hardy-Weinberg principle, inheritance of quantitative traits.

### Unit 2 17 Lectures

**Chromosomal mutations and Gene concept:** Type of 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. Gene concept: Fine structure of gene and gene concept, Fine structure analysis –

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Benzer's experiments, Complementation analysis and fine structure of gene, Complementation and recombination.

## Unit 3 17 Lectures

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

## Unit 4 14 Lectures

**Extra-chromosomal inheritance:** Chloroplast and Mitochondrial inheritance, Yeast, *Chlamydomonas/Neurospora* and higher plants, Symbiosis.

### Suggested Readings:

1. Klug WS and Cummings MR. Concepts of Genetics. Prentice-Hall.
2. Anthony, J.F., Miller, J.A., Suzuki, D.T., Richard, R.C., Gilbert, W.M. (1998). *An introduction to Genetic Analysis*. W.H. Freeman publication, USA.
3. Pierce BA. Genetics: A Conceptual approach. Freeman Publishers.
4. Hartle DL and Jones EW. Genetics: Analysis of Genes and Genomes. Jones & Bartlett.
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.
8. Griffith AF et al. An Introduction to Genetic Analysis. John Wiley & Sons.

### LSP.508: 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.



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**HGL.509: Human Cytogenetics and Biochemical Genetics**

**Credits Hours: 4**

**Course Objectives:** The basic and specialized knowledge and understanding the aspects of Cytogenetics and Biochemical genetics is essential to understand Human Genetics.

**Unit 1** **15 Lectures**

**General features of Human Chromosome and Chromosome staining:** Chromatin structure, Constitutive and Facultative Heterochromatin, Centromeres, Telomere and its maintenance, Nuclear Organization Region (NOR), Sister Chromatid Exchanges (SCE), Mosaicism, Structure of Human X and Y chromosome, Human Artificial Chromosome.

**Unit 2** **15 Lectures**

**Cytogenetic and Molecular Cytogenetic Techniques:** Chromosome Banding Techniques, Fluorescent in situ hybridization (FISH), Comparative Genomic Hybridization (CGH) mapping technique, Whole Chromosome Painting, Spectral Karyotyping (SKY).

**Unit 3** **15 Lectures**

**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.

**Normal Biochemical Polymorphisms and Variants:** Quantitative and qualitative variation of enzymes; Haemoglobin variants; Effects of Single Amino Acid Substitutions i.e. Sickle cell disease.

**Unit 4** **15 Lectures**

**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 Pyrimidine 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 Cytogenetics, 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.

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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.
14. Nelson, D. and Cox, M.M. (2013). *Lehninger Principles of Biochemistry*. W.H. Freeman.

## HGP.510: Human Cytogenetics and Biochemical Genetics-Practical

Credits Hours: 1

1. Cell counting by using hemocytometer.
2. Calculation of cell doubling time.
3. Human lymphocyte culture.
4. Karyotyping of normal and abnormal chromosome sets.
5. Identification of inactivated X chromosome as Barr body and drumstick.
6. Chromosome banding.
7. FISH
8. Sickling Test
9. Separation of abnormal hemoglobins
10. Estimation of Hb A2
11. Red Cell Enzymes – ACP, ESD
12. Plasma proteins – HP, CP

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

## Interdisciplinary courses offered to students of other Centre

HGL.511: Basics of Human Genetics

Credits Hours: 2

**Course Objective:** The course gives an overview of basics of Human Genetics and makes familiar with the common genetic disorders.

**Unit 1** **18 Lectures**

**Chromosomal analysis and Genetic assessment:** Classification of Genetic Disorders, Human Chromosomes, The Life Cycle of a Somatic Cell, Mitosis, Meiosis, Medical Applications of Chromosomes, Drawing of a pedigree, Consanguinity.

**Unit 2** **18 Lectures**

**Common chromosomal disorders and Mendelian disorders:** Down syndrome, Edwards syndrome, Patau's syndrome and other trisomies, Structural aberrations, Single gene disorders: autosomal and sex chromosomal, Multifactorial disorders.

**Suggested Reading:**

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1. Emery and Rimoin's, et al., 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)

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## M.Sc. (Life Sciences with Specialization in Human Genetics)

### SEMESTER II

S.No	Paper Code	Course Title	L	T	P	Cr
<b>Core courses</b>						
3	LSL.521	Human Physiology	3	1	-	4
4	LSP.522	Human Physiology	-	-	1	1
5	LSL.523	Essentials of Immunology	2	1	-	3
6	LSL.524	Advanced Techniques in Human Genetics & diagnostics	2	1	-	3
7	HGS.599	Seminar	-	-	1	1
		<b>Elective course 1 (choose any one)</b>				
8	HGL.525	Human Embryology and Developmental Biology	3	1	-	4
9	LML.525	Regenerative Medicine and Stem cell Therapies	3	1	-	4
		<b>Elective Courses 2( choose any one course)</b>				
10	HGL.526	Population Genetics and Genetic Epidemiology	4	-	-	4
11	LML.526	Molecular and Cellular Oncology	4	-	-	4
12	LML.527	Molecular Endocrinology and Signal Transduction	4	-	-	4
	.XXX	<b>Interdisciplinary Elective Course-1 (choose from other Centre)</b>	2	-		2
			<b>16</b>	<b>4</b>	<b>2</b>	<b>22</b>
<b>Interdisciplinary courses offered to students of other Centre</b>						
13	HGL.527	Prenatal Diagnosis and Genetic Counseling	2	-	-	2
14	HGL.528	Introduction with Population Genetics	2	-	-	2

**L: Lectures, T: Tutorial, P: Practical, Cr: Credit.**

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## LSL.521: Human Physiology

Credit Hours: 4

**Course 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 will include neural & hormonal homeostatic control mechanisms, as well as study of the musculoskeletal, circulatory, respiratory, digestive, urinary, immune, reproductive, and endocrine organ systems.

### Unit: 1 17 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

**Respiratory system:** Anatomical considerations, Transport of gases, Exchange of gases, Waste elimination, Neural and chemical regulation of respiration. Alveolar Ventilation, Diffusion Across Alveoli. Transport of Respiratory Gases in Blood. The Respiratory System Under Stress: Altitude, Hypoxia

**Excretory system:** Comparative physiology of excretion, Kidney, Urine formation, Urine concentration, Waste elimination, Micturition, Regulation of water balance, Blood Volume, Blood pressure, Electrolyte balance, Acid-base balance. Renal Function and Hemodynamics

### Unit: 2 17 Lectures

**Muscle Physiology:** Types of muscles, Properties; Contractile force; Motor Unit. Skeletal, cardiac and smooth Muscle Mechanics & Metabolism. Control of Body Movement.

**Cardiovascular system:** Comparative anatomy of heart structure, Myogenic heart, specialized tissue, ECG – its principle and significance, Cardiac cycle, Heart as a pump, blood pressure, neural and chemical regulation of all above, Plasma function, Blood volume, Blood volume and its regulation,, Haemoglobin,, Haemostasis.

### Unit: 3 12 Lectures

**Nervous system:** Neurons, action potential, Gross neuroanatomy of the brain and spinal cord, Central and peripheral nervous system, Neural control of muscle tone and posture.

**Sense organs:** Vision, hearing and tactile response.

### Unit: 4 8 Lectures

**Endocrinology:** Endocrine glands, Hormone Structure and Function, Basic mechanism of hormone action, Hormones and diseases, Reproductive processes, Neuroendocrine regulation. Hormone Receptors and Intracellular Signaling.

### 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.

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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; 6<sup>th</sup> edition.
9. Sherman V. (2013) *Vander's Human Physiology*. McGraw-Hill 13<sup>th</sup> edition.

## LSP.522: Human Physiology-Practical

Credit Hours: 1

1. Determination of hemoglobin in the blood by various methods.
  2. Measurement of Blood Pressure, Pulse rate and Heart rate.
  3. Digestive enzymes analysis.
  4. Respiratory function: Tidal volume.
  5. Sense organs and muscle reflexes.
  6. Urine analysis.
  7. Blood glucose estimation.
  8. RBC, WBC count from human blood.
  9. Extraction and estimation of acid phosphatases from serum.
  10. Electrophoresis of egg proteins.
- \*Practical will be conducted depending upon the faculty/facilities.

## LSL.523: Essentials of Immunology

Credit Hours: 3

**Course Objectives:** 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** **9 Lectures**

**Immune system:** Cells and organs of the immune system. Humoral and cellular components of the immune system, Innate & adaptive immunity, Antigens, antigenicity vs immunogenicity. Antigen processing and presentation, Structure, function, classes and subclasses of immunoglobulins, MHC, Primary and secondary immune response.

**Unit: 2** **9 Lectures**

**Immune Effectors:** Complement system, their structure, functions and mechanisms of activation by classical, alternative and lectin pathway. Th1 and Th2 response, cytokines, Chemokines. Antigen and antibody interactions.

**Unit: 3** **9 Lectures**

**Mechanisms of Immune System Diversity:** Organization and expression of immunoglobulin genes, Mechanisms of antibody diversity, class switching. Structure and functions of Major

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Histocompatibility Complex (MHC) and Human Leukocyte Antigen (HLA) system, polymorphism, distribution, variation and their functions.

**Unit: 4**

**9 Lectures**

**Immune System in Health and Diseases:** Inflammation, hypersensitivity and autoimmunity, Immunity to microbes, immunity to tumors, AIDS and immunodeficiencies,

## Suggested Reading:

1. Kindt, T.J., Osborne, B.A. and Goldsby, R.A. (2007). *Kuby Immunology* .7<sup>th</sup> 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.

**LSL.524: Advanced Techniques in Human Genetics**

**Credit Hours: 3**

**Course Objectives:** This course will help the students to understand safe laboratory practices and basic molecular biology techniques and specialized molecular and cell biology techniques.

**Unit: 1**

**9 Lectures**

**Biochemical Techniques:** Sterilization techniques; Spectrometry; Colorimetry, Mass, UV, IR, NMR and atomic absorption spectrophotometry; 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**

**9 Lectures**

**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**

**9 Lectures**

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**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

9 Lectures

**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 Reading:

1. Brown, T.A. (2010). *Gene cloning and DNA analysis: An Introduction*. 6<sup>th</sup> Edition, Wiley-Blackwell Publisher, New York.
2. Goldsby, R.A., Kindt, T.J. and Osborne, B.A. (2008). *Kuby Immunology*. 6<sup>th</sup> 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). 3<sup>rd</sup> 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.



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14. Wilson, K. and Walker, J. (2006). *Principles and Techniques of Biochemistry and Molecular biology*. 6<sup>th</sup> Edition, Cambridge University Press India Pvt. Ltd., New Delhi.

## Elective courses

### HGL.525: Human Embryology and Developmental Biology

Credit Hours: 4

**Course Objectives:** The course aims to make students familiar with the embryonic and other developmental processes.

#### Unit: 1 18 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: 2 18 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 cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development.

#### Unit: 3 12 Lectures

**Gene expression regulation during development:** Role of developmental genes: Polycomb gene, P granules, *SOX*, *BMP*, *HOX* and *PAX*. Genetics of sex determination in humans; Programmed cell death and role of cell death in formation of digits and joints.

#### Unit: 4 12 Lectures

**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.

### 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. and 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., 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.

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- Schaefer, B.D. (2013). *Medical Genetics: An integrated Approach*. McGraw Hill Education, New Delhi.
- Tyagi R. (2011). *Understanding Evolutionary Biology*. Discovery Publication House Pvt. Ltd., New Delhi.

## LML.525: Regenerative Medicine and Stem Cell Therapies

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** **16 Lectures**

**Stem Cells:** Stem cells and their properties, classification of stem cells: Hematopoietic Stem Cells, mesenchymal Stem Cells, Embryonic Stem Cells, Fetal Stem Cells, adult stem cells, cancer stem cells, *In-vitro* culture techniques, isolation, identification and characterization of stem cells, stem cells in gastrointestinal, liver, pancreas, kidney, heart, spinal cord, eye diseases and cancer.

**Unit: 2** **16 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: 3** **20 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 bioartificial pancreas, lung regeneration

**Unit: 4** **20 Lectures**

**Somatic and Germline Engineering:** 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 teratogenesis, teratomas. Stem cell culture, organ culture, artificial blood, Somatic cell fusion and somatic cell genetics, radiation hybrids.

### Suggested Reading:

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

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## Related Weblinks:

1. [www.stemcells.wisc.edu](http://www.stemcells.wisc.edu)
2. <http://stemcells.nih.gov/info/scireport/Pages/2006report.aspx>
3. [stemcells.nih.gov/](http://stemcells.nih.gov/)
4. <http://instem.res.in/>

## HGL.526: Population Genetics and Genetic Epidemiology

Credit Hours: 4

### Course 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 18 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; Construction of Pedigree and Pedigree analysis.

### Unit: 2 12 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: 3 12 Lectures

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

### Unit: 4 12 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.

### Suggested reading:

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.

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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*, 1<sup>st</sup> Edition (CABI Publishing)

## LML.526: Molecular and Cellular Oncology

Credit Hours: 4

**Course 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

18 Lectures

**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

18 Lectures

**Signal transduction in cancer progression:** Role of growth factors and receptors in carcinogenesis, Interaction of cancer cells with variety of immune cells. Dereglulation 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

18 Lectures

**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,

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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**

**18 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 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 Reading:

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 Stanford 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.

## LML.527: Molecular Endocrinology and Signal Transduction

**Credit Hours: 4**

**Course Objectives:** The course is designed for the students of life sciences who are interested to learn the basics of signal transduction and its role in various cellular processes. Various pathways deregulated during disease manifestation will also be discussed in detail.

**Unit: 1**

**16 Lectures**

Introduction to signal transduction, basics of cell signaling, types of signaling, signaling molecules and their classification, signal receptors types and subtypes, hormonal signaling, role of biological membranes in signaling, ion channels and other types of receptor channels, G and non G protein receptors, second messengers and effector molecules, mechanism of protein

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activation/inactivation, various signaling pathways: MAPK, PI3K, MEK, Ras/Raf signaling, TGF beta, NFkB etc.

## Unit: 2 18 Lectures

Regulation of cell cycle, cell division, proliferation, apoptosis via signal transduction, Signal transduction pathways during embryonic development, cellular differentiation and de-differentiation, epithelial to mesenchymal transition, cytoskeleton proteins and signal transduction.

## Unit: 3 18 Lectures

Signal transduction in human diseases: Deregulated cell signaling in diabetes, cancer, cardiovascular diseases, genetic and metabolic disorders, Ageing and free radical stress biology, neuronal diseases, blood borne disorders and infectious diseases.

## Unit: 4 20 Lectures

**Nuclear Receptors in Health and Disease:** Nuclear Receptor superfamily: an introductory overview; structural and functional domains of nuclear receptors; ligand-mediated regulation of nuclear receptor function; nuclear receptor localization; receptor-ligand interactions and gene transcription regulation; co-activators and co-repressors; SRC/ p160, CBP/p300, histone (acetylase, deacetylase, methylase, demethylase), ATP dependent chromatin re-modellers; receptor regulation by post-translational modifications e.g. phosphorylation, sumoylation, ubiquitination, acetylation, deacetylation, methylation etc.; nuclear receptors as drug targets; xenobiotic receptors and drug metabolism; screening and analysis of therapeutic ligands by high-throughput microscopy, co-transfection and transcriptional assays; steroid hormones and their receptors; molecular basis of endocrinopathies: endocrine-related cancers (prostate, breast, endometrial cancers); ligand-independent transcriptional activation of steroid hormone receptors; endocrine disruptors and selective steroid receptor modulators; current concepts and future challenges.

### Suggested Reading:

1. Alberts, B. Bray, D. Lewis, J., Raff, M., Roberts, K. and Watson, J.D. (2010). *Molecular Biology of the Cell*. Garland publishers, Oxford.
2. Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments*. John Wiley & Sons. Inc., New Delhi, India.
3. Cooper GM. (2000). *The Cell: A Molecular Approach*. 2nd edition. Sunderland (MA): Sinauer Associates.
4. Lodish H, Berk A, Zipursky SL, et al. (2000). *Molecular Cell Biology*. 4th edition. New York: W. H. Freeman.
5. Robertis, E.D.P.D.E and Robertis, E.M.F.De. (2011). *Cell and Molecular biology*. Lippincott Williams & Wilkins
6. Nelson and Cox, *Lehninger Principles of Biochemistry 5e* W H Freeman & Co (2009) ISBN: 978-0-716-77108-1
7. Liciniio, J., Wong, M. L. (2003). *Pharmacogenomics: The Search for Individualized Therapies*. Wiley-VCH Verlag GmbH & Co. KGaA.

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- Kramer, I., Gomperts, B., Tatham, P. (2009). Signal Transduction, 2nd Edition, Academic Press.
- Sitaramaya, A. (2010). Signal Transduction: Pathways, Mechanisms and Diseases. Springer

## Interdisciplinary Courses offered to students of other Centre

### HGL.527: Prenatal Diagnosis and Genetic Counseling

Credit Hours: 2

**Course Objectives:** The course gives an overview about the various techniques of prenatal diagnosis and the strategies to console the patient and their families.

**Unit: 1** **14 Lectures**

**Prenatal Diagnosis:** Indications for Prenatal Diagnosis, Preliminaries to Prenatal Diagnosis, Procedures for Obtaining Fetal Tissue, Ultrasonography, Laboratory Studies, Psychosocial issues.

**Unit: 2** **14 Lectures**

**Genetic Counseling:** History taking, Examination, Genetic Counseling in Clinical Genetics, Determining Recurrence Risks, Population Screening for Genetic Diseases, Reproductive decision making

#### Suggested readings:

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

### HGL.528: Introduction with Population Genetics

Credit Hours: 2

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

**Unit: 1** **18 Lectures**

**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 coefficient and fitness, Heterozygous advantages, Inbreeding and its consequences.

**Unit: 2** **18 Lectures**

**Kinetics of changes of Gene Frequencies:** Non-recurrent and recurrent mutation, mutation pressure and estimation of rates, Genetic load, Selection coefficient and fitness, Heterozygous advantages, Equilibrium between mutation and selection, Dynamics of migration and genetic drifts

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## 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.



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## SEMESTER III

S.No	Paper Code	Course Title	L	T	P	Cr
		<b>Core courses</b>				
1	HGL.601	Biosafety, Bioethics and Intellectual Property Rights	3	1	-	4
2	LSL.602	Bioinformatics and Computational Biology	3	1	-	4
3	HGD.600	Research Project *	-	-	8	8
		<b>Elective course 1 (choose any one)</b>				
4	HGL.603	Genetic Diseases and Therapies	3	1	-	4
5	LML.603	Evolution and Developmental Genetics	3	1	-	4
		<b>Elective courses (choose any one theory along with the respective Practical)</b>				
6	HGL.604	Pharmacogenomics & Nutrigenomics	4	-	-	4
7	LML.605	Molecular Endocrinology and Signal Transduction	4	-	-	4
			<b>13</b>	<b>3</b>	<b>8</b>	<b>24</b>

**L: Lectures, T: Tutorial, P: Practical, Cr: Credit.**

\* Internal Evaluation

Note: Each of the students need to present their "Project Work" synopsis seminar

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**HGL.601: Biosafety, Bioethics and Intellectual Property Rights**

**Credit Hours: 4**

## **Unit: 1**

**18 Lectures**

**Biosafety:** Good laboratory practices, Biosafety for human Health and Environment. Biosafety issues for using cloned genes in Medicine, Agriculture, Industry, and Ecoprotection. Gene Pollution, Biological Invasion, Risk and Safety Assessment from Genetically Engineered Organisms, Special Procedures for r-DNA based products, Biological Warfare, Biological Containment (BC) and Physical Containment (PC), CDC Biosafety levels, Biosafety in Clinical Laboratories and Biohazard Management.

## **Unit: 2**

**18 Lectures**

**Bioethics:** Ethical Theories, Ethical Considerations during Research, Data Manipulations, Subject Consent, Animal Testing. Animal Rights, Perspectives and Methodology, Ethical Issues of the Human Genome Project, Code of Ethics in Medical/clinical laboratories. Healthcare rationing, Ethical Issues of Xenotransplantation, Ethics involved in Embryonic and Adult Stem Cell Research, Ethics in Assisted Reproductive Technologies: animal and human cloning and *In-vitro* fertilization, the element of Informed Consent, Ethical issues in MTP and Euthanasia.

## **Unit: 3**

**9 Lectures**

**Intellectual Property Rights (IPRs):** Various forms of IP – Patents, Copyright, Industrial Designs, Trade Secrets, Trade Secrets, Geographical Indications and Plant breeder's right; Fair use, plagiarism and open access publishing; Criticism of intellectual property; Indigenous intellectual property.

## **Unit: 4**

**9 Lectures**

**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); Patenting of Natural and Genetic resources: Gene patent, Patenting of Living Organisms, Traditional knowledge digital library (TKDL).

### **Suggested Reading:**

1. Clarke, A (2012). *Genetic Counseling: Practice and Principles*. Taylor & Francis
2. Fleming, D.O. and Hunt, D.L. (2006). *Biological Safety: Principles and Practices*. American Society for Microbiology, USA.
3. Mahop, M.T. (2010). *Intellectual Property, Community Rights and Human Rights: The Biological and Genetic Resources of Developing Countries*. Routledge.
4. Rockman, H.B. (2004). *Intellectual Property Law for Engineers and Scientists*. Wiley-IEEE Press, USA.
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 Biosafety Manual*. World Health Organization.

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## HGL.602: Bioinformatics and Computational Biology

Credit Hour: 4

**Course Objectives:** Bioinformatics course is being offered to the students as fundamental course to brush up the basics of the students in this important emerging area. Students will be composed to the concepts of data mining, computational and algorithmic tools for biological data analysis and are expected to get a good idea on using computational resources to understand and resolve biological problems.

### Unit: 1 9 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: 2 9 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: 3 9 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: 4 9 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.

### Suggested Reading:

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,

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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.
10. Orenge, C., Jones, D., Thornton, J. (2005). *Bioinformatics: Genes, Proteins and Computers (Advanced Texts)*. Taylor and Francis Publishers.

## HGD.600: Research Project

Credit Hours: 8

Project Objective: The objective of this course would be to ensure that the student learns the nuances of the scientific aptitude 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.

The Evaluation criteria shall be multifaceted as detailed below:

Total marks 200

S.No.	Criteria	Marks allotted
1.	Review of literature:	50
2.	Identification of gaps in knowledge:	20
3.	Objective formulation:	25
4.	Methodology	75
5.	References	30

The synopsis shall be evaluated by a three membered committee consisting of -

- CoC of the Centre
- Supervisor or Co-supervisor
- One faculty of allied Centre

## Elective courses

### HGL. 603: Genetic Diseases and Therapies

Credit Hours: 4

**Course 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 method.

Unit: 21

9 Lectures

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**Monogenic Disorders:** Cystic fibrosis, Huntington's disease, Duchenne Muscular dystrophy, X-linked rickets

**Multifactorial Diseases in man:** Diabetes type 2, Celiac disease, Rheumatoid arthritis, inflammatory bowel disease, chronic obstructive pulmonary disease.

**Unit: 2** **18 Lectures**

**Genomic Imprinting and Human Diseases:** Uniparental Disomy & Genomic Imprinting Prader-Willi & Angelman syndromes, 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** **18 Lectures**

**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** **9 Lectures**

**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, Problems in gene therapy, Chemo and Radio therapies; Techniques in tissue engineering: tissue grafting, synthetic blood, skin grafts and metallic implants.

## Suggested reading:

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 Bartlett India Pvt. Ltd.
4. Lodish, H., Berk, A., Chris, A. K., Krieger, M. (2008), *Molecular Cell Biology*. W.H. Freeman, USA.
5. Milunsky A, Milunsky J (2009). *Genetic Disorders and the Fetus: Diagnosis, Prevention and Treatment*, 6th Edition. Wiley-Blackwell publishers.

## LML.603: Evolution and Developmental Genetics

**Credit hours: 4**

**Course Objective:** This course is an introduction to animal evolution and development. The principal objective is to introduce students to the origin of life and developmental processes that lead to the establishment of the body plan of vertebrates and the corresponding cellular and genetic mechanisms. This will allow students, at a later stage, to understand organogenesis and histogenesis, as well as pathology related to mechanisms of development and differentiation.

**Unit: 1** **16 Lectures**

**Emergence of evolutionary thoughts & 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

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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: 2 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: 3 14 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: 4 10 Lectures

**Gametogenesis, fertilization and cell death:** Production of gametes, Cell surface molecules in sperm-egg recognition in animals; Embryo-sac development and double fertilization in plants, Zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals, Embryogenesis and establishment of symmetry in plants, Seed

formation. Hypersensitive response, functions, relevance with diseases, apoptosis, Caspases, Importance of PCD in plant development, role of PCD, model of PCD.

### Suggested Reading:

1. Darwin, C.R. (1911). *On the origin of species by means of natural Selection, or preservation of favoured races in the struggle for life*. Hurst Publishers, UK.
2. Dawkins, R. (1996). *The Blind Watchmaker*, W.W. Norton & Company Jones and Bartlett Publishers.
3. Futuyma, D.J. (2009). *Evolution*. Sinauer Associates Inc. USA.
4. Hake, S. and Wilt, F. (2003). *Principles of Developmental Biology*. W.W. Norton & Company, New York, USA.
5. Hall, B.K. and Hallgrímsson, B. (2007). *Strickberger's Evolution*. Jones and Bartlett Publishers, India.
6. Lewin, R. (2004). *Human Evolution - An Illustrated Introduction*. Wiley-Blackwell, USA.
7. Scott, F. and Gilbert, S.F. (2010). *Developmental Biology*. Sinauer Associates, Inc. USA.
8. Slack, J.M.W. (2005). *Essential Developmental Biology*, Wiley-Blackwell, USA.

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## HGL.604: Pharmacogenomics and Nutrigenomics

Credit Hours: 4

**Course Objectives:** The course is designed for the students of life sciences who are interested to in understanding the prevalent diseases in India. The course will include epidemiological data, potential known disease mechanisms and mechanisms of disease manifestation will also be discussed in detail.

### Unit: 1 9 Lectures

**Pharmacogenomics:** Introduction with example of Warfarin, anti-psychotic, anti-epileptic and anti-cancer drugs like Methotrexate and Tamoxifen, Trends in pharmacogenomics studies, Functional genomics in new drug discovery, Genome-guided identification and validation of drug targets, personalized medicine.

### Unit: 2 18 Lectures

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

### Unit: 3 18 Lectures

**Nutrigenomics vs Nutrigenetics:** Diet and gene expression: nutrients as regulators of activity and transcription factors. Diet in early life and metabolic programming. Diet as a possible risk or preventive factor in illnesses. Gene polymorphisms and responses to diet. Examples related to cardiovascular disease, cancer, osteoporosis.

### Unit: 4 9 Lectures

**Biomarkers and recent advances in Nutrigenomics:** Risk/benefit biomarkers, Genetic and nutritional control of Lipid Metabolism, Metabolomics and personalized nutrition.

### 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

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## LML.605: Molecular Endocrinology and Signal Transduction

Credit Hours: 4

**Course Objectives** The course is designed for the students of life sciences who are interested to learn the basics of signal transduction and its role in various cellular processes. Various pathways deregulated during disease manifestation will also be discussed in detail.

### Unit: 1 15 Lectures

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

### Unit: 2 18 Lectures

**Cell Signaling and Mechanism of Hormone Action:** Receptor study, Binding affinity, specificity, Scatchard plot and purification. 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- EGFR 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: 3 18 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: 4 16 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.

### Suggested Reading:

1. Norris, D.O., and Carr, J.A. *Vertebrate Endocrinology*, 5th Edition. Academic Press, 2012.
2. Nelson, David L., and Cox, Michael M., *Lehninger Principles of Biochemistry*, 5<sup>th</sup> Edition. WH Freeman & Company, New York, 2008.
3. Widmaier, E.P., Raff, H., and Strang, K.T. *Vander's Human Physiology*, 13th Edition. McGraw-Hill Higher Education, 2013.
4. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., and Scott, M.P. *Molecular Cell Biology*, 7th Edition. W.H. Freeman, 2012



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**M.Sc. (Life Sciences with Specialization in Human Genetics)**

## SEMESTER – IV

S.No	Paper Code	Course Title	L	T	P	Cr
1	HGL.621	Recombinant DNA technology and therapies	3	1	-	4
3	HGD.600	Research Project *	-	-	16	16
			3	1	16	20

**L: Lectures, T: Tutorial, P: Practical Cr: Credit.**

**\* Internal Evaluation**

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## HGL.621: Recombinant DNA technology and therapies

Credit Hours: 4

**Learning Objective:** This course will introduce modern techniques for genetic engineering and students will learn cutting edge molecular engineering. Course will start with the basics of genetic engineering, the methodology of gene manipulation, and the implications of genetic engineering.

### Unit: 1

16 Lectures

**Basics of Genetic Engineering:** Gene Manipulation, Tools for molecular cloning. Restriction enzymes their types, Type I, II and III, restriction modification systems, Cohesive and blunt and ligation, linkers, adaptors, homopolymeric tailing, transformation, transfection: chemical and physical methods, sequencing and clone confirmation, expression optimization, *in-silico* methods of design.

### Unit: 2

16 Lectures

**Gene Cloning Vectors:** Plasmids, bacteriophages, cloning in M13 mp Vectors, phagemids, Lamda vectors; insertion and replacement vectors, EMBL,  $\lambda$  DASH,  $\lambda$  gt10/11,  $\lambda$ ZAP etc. Cosmid vectors.

### Unit: 3

20 Lectures

**Expression Vectors:** Artificial chromosome vectors (YACs, BACs), Animal virus derived vectors-Sv-40, vaccinal/baculo& 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: 1

20 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 techniques. Sites specific mutagenesis: Yeast two hybrid system, phage display, characterization of expressed proteins through various biophysical, biochemical methods. Gene mapping and Microarrays. Genetically modified microbes (Recombinant bacteria) for the production of commercial scale production of proteins and pharmaceuticals, antibiotics, enzymes, insulin, growth hormones, monoclonal antibodies. Applications rDNA in diagnosis of pathogens and abnormal genes. Transgenic animals. Transgenic animals for production of proteins and pharmaceuticals. Genetically modified insect cells for the production of commercially important bioproducts. Biosafety and Ethical considerations in rDNA and genetic engineering.

### Suggested Reading:

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* 4<sup>th</sup> Edition ASM Press Washington.

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3. James, Watson Micheal Gilman Jan Witkowsk (2007) *Recombinant DNA* 3<sup>rd</sup>-edition . CSHL, New York.
4. CokinRateldge and Bjorn Christiansen, (2006) *Basic Biotechnology* 3<sup>rd</sup>-Edition Cambridge University press.
5. John E. Smith. (2009) *Biotechnology* 5<sup>th</sup> Edition by Cambridge University press.
6. *Molecular Biology of Gene* 6<sup>th</sup> Edition by Watson CSHL Press New York.
7. Sambrook& Russell *Molecular cloning* , CSHL Press, New York.
8. David &Freifelder John &Barlett (2008) *Molecular biology* 2<sup>nd</sup>Edition ,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>

## HGD 600: Research Project

**Credit Hours: 16**

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

The synopsis shall be evaluated by a three membered committee consisting of -

- CoC of the Centre
- Supervisor or Co-supervisor
- One faculty of the Centre