Outline of NEP 4 year undergraduate syllabus: Department of Zoology, University of Lucknow
Genetics and Genomics

Year	Semester	Paper	Paper type	Major Subject 1 (Zoology) @4 credits	Major Subject 2 (Another subject from same faculty) @4 credits	Minor 1 @4 credits (from another department	@4 credits
CERTIFICATE COURSE IN BIOTECHNIQUES							
Year 1	Sem 1	P1	Compulsory (Theory)	Biochemistry and Physiology		Biochemistry and Physiology	Curricular course 1
		P2	Compulsory (Practical)	Theory based practical			
	Sem 2	P3	Compulsory (Theory)	Cell Biology, Bioinstrumentation and Biotechniques		Cell Biology Bioinstrumentation and Biotechniques	Vocational course 1
		P4	Compulsory (Practical)	Theory based practical			
DIPLOMA IN MEDICAL GENETICS							
Year 2	Sem 3	P5	Compulsory (Theory)	Basic and Advanced Genetics		Basic and Advanced Genetics	Curricular course 2
		P6	Compulsory (Practical)	Theory based practical			
	Sem 4	P7	Compulsory (Theory)	Clinical Genetics		Clinical Genetics	Vocational course 2
		P8	Compulsory (Practical)	Theory based practical			
BACHELOR OF SCIENCE IN GENETICS AND GENOMICS							
Year 3	Sem 5	P9	Compulsory (Theory)	Diversity of Life			Internship
		P10	Compulsory (Practical)	Theory based practical			
		P11X	Optional (Theory)	Developmental Genetics			
		P11Y	Optional (Theory)	Behavioural Genetics			
	Sem 6	P12	Compulsory (Theory)	Genomics and Computational Biology			Minor project
		P13	Compulsory (Practical)	Theory based practical			
		P14X	Optional (Theory)	Immunology and Immunogenetics			
		P14Y	Optional (Theory)	Microbial Genetics			
HONOURS IN GENETICS AND GENOMICS							
Year 4	Sem 7	P15	Compulsory (Theory)	Population and Evolutionary Genetics			Research

		P16	Compulsory (Theory)	Genetic Engineering			Methodology
		P17	Compulsory (Practical)	Theory based practical			
		P18X	Optional (Theory)	Cancer Genetics			
		P18Y	Optional (Theory)	Human Genetics			
		P19X	Optional (Theory)	Toxicogenomics			
		P19Y	Optional (Theory)	Biophysics			
	Sem 8			**Major Project (24 credits)**			

B. Sc. in Genetics and Genomics

Program Objectives (POs):

Genetics and Genomics, a four-year undergraduate program divided into eight equal semesters, should be studied in an integrated and cross-disciplinary manner. B.Sc in Genetics and Genomics covers various subjects related to heredity, evolution, and variation in living beings. The students are offered in-depth knowledge about how genetic traits are passed down from one generation to another. The course includes topics from and subjects like Biochemistry, Genetic Engineering, Model Organisms, Microbiology, Cloning, Microscopy etc. The candidates willing to pursue a career in genetics must have a keen interest and in-depth knowledge of medical genetics and cloning. They should also have an understanding and interest towards genetic disorders, variability, heterogeneity, and history of genetics. B.Sc in Genetics and Genomics is becoming a widely popular course among students these days because of the new techniques and technological advancements in the field of genetics and life sciences has led to various new discoveries in the respective field. Within the broad-range skill sets related to the discipline, it is required to impart and assess the quality of critical thinking, analytical and scientific reasoning, and problem-solving capacity.

Our undergraduate program in Genetics and Genomics is designed to prepare students to have:

Degree in Bachelor of Science		
Programme Outcomes (POs)		
PO 1	**Academic competence:**	Develop deeper understanding of key concepts of genetics related to heredity, evolution, and variation in living beings at biochemical, molecular, cellular, physiological and systematic level.
PO 2	**Inspire Knowledge:**	From classical Mendelian inheritance to modern analytical disciplines of Genetics and Genomics.
PO 3	**Impart Science-based Entrepreneurship:**	Impart knowledge and skills through applied disciplines like genetic engineering, cloning, medical genetics, molecular diagnostics etc.
PO 4	**Develop Competency:**	To make our students competent to excel in competitive examinations.
PO 5	**Research Competence:**	Integrate and explore biological data. Use current laboratory setup, instrumentation, statistical and biological techniques in the collection, organization, analysis, interpretation and manipulating the data related to Genetics and Genomics discipline and allied branches.
PO 6	**Entrepreneurial and Social competence:**	Empower the students by enhancing their self-sustainability capabilities through a thorough understanding of skill-based subjects and techniques by learning. Develop social competence including listening, speaking and observational, effective interactive skills and presenting skills to meet global competencies.
PO 7	**Environment and Sustainability**:	Understand the issues of environmental contexts and sustainable development.
PO 8	**Ethics**:	Aware students about ethical principles and commit to professional ethics and responsibilities.

B. Sc. I (Semesters I and II)

CERTIFICATE COURSE IN BIOTECHNIQUES	
B.Sc. I (Semesters I and II) Programme Specific Outcomes (PSOs)	
PSO 1	Students will have a comprehensive knowledge of the Basic Genetics and cell biology.
PSO 2	The course will provide an insight into the life processes at the subcellular and molecular levels
PSO 3	Students will be able to understand the structure of gene, Mendelian principles and learn how the information contained within them gets transferred from one generation to another.
PSO 4	Students will be able to apply fundamental principles of genetics to make informed decisions on socio-scientific issues.
PSO 5	Students will be able to apply their knowledge in problem solving and future course of their career development in higher education and research. The student will be offered 'CERTIFICATE IN BIOTECHNIQUES after completion of one year of the programme or two semesters.

B. Sc. II (Semesters III and IV)

DIPLOMA IN MEDICAL GENETICS	
B.Sc. II (Semesters III and IV) Programme Specific Outcomes (PSOs)	
PSO 1	Students will be able to understand concept of Genomics and Applied Molecular genetics and the use of corresponding instruments.
PSO 2	Students will be able to find better carrier prospective in private companies, labs as assistants and they can pursue various research related programs.
PSO 3	Students will be able to comprehend the genetic studies to elucidate genome organization and gene mapping, apply the knowledge gained from comparative and functional genomics to prediction of protein complex structure, and understand genetic basis of a disease and designing of drugs and gene chips. Students will be able to develop critical thinking, analysis and evaluation skills in applying knowledge in the class to solve research questions.
PSO 4	Students can get subsidy and loan from state government to start their own laboratories under various schemes run by state govt. and become "ATMNIRBHAR" and generate jobs for others.
PSO 5	These Diploma courses will enable students to apply for various positions in health care, medicine etc. in both government and private labs/institutes including NGOs as genetic counselor, manager, educator, outreach specialist, as Research Officer. Besides this, the students can also take up higher studies and research as their career. The student will be offered 'DIPLOMA IN MEDICAL GENETICS' after completion of 2 years of the programme or 4 semesters.

B. Sc. III (Semesters V and VI)

Degree in Bachelor of Science in Genetics and Genomics	
B.Sc. III (Semesters V and VI) Programme Specific Outcomes (PSOs)	
PSO 1	This programme aims to develop an understanding diversity and biology of Non-Chordates and Chordates and elective topics Developmental Genetics, Quantitative Genetics, Evolutionary Genetics, and Behavioural Genetics.
PSO 2	Students will learn the distribution, diversity, classification, physiology, and form and function of each major animal lineage within Non-chordates.
PSO 3	Students will be able to apply for various positions in museums, wildlife/ biodiversity data collection, conservation programs, health care, and zoos etc. in both government and private labs/institutes including NGOs.
PSO 4	This course will provide students mechanistic view in complete developmental processes and understanding of quantitative genetic traits develop critical thinking, analysis and evaluation skills in applying knowledge in the class to solve research questions. They will also be able to understand concept and applications of evolutionary biology and Behavioural Genetics.
PSO 5	Students will be able to apply the concepts of quantitative genetics in genetic improvements of livestock.
PSO 6	After completion of 3 years of the programme or 6 semesters, the student will be offered the 'BACHELOR DEGREE IN GENETICS AND GENOMICS'.. This programme will enable students to go for higher studies like Masters and then pursue Ph.D. in Zoology, Genetics and Genomics and allied subjects.

B. Sc. IV (Semesters VII and VIII)

B.Sc. (Hons.) in Genetics and Genomics	
B.Sc. IV (Semesters VII and VIII) Programme Specific Outcomes (PSOs)	
PSO 1	Students will be able to develop an understanding of functioning of an organisms body and learn how animals react to internal and external elements in their environment. Individuals in this profession may work as instructors, scientists, or consultants.
PSO 2	This programme aims to develop an understanding of structural, functional, biochemical and behavioral aspects of life.
PSO 3	This course will provide theoretical and applied knowledge on the effects of chemical substances on human health.
PSO 4	Students will gain skills in basics of computers, information technology in biological sciences, application of internet and statistical bioinformatics in research and various biostatistical tools and their application in analysis of data.
PSO 5	The course will provide knowledge about immune system and allows the student to create insight as how to improve the immune system and good health. It will also develop understanding of the immune mechanism related to different Immunological diseases & disorders.
PSO 6	This course will provide insight on the molecular basis of cancer, the stem cell theory of cancer and concepts of tumor immunology and transplantation immunology. The student will be able to relate the signaling pathways with the diagnostic methods and treatment approaches for cancer.
PSO 7	The students will learn the Genetic constituents of bacteria with special emphasis on inheritance and mutations. They also study different techniques used to study the microbial genetics and utilizing the microbial phenomenon in different biotechnological applications

	The course provides suitable platform to use different genetic tools for the proper detection and diagnosis of both common and complex genetic disorders. The course also stresses upon the use of genetic concepts for generating awareness among general public. The students can conduct surveys regarding the identification of various genetic disorders. The student will be able to construct and interpret pedigree charts, learn the importance and role of genetic counseling and personalized or precision medicine.
PSO 7	Hands on training in the prospective field of interest/ employment.
PSO 8	The Honours course will enable students to go for higher studies and research (Ph.D) in specialized fields of Genetics and Genomics and allied subjects viz M.Sc. in Genetic Counseling & Biomedical Genetics. Students will be eligible for integrated M.Sc.-Ph.D. programmes and for appearing in national level competitive exams like CSIR-JRF, DBT-JRF etc.

Semester I

P1: Biochemistry and Physiology

Total Credits: 04 **Teaching Hours: 60**

Course objectives

- To appreciate the structure and function of biomolecules– proteins, lipids and carbohydrates
- To understand the structure and function of enzyme and enzyme thermodynamics
- To develop an understanding of functioning of an organisms' body

Unit I

15

Structure and Function of Biomolecules

- Structure and classification of carbohydrates
- Structure and classification of lipids
- Structure and classification and proteins; Levels of organization in proteins; Simple and conjugate proteins.

Enzyme structure, function and regulation

- Nomenclature and classification of enzymes; Cofactors; Specificity of enzyme action
- Isozymes; Mechanism of enzyme action
- Enzyme kinetics; Factors affecting rate of enzyme-catalysed reactions; Derivation of Michaelis-Menten equation, Concept of Km and Vmax, Lineweaver-Burk plot; Enzyme inhibition;
- Allosteric enzymes and their kinetics; Regulation of enzyme action
- Vitamins

Unit II

15

Metabolism of Macromolecules (Carbohydrates, Lipids, Proteins)

- Metabolism of Carbohydrates: glycolysis, citric acid cycle, gluconeogenesis, phosphate pentose pathway
- Glycogenolysis and Glycogenesis
- Lipids --- Biosynthesis of palmitic acid; Ketogenesis,
- β-oxidation and omega -oxidation of saturated fatty acids with even and odd number of carbon atoms
- Catabolism of amino acids: Transamination, Deamination, Urea cycle
- Review of mitochondrial respiratory chain, Oxidative phosphorylation, and its regulation

Unit III

15

Digestion and Respiration

- Structural organization and functions of gastrointestinal tract and associated glands
- Mechanical and chemical digestion of food; Absorption of carbohydrates, lipids, proteins, water, minerals and vitamins
- Mechanism of respiration, Pulmonary ventilation; Respiratory volumes and capacities; Transport of oxygen and carbon dioxide in blood Respiratory pigments, Dissociation curves and the factors influencing it; Control of respiration

Circulation and Excretion

- Components of blood and their functions
- Haemostasis: Blood clotting system, Blood groups: Rh factor, ABO and MN
- Structure of mammalian heart
- Cardiac cycle; Cardiac output and its regulation, Electrocardiogram, Blood pressure and its regulation

Structure of kidney and its functional unit; Mechanism of urine formation

Unit IV

15

Nervous System and Endocrinology

- Structure of neuron, resting membrane potential
- Origin of action potential and its propagation across the myelinated and unmyelinated nerve fibers
- Types of synapses and neurotransmitters
- Endocrine glands - pineal, pituitary, thyroid, parathyroid, pancreas, adrenal; hormones secreted by them

Muscular System

- Types and structure of muscle;
- Muscle contraction: Theories, Molecular and chemical basis.
- Characteristics of muscle twitch; Motor unit, summation and tetanus

Course outcomes:

At the completion of the course, the student will be able to:

- demonstrate and demarcate the normal and abnormal physiology of various functional components of the body,
- evaluate and estimate biomolecules.

Suggested Reading

1. Nelson & Cox: Lehninger's Principles of Biochemistry: McMillan (2000)
2. Zubay*et al:* Principles of Biochemistry: WCB (1995)
3. Voet&Voet: Biochemistry Vols 1 & 2: Wiley (2004)
4. Murray *et al:* Harper's Illustrated Biochemistry: McGraw Hill (2003) Elliott and Elliott: Biochemistry and Molecular Biology: Oxford University Press
5. Guyton, A.C. & Hall, J.E. Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. /W.B. Saunders Company. (2006).
6. Tortora, G.J. & Grabowski, S. Principles of Anatomy & Physiology. XI Edition John Wiley & sons (2006).
7. Christopher D. Moyes, Patricia M. Schulte. Principles of Animal Physiology. 3rd Edition, Pearson Education (2016).
8. Hill, Richard W., et al. Animal physiology. Vol. 2. Sunderland, MA: Sinauer Associates, (2004).
9. Chatterjee C C Human Physiology Volume 1 & 2. 11th edition. CBS Publishers(2016).

Assignments (any one)

1. Project (500 words)/ presentation based on the above course content
2. Analytical MCQ based questions
3. Biological Crosswords
4. Charts
5. 500 words answer to analytical questions
6. Study based report of animals in nature

P2: Biochemical and Physiology Lab

Total Credits: 04

1. Ninhydrin test for α-amino acids.
2. Benedict's test for reducing sugar and iodine test for starch.
3. Test for sugar and acetone in urine.
4. Qualitative tests of functional groups in carbohydrates, proteins and lipids.
5. Action of salivary amylase under optimum conditions.
6. To study different mammalian blood cell types using Leishman stain.
7. Recording of blood pressure using a sphygmomanometer
8. Recording of blood glucose level by using glucometer
9. Estimation of haemoglobin using Sahli'shaemoglobinometer
10. Preparation of haemin and haemochromogen crystals
11. Counting of RBCs and WBCs using Haemocytometer
12. Study of permanent slides of Mammalian skin, Cartilage, Bone, Spinal cord, Nerve cell, Pituitary, Pancreas,
13. Testis, Ovary, Adrenal, Thyroid and Parathyroid
14. Recording of simple muscle twitch with electrical stimulation (or Virtual)

Semester II

P3: Cell Biology, Bioinstrumentation and Biotechniques

Total Credits: 04 **Teaching Hours: 60**

Course objectives

- To understand the structure and function of organelles in a cell
- To learn about cellular transport and protein trafficking
- To understand the DNA structure & types, chromatin structure and organization

Unit I

16

Structure and Function of Cell Organelles
Plasma membrane: chemical structure—lipids and proteins
Cell-cell interaction: cell adhesion molecules, cellular junctions
Endomembrane system: protein targeting and sorting, endocytosis, exocytosis
Cytoskeleton: microtubules, microfilaments, intermediate filaments
Mitochondria: Structure, oxidative phosphorylation
Peroxisome and ribosome: structure and function

Unit II

16

Nucleus and Chromatin Structure
Structure and function of nucleus in eukaryotes
Chemical structure and base composition of DNA and RNA
DNA supercoiling, chromatin organization, structure of
Chromosomes, Types of DNA and RNA
Cell cycle, Cell Division and
Cell division: mitosis and meiosis, Cell cycle, Cell cycle regulation, Apoptosis

Cell Signalling
Signal transduction
Intracellular signaling
Cell surface receptors, via G-protein linked receptors, JAK-STAT pathway

Unit III

15

Principle of Microscopy and Applications
Types of Microscopes: light microscopy, dark field microscopy, phase-contrast microscopy,
Fluorescence microscopy, confocal microscopy, electron microscopy
Principle of Centrifugation
Types of Centrifuges: high speed and ultracentrifuge
Types of rotors: Vertical, Swing-out, Fixed-angle etc.
Principle and Types of Chromatography: paper, ion-exchange, gel filtration, HPLC, affinity

Unit IV

15

Biochemical techniques: Preparation of buffers and solutions
Measurement of pH
Principle of Colorimetry/Spectrophotometry: Beer-Lambert law
Measurement, applications and safety measures of radio-tracer techniques

Course outcomes:

The student at the completion of the course will be able to:

- Understand the structure and function of all the cell organelles.
- Know about the chromatin structure and its location.
- To be familiar with the basic principle of life, how a cell divides leading to the growth of an organism and also reproduces to form new organisms.
- How one cell communicates with its neighbouring cells?
- Understand the utility of bio-instruments and how they can be used for different biotechniques in life sciences.

Suggested Reading

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). Principles of Genetics. VIII Edition. Wiley India
2. Brown, T.A. Genomes 4. 4th Edition. Garland Science
3. Krebs et al. Lewin's GENES XII, Twelfth Edition. Jones and Bartlett Learning.
4. Lodish et al: Molecular Cell Biology: Freeman & Co, USA (2004).
5. Alberts et al: Molecular Biology of the Cell: Garland (2002).
6. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley and Sons. Inc.
7. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
8. Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. V Edition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA.

Assignments (any one)

1. Project (500 words)/ presentation based on the above course content
2. Analytical MCQ based questions
3. Biological Crosswords
4. Charts
5. 500 words answer to analytical questions

P4: Cytology and Bioinstrumentation Lab

Total Credits: 04

1. To study the working principle and Simple, Compound and Binocular microscopes.
2. Phase-contrast microscopy, Fluorescence microscopy.
3. To study the working principle of various lab equipments such as pH Meter, Electronic balance.
4. Use of glass and micropipettes, Laminar flow, Incubator, Waterbath, Centrifuge, Chromatography apparatus, etc.
5. To study different cell types such as buccal epithelial cells, neurons, striated muscle cells.
6. To study the different stages of Mitosis in root tip of onion.
7. To study the different stages of Meiosis in grasshopper testis.
8. To prepare molecular models of nucleotides, amino acids, dipeptides using bead and stick method.
9. To check the permeability of cells using salt solution of different concentrations.
10. To prepare solutions and buffers.
11. Differential centrifugation to fractionate different components in a mixture.
12. To identify different amino acids in a mixture using paper chromatography.

Semester III

P5: Basic and Advanced Genetics

Total Credits: 04 **Teaching Hours: 60**

Course objectives

- To equip the students to understand the basic mechanism and molecular basis of heredity
- To understand extra nuclear inheritance, linkage & crossing over
- The course will provide an insight into the life processes at the subcellular and molecular levels

Unit I

15

Mendelian Genetics

Basic principles of heredity: Mendel's laws, monohybrid and dihybrid crosses
Complete and Incomplete Dominance
Penetrance and expressivity
Sex Determination
Sex-linked inheritance and Dosage compensation

Unit II

15

Mendelian extensions

Multiple Alleles, Gene Interaction
The Interaction Between Sex and Heredity: Sex-Influenced and Sex-Limited traits
Cytoplasmic Inheritance, Genetic Maternal Effects
Genomic Imprinting, Genetic anticipation
Interaction Between Genes and Environment: Environmental Effects on Gene Expression, Inheritance of continuous, meristic and threshold characters; modifiers

Unit III

15

Molecular Biology

Fine structure of gene
RNA polymerases, Transcription factors and machinery, Formation of initiation complex
Initiation, elongation and termination of transcription in prokaryotes and eukaryotes
Genetic code, Ribosome, Factors involved in translation
Aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase
Initiation, elongation and termination of translation in prokaryotes and eukaryotes

Unit IV

15

Gene regulation

Regulation of gene expression in prokaryotes: *lac* and *trp* operons in *E. coli*
Regulation at transcriptional level, Post-transcriptional modifications: Capping, Splicing, Polyadenylation, RNA editing.
Regulation of gene expression in eukaryotes, Role of chromatin in gene expression
Regulation at translational level, Post- translational modifications: protein folding etc.
Intracellular protein degradation
Gene silencing, RNA interference (RNAi)

Course outcomes:

The student at the completion of the course will be able to have:

- Understand of basic laws of inheritance and its molecular basis along with the practical knowledge.
- Understand the Mendel's laws and the deviations from conventional patterns of inheritance.
- Comprehend how environment plays an important role by interacting with genetic factors.
- A detailed and conceptual understanding of molecular processes *viz.* DNA to trait.
- A clear understanding of the processes of central dogma *viz.* transcription, translation *etc.* underlying survival and propagation of life at molecular level.
- Understanding of how genes are ultimately expressed as proteins which are responsible for the structure and function of all organisms.
- Learn how four sequences (3 letter codons) generate the transcripts of life and determine the phenotypes of organisms.
- How genes are regulated differently at different time and place in prokaryotes and eukaryotes.

Suggested Reading

1. Cooper: Cell: A Molecular Approach: ASM Press (2000).
2. Karp: Cell and Molecular Biology: Wiley (2002).
3. Watson et al. Molecular Biology of the Gene. Pearson (2004).
4. Lewin. Genes VIII. Pearson (2004).
5. Pierce B. Genetics. Freeman (2004).
6. De Robertis. Cell and Molecular Biology CCH, a Wolters Kluwer Business 8th Edition

Assignments (any one)

1. Project (500 words) highlighting recent advancements.
2. Presentation highlighting recent advancements.
3. Analytical MCQ based questions
4. Biological Crosswords
5. Charts
6. 500 words answer to analytical questions

P6: Genetics Lab

Total Credits: 04

1. Maintenance of Drosophila culture as a genetic model.
2. Study of mutant phenotypes of *Drosophila.*
3. Preparation of polytene chromosomes.
4. Study of sex chromatin (Barr bodies) in buccal smear and hair bud cells (Human).
5. To measure absorbance in Colorimeter or Spectrophotometer.
6. To prepare dilutions of Riboflavin and verify the principle of spectrophotometry.
7. Estimation of proteins in different samples
8. Demonstration of DNA extraction from blood or tissue samples.
9. To estimate amount of DNA using spectrophotometer.
10. Agarose gel electrophoresis for detection of DNA.
11. Restriction digestion of Lamda DNA using teaching kit.
12. Virtual Labs.

Semester IV

P7: Clinical Genetics

Total Credits: 04 **Teaching Hours: 60**

Course objectives:

- To apply the Mendel's law in human population and analysis of normal and abnormal genotypes and phenotypes
- To understand the abnormality due to defective genetic components

Unit I

15

Genetic disorders in humans

Human karyotype
Chromosomal anomalies and diseases
Pedigree analysis
Modes of inheritance, Autosomal dominant, Autosomal recessive, X-linked, Y-linked
Inborn errors of metabolism
Triplet repeat disorders, Monogenic disorders, Multifactorial diseases
Genome imprinting syndromes, Mitochondrial syndromes

Unit II

15

Clinical genetics 1

Types of cancer and their symptoms
Cell transformation and tumorigenesis
Characteristics of cancer cells, Apoptosis
Proto-oncogenes, Oncogenes, Tumour suppressor genes,
DNA repair mechanisms and DNA repair genes

Unit III

15

Clinical genetics 2

Physical, Chemical, Biological carcinogens
Causes and effects of epigenetic modifications
Mutations and Genomic instability
Cancer and environment

Unit IV

15

Management of genetic disorders

Population screening
Pre-natal diagnosis
Calculation of genetic risk
Association studies
Predictive medicine
Genetic counselling

Course outcomes:

The student at the completion of the course will be able to:

- Inborn errors of metabolism, propensity to genetic disease and preventive measures through specially acquired skills
- Screen molecular markers

Suggested Readings:

1. Sambrook *et al* .Molecular Cloning Vols I, II, III. CSHL (2001).
2. Primrose. Molecular Biotechnology. Panima (2001).
3. Sudbery. Human Molecular Genetics. Prentice-Hall (2002).
4. Wilson. Clinical Genetics-A Short Course, Wiley (2000).
5. Pasternak. An Introduction to Molecular Human Genetics. Fritzgerald (2000).

Assignments (any one)

1. Project (500 words) highlighting recent advancements.
2. Presentation highlighting recent advancements.
3. Analytical MCQ based questions
4. Biological Crosswords
5. Charts
6. 500 words answer to analytical questions

P8: Clinical Genetics Lab

Total Credits: 04

1. Recombinant DNA Technology, Molecular cloning, Restriction Enzymes, DNA modifying enzymes, Cloning Vectors, Ligation, genomic libraries, Selection and identification of recombinant cells
2. Gene transfer techniques, Development of transgenics
3. Gene therapy, Crop and livestock improvement,
4. Development of DNA drugs and vaccines
5. Nucleic acid fractionation, detection by electrophoresis, DNA sequencing, polymerase Chain Reaction (PCR), primer designing, site directed mutagenesis, RFLP
6. Oligonucleotide synthesis, preparation of probes, hybridization, Southern, Northern and south-western blotting
7. Detection of proteins, PAGE, ELISA, western blotting, hybridoma technology
8. DNA diagnostics--genetic analysis of human diseases, detection of known and unknown mutations
9. Preparation of human karyotype and study the chromosomal aberrations with respect to number, translocation, deletion etc. from the pictures provided.
10. To prepare family pedigrees.
11. DNA fingerprinting using teaching kit.
12. Multiplex Polymerase Chain Reaction (mPCR) using teaching kit
13. Demonstration of RT-PCR
14. Visit to Clinic

Semester V

P9: Diversity of Life

Total Credits: 04 **Teaching Hours: 60**

Course objectives

- To familiarise the students with myriad forms of life.
- To develop in the students the understanding of function diversity and evolutionary relationship

UNIT I

15

Biological diversity and its evolutionary history
Introduction to the biological diversity.
Kingdoms of Life– the Monera, the Protista (Protoctista), the Fungi, the Plantae and the Animalia.
Early earth and the origin of life; Tree of life.
Theories of evolution.
Speciation and its mechanism.

UNIT II

15

Biodiversity I: Microbes
Viruses: General characteristics; Classification; General structure (bacteriophage T4, TMV, HIV); Replication (Lytic and Lysogenic cycle); Major viral diseases

Bacteria: Discovery; General structure; Nutrition; Reproduction; Economic importance; Major bacterial diseases with emphasis on Tuberculosis and Cholera.

Algae: General characteristics; Ecology and distribution; Classification; Important examples in relation to applied Phycology (Nostoc, Volvox, Diatoms).

Fungi: General characteristics; Ecology and distribution; Classification; Cell structure; Wall composition; Nutrition; Lifecycle

UNIT III

15

Biodiversity 2: Non-chordata
General characters: Protozoa, Porifera, Coelentrata, Platyhelminthes, Nemethehelminthes, Anelida, Arthropoda, Mollusca, Echinodermata.
General account: Life cycle of *Plasmodium*, Canal system in Porifera, Polymorphism in cnidarians, Life cycle of *Taenia solium*, Social life in insects, Pearl Formation, Water vascular system in starfish.

UNIT IV

15

Biodiversity 3: Chordata
General characters: Protochordata, Pisces, Amphibia, Reptilia, Aves, Mammals.
General account: Origin of tetrapods; Evolutionary radiation of reptiles including dinosaurs; Flight adaptations in birds; Evolution of Man.

Course objectives

At the completion of the course, the student will be able to:

- understand and appreciate the diversity of life
- describe the general plan of life firms
- arrange animal as taxonomic category
- understand adaptation in living systems

Suggested books

1. Barnes, R.D. (1992). Invertebrate Zoology. Saunders College Pub. USA.
2. Ruppert, Fox and Barnes (2006) Invertebrate Zoology. A functional Evolutionary Approach 7th Edition, Thomson Books/Cole
3. Campbell & Reece (2005). Biology, Pearson Education, (Singapore) Pvt. Ltd.
4. Kardong, K. V. (2002). Vertebrates Comparative Anatomy. Function and Evolution. Tata McGraw Hill Publishing Company. New Delhi.
5. Raven, P. H. and Johnson, G. B. (2004). Biology, 6th edition, Tata McGraw Hill Publications. New Delhi.

Assignments (any one)

1. Project (500 words)/ presentation based on the above course content
2. Analytical MCQ based questions
3. Biological Crosswords
4. Charts
5. 500 words answer to analytical questions
6. Study based report of animals in nature

P10: Biodiversity Lab

Total Credits: 04

1. Viruses: EM/ Model of TMV, bacteriophage and HIV.
2. Infected specimens of any plants infected with mosaic virus and vein clearing virus.
3. Bacteria: Study through permanent slides
4. Surface details and sectional view of bacterial cell
5. Endospore, binary fission, conjugation.
6. Specimens/ photographs and permanent slides of root nodules.
7. Algae: Study through permanent slides.
8. Fungi: Study through temporary preparations and permanent slides
9. Study of symptoms of plants infected with rust and early blight
10. Demonstration of culture of fungi

P11X: Developmental Genetics

Total Credits: 04 **Teaching Hours: 60**

Course objectives

- To develop in the student an understanding of basic concepts of developmental biology.
- To develop in the student an understanding of role of genes in cellular and developmental events.
- To describe the genetics and molecular basis underlying growth, reproduction, development, cell signaling.
- Students will be able to develop critical thinking, analysis and evaluation skills inapplying knowledge in the class to solve research questions.

Unit I

15

Gametogenesis
Fertilization
Cleavage and its pattern
Gastrulation, fate maps
Developmental mechanics of cell specification
Morphogenesis and cell adhesion

Unit II

15

The dynamics of organ development
Development of eye, kidney, limb
Metamorphosis: the hormonal reactivation of development in amphibians, insects
Regeneration: salamander limbs, mammalian liver, *Hydra*

Unit III

15

The Embryological origins of Gene Theory
Early attempts at Developmental Genetics
Genomic equivalence
Determining the function of genes during development,
Gene targeting (Knockout) experiments
Differential gene expression

Unit IV

15

Cell Signaling Events That Instruct Development: The RTK pathway, The JAK-STAT pathway, The hedgehog pathway, The canonical wnt pathway, The noncanonical wnt pathways, Notch Signaling.

Identification of novel signaling pathway components: Phenotype-Driven Screens
Systems Biology Approaches, RNAi Screens, Interactome Mapping, Identification of Synexpression Groups, Crosstalk Between Signaling Pathwaysi, Mutants and transgenics in analysis of development

Course Outcomes:

At the completion of the course, the student will be able to:

1. understand basic processes of developmental biology
2. underline genetic mechanism and control of the development.
3. the manipulation of genetic system to understand the role of genes at different stage.

Suggested Reading

1. Gilbert, Scott F. and Barresi, Michael J. F. Developmental Biology. Eleventh Edition.
2. Sunderland (Massachusetts): Sinauer Associates
3. Carlson BM. (1988). Patten's Foundations of Embryology. 5th Ed. New York: McGraw-Hill.
4. Moody, Sally A. Principles of Developmental Genetics. 2007. Elsevier Academic Press publications.

Assignments (any one)

1. Project (500 words) highlighting recent advancements.
2. Presentation highlighting recent advancements.
3. Analytical MCQ based questions
4. Biological Crosswords
5. Charts
6. 500 words answer to analytical questions
7. Outreach activities promoting awareness of developmental disorders
8. Projects observing axis formation in *Drosophila*.

P11Y: Behavioural Genetics

Total Credits: 04 **Teaching Hours: 60**

Course objectives

Behavioral Genetics is considered to lie at the intersection of Psychology and Genetics. The overall aim of this course is

1. To strengthen working knowledge of the mechanisms and principles underlying Mendelian, population and quantitative genetics.
2. To gain an appreciation for the diversity and the complexity of the genetic interactions that shape behavioral outputs.
3. To understand the genetic basis of behavior like social behavior, responses to environmental stimuli, learning, memory, and the etiology of neuropsychiatric disorders.
4. To understand approaches in Behavioral Genetics through discussion of current techniques and critical thinking about how genes that control behavior are discovered.

Unit I

15

Types of behaviour

Learning and Memory

Territoriality and conflict behaviour

Fixed Action Patterns and the CNS

Social and reproductive behaviour

Behavioral aberration: Cognitive Disabilities (Mental Retardation and Learning Disorders); Psychological Disorders (Mood Disorders, Anxiety Disorder, Schizophrenia); Dischronometria, Sleep disorders

Unit II

15

Methods of behavioural studies

Methods of studying animal behaviour: introspection method, observation method, experimental method, clinical method/case history, field study, genetic method and testing method

Investigating the Genetics of Human Behavior- Adoption Designs and Twin Design

Unit III

15

Genetic basis of behaviour

Historical perspectives of behavior genetics studies

DNA markers, Complex traits and Quantitative Trait Loci (QTL)

QTL mapping–Linkage studies and Association Studies

Application in genetics study of human behavior (Drosophila & Mouse model)

Genetic basis of hygienic behaviour in honeybee

Selection studies; Inbred strains

Unit IV

15

Behavior: nature and nurture

Heritability of behaviour

Epigenetics

Gene–environment correlation and interaction

Endophenotypes

Ethical implications of behavioral genetics

Course Outcomes:
By the end of the course students will be able to:

- Explain the core principles of Mendelian, population and quantitative genetics, in relation to the study of neuro-behavioral phenotypes, characteristics and traits.
- Describe hereditary mechanisms and processes relevant for the nervous system and behavior.
- Outline and describe a set of experiments necessary to identify genes that control behavior

Suggested Reading

1. Human Genetics for the Social Sciences by Carey, G. Thousand Oaks, CA: Sage Publications, 2003
2. Behavioral Genetics by Knopik, V. S., Neiderhiser, J. M., DeFries, J.C., Plomin, R., Worth Publishers, Mcmillan Learning, New York.
3. Handbook of Behavior Genetics by Kim Y.-K. Springer Science Business Media, LLC 2009

Assignments (any one)

1. Project (500 words) highlighting recent advancements.
2. Presentation highlighting recent advancements.
3. Analytical MCQ based questions
4. Biological Crosswords
5. Charts
6. 500 words answer to analytical questions

Semester VI

P12: Genomics and Computational Biology

Total Credits: 04 **Teaching Hours: 60**

Course objectives

- To study the organization of genome in prokaryotic and eukaryotic systems
- To study comparative genomics to study gene mapping and human disease genes
- To gain knowledge of functional genomics
- To understand the concept, need and process of personalized medicine

Unit I

15

Organization of genomes
Gene families and super families
Mitochondrial genome, nuclear genome, gene density, CpG islands
Organization of genome: prokaryotes and eukaryotes
Gene duplication, pseudogenes, repetitive DNA and transposable elements
Human genome project: mapping strategies

Unit II

15

Functional and Comparative Omics
Conservation and diversity of genomes,
Genome size and organization of genes, C-value paradox, number of genes and complexity of genomes
Comparative genomics as an aid to gene mapping
Concepts of transcriptome and proteome

Unit III

15

Pharmacogenomics
Personalized medicine: Concept of pharmacogenomics and pharmacogenetics
Genetic polymorphisms in drug metabolizing enzymes, drug targets, Genes in drug response
Gene chips: Applications in disease profiling and Drug target discovery

Unit IV

15

Bioinformatics
Basics of computers (CPU, I/O units and operating systems)
Concept of homepages, websites, World Wide Web, URLs, and use of search engines
Databases: nucleic acids, genomes, protein sequences and structures
Dynamic programming, Pairwise and multiple sequence alignments (CLUSTALW), BLAST,
Phylogenetic analysis

Course Outcomes:

At the completion of the course, the student will be able to:

- Comprehend the genetic studies to elucidate genome organization and gene mapping.
- Apply the knowledge gained from comparative and functional genomics to prediction of protein complex structure
- Understand genetic basis of a disease and designing of drugs and gene chips.
- Students will be able to develop critical thinking, analysis and evaluation skills in applying knowledge in the class to solve research questions.

Suggested Reading

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). Principles of Genetics. VIII Edition. Wiley India
2. Brown, T.A. Genomes 4. 4th Edition. Garland Science
3. Krebs et al. Lewin's GENES XII, Twelfth Edition. Jones and Bartlett Learning.
4. Westhead*et al* Bioinformatics: Instant Notes. Viva Books (2003).
5. Primrose &Twyman. Principles of Genome Analysis and Genomics. Blackwell (2003).
6. Hartl& Jones. Genetics: principles &Analsysis of Genes & Genomes. Jones & Bartlett (1998).
7. Sambrook*et al* .Molecular Cloning Vols I, II, III. CSHL (2001).
8. Primrose. Molecular Biotechnology. Panima (2001).

Assignments (any one)

1. Project (500 words) highlighting recent advancements.
2. Presentation highlighting recent advancements.
3. Analytical MCQ based questions
4. Biological Crosswords
5. Charts
6. 500 words answer to analytical questions

P13: Genomics and Bioinformatics Lab

Total Credits: 04

1. MS Word, MS Powerpoint, MS Excel, etc
2. Adobe Photoshop, using internet, E-mail
3. Search engines, homepages etc.
4. Databases
5. To learn sequence analysis using BLAST
6. To learn Multiple sequence alignment using CLUSTALW
7. Protein structure prediction (ExPasy, PROSITE).
8. To learn about Phylogenetic analysis using the programme PHYLIP.
9. **Virtual Labs (Suggestive sites)**
    - To learn how to perform Primer designing for PCR using available softwares etc. like Primer3, NEB cutter
    - NCBI, BLAST, CLUSTAL W, PHYLIP

P14X: Immunogenetics

Total Credits: 04 **Teaching Hours: 60**

Course objectives

Provides basics knowledge to

- equip the students about the immunity, components of immune system
- understand the abnormality in immune system leading to diseases
- understand the immune mechanisms in disease control, vaccination, process of immune interactions
- Ability to understand concepts of tumor immunology and transplantation immunology

Unit I

15

Concept of immunity
Immunity: Innate immunity and Adaptive immunity; Humoral immunity and cell mediated immunity
Major histocompatibility complex
Clonal selection and Complementation
Autoimmune diseases, hypersensitive reactions

Unit II

15

Immunoglobulin and T cell receptor genes: Organization of Ig gene loci
Molecular mechanism of antibody diversity.
HLA complex, class I and II HLA molecule: organization and expression.

Unit III

15

Blood group genetics
Genetic control of immune responses
Immune response genes: histocompatibility-linked and allotype-linked
Genetics of antigen presentation.

Unit IV

15

Role of major histocompatibility complex in genetics of transplantation
Immunogenetics of vaccine
Immunogenetics of tumours
Immunogenetics of diseases: personalised medicine and cancer
Immunogenomics and its application

Course Outcomes:

At the completion of the course, the student will be able to:

- appreciate immune response, the cell mediated immune responses, autoimmune and immunodeficiency disorders.
- therapeutic implications for immunoglobulin and vaccine
- the basis of success and failure of organ transplantation.
-

Suggested Reading

1. Emery's Elements of Medical Genetics- Peter Turnpenny, SlanEllard 15th Edition. 2017.
2. Essentials of Human Genetics by S.M. Bhatnagaretal (1999) IV edition. Orient Longman.
3. Genetic basis of common diseases by R. A. King et al, Oxford University Press 2002.
4. Genetics in Medicine by M.W. Thompson et al, 5 Edition, W.B. Sounders Company, London 1996.
5. Basic immunogenetics - Fudenberg et al

Assignments (any one)

1. Project (500 words) highlighting recent advancements.
2. Presentation highlighting recent advancements.
3. Analytical MCQ based questions
4. Biological Crosswords
5. Charts
6. 500 words answer to analytical questions
7. Outreach activities promoting awareness of physiological and immunological diseases and disorders.
8. Surveys on health indices, disease spread in family, neighbours, communities.

P14Y: Microbial Genetics

Total Credits: 04 **Teaching Hours: 60**

Course objectives

- To understand the Genetic constituents of bacteria with special emphasis on inheritance and mutations.
- To familiarize the students with genetics of bacteria and viruses
- understand the genetics of microbes.
- To understand the different diseases posed by microbes
- To familiarize the students with industrial harnessing of microbes

Unit I

15

Bacterial Genetics

Types of bacterial genetic elements: genomic DNA & plasmid
Methods of Gene transfer: Conjugation, Transformation, Transduction
Genetics of bacteria using mutation analysis
Genetic Mapping
Inheritance in bacteria
Selecting mutants, isolating mutants, mutant enrichment. Reversions versus suppression.
Complementation tests, recombination tests and gene replacements.

Unit II

15

Viral Genetics

Viruses: type and structural organization; genetic material
Bacteriophage (T4, and Lambda phage): structure, genome organization and life cycle (lytic and lysogenic)
Human viral diseases (HIV, Foot-and-mouth disease)
Viral vaccines including DNA vaccines, RNA Vaccines and interferons.
Virion and prion

Unit III

15

Microbes and Pathogenesis

Host-pathogen interaction, regulation of virulence, evolution of pathogenicity
Mechanism of drug resistance in pathogens
Mutation and drug resistance in pathogens
Molecular biology of pathogens: *Mycobacterium tuberculosis*, *Vibrio cholerae, Plasmodium, Leishmania, Entamoeba*

Unit IV

15

Applications of Microbial Genetics

Microbial technology in industry (Fermentation technology, Quorum Sensing and bioreactor) and medicine and health (large scale production of biomolecules)
Genetically Modified and biofortified crops
Genes and gene products in different model systems: *E. coli*, *Saccharomyces cerevisae*
Bacterial strain construction, gene fusions & genetic reporters in various molecular studies

Course Outcomes:

At the completion of the course, the student will be able to:

- To understand the genetics of bacteria and viruses
- To understand the dep understanding of viral, bacteria and other pathogenic diseases
- To explain the industrial uses of microbes and its processes.

Suggested Reading

1. Molecular Genetics of Bacteria by Larry Snyder and Wendy Champness, 3rd edition; ASM press; 2007.
2. Fundamental Bacterial Genetics by Nancy Trun and Janine Trempy, 1st edition; Blackwell Science Publishers; 2004.
3. Modern Microbial Genetics by U.N. Streips and R.E. Yasbin, 2nd edition; Wiley Publishers; 2002.
4. Microbial Genetics by Stanly R. Maloy, John E. Cronan, Jr. & David Freifelder, 2nd edition; Narosa Publishing House; 1987.
5. Principles of Virology- Molecular Biology, Pathogenesis and Control. ASM Press, Washington,D.C.
6. Principles of Genetics by D. Peter Snustad and Michael J. Simmons: 6th Addition. John Wiley & Sons, Inc.

Assignments (any one)

1. Project (500 words) highlighting recent advancements.
2. Presentation highlighting recent advancements.
3. Analytical MCQ based questions
4. Biological Crosswords
5. Charts
6. 500 words answer to analytical questions
7. Outreach activities promoting awareness of physiological and immunological diseases and disorders.
8. Surveys on health indices, disease spread in family, neighbours, communities.

Semester VII

P15: Population and Evolutionary Genetics

Total Credits: 04 **Teaching Hours: 60**

Course objectives

- To develop an understanding of the genetics of complex traits.
- To learn, based on a model, the influence of many genes on the trait and non-genetic factors.
- Students will be able to develop critical thinking, analysis and evaluation skills in applying knowledge in the class to solve research questions.

Unit I

15

Population evolution

Population: structure and characteristics
Allele frequencies, genotype frequencies
Hardy-Weinberg equilibrium and conditions for its maintenance
Forces of evolution: mutation, migration, natural selection, genetic drift etc

Unit II

15

Genetic structure of population

Chromosomal and its aberration.
DNA and allozyme polymorphism in natural population
Adaptive genetic polymorphism
Balanced polymorphism and heterosis
Genetic coadaptation and linkage disequilibrium

Unit III

15

Process of evolution 1

Concept of species and modes of speciation: sympatric, allopatric, stasipatric, parapatric
Isolating mechanisms: pre zygotic and post zygotic
Molecular evolution (neutral theory, punctuated equilibrium)
Molecular phylogeny

Unit IV

15

Process of evolution 2

Population substructure, hierarchical population structure,
Non-random mating: inbreeding and assortative mating, Wahlund principle, Isolate breaking
Path diagram construction and inbreeding coefficient
Allelic identities by descent

Course Outcomes:

At the completion of the course, the student will be able to:

1. To understand the genetic structure and basic concept of population evlution
2. To understand the concept and application of genetic changes in population
3. To understand the forces of evolution at molecular level

Suggested Reading

1. Falconer, D. S. and T. F. C. Mackay. Introduction to Quantitative Genetics, 4th Edition
2. Lynch, M. and B. Walsh. 1998. Genetics and Analysis of Quantitative Traits. Sinauer.
3. Saxton, A. M. (Ed). 2004. Genetic Analysis of Complex Traits Using SAS. SAS Press.
4. Evolution - Stickberger, M. W (1990) Jones and Bartlett, Boston.
5. Evolutionary Genetics by Maynard Smith J (1989), Oxford University press.
6. Principles of Evolutionary Genetics by B Milligan
7. Hartl & Clark (1997). Principles of Population Genetics.Sinaur
8. 2.Hartl and Jones(1998). Genetics. Principles and Analysis. Jones and Bartlet
9. 3.Hoelzel (1998). Molecular Genetic Analysis of Populations. Oxford Univ
10. Brown (2007). Genomes. Bios
11. 2.Jobling et al (2004). Human Evolutionary Genetics. Garland
12. 3.Moody (1964). Evolution. Harper and Row
13. 4.Roberts &DeStefano (1986). Genetic Variation and its Maintenance. Cambridge Univ
14. 5.Smith (1998). Evolutionary Genetics. Oxford

Assignments (any one)

1. Project (500 words) highlighting recent advancements.
2. Presentation highlighting recent advancements.
3. Analytical MCQ based questions
4. Biological Crosswords
5. Charts
6. 500 words answer to analytical questions

P16: Genetic Engineering

Total Credits: 04 **Teaching Hours: 60**

Course objectives

1. To develop an understanding of laboratory techniques employed in genetic engineering
2. To appreciate the processes involved in the applied genetic engineering
3. To acquaint the recent products of the genetic engineering used in health care, agriculture, disease diagnostic and breed improvements

Unit I

15

Introduction to Genetic engineering

Enzymes for recombinant DNA technology: Restriction endonucleases and its types; DNA ligases; Other enzymes (Alkaline phosphatase, Polynucleotide kinase, Exonuclease III, DNase I, DNA polymerase and Klenow fragment, Terminal nucleotidyl transferase, RNA dependent DNA Polymerase).
Vectors for Recombinant DNA Technology: Types (Cloning and expression vectors), Properties, Selection criteria of vectors

Unit II

15

Methods of Genetic engineering

Isolation of the desired gene, cDNA library, Genomic library, Amplification through PCR
Direct gene transfer methods: Chemical methods, Lipofection, Electroporation, Microinjection, Ballistic method (Particle shot gun method)
Selection and screening of recombinants: Identification and selection of transformed cell (Direct and indirect methods)

Unit III

15

Technique for Genetic engineering

Gel electrophoresis: Agarose gel electrophoresis and SDS-PAGE
Hybridization: Southern; Northern; Western; Dot blots
Autoradiography
DNA sequencing: Sanger's Dideoxy methods
Molecular probes

Unit IV

15

Applications of genetic engineering

Transgenic animals: Mouse, Sheep, Fish with value added attributes.
Transgenic Plants: Resistance to diseases (Pathogen resistant-viral, fungal and bacterial); insects (Bt gene transfer); Fertilizer management [nitrogen fixation (nif) gene transfer].
Therapeutic products for use in human health care– insulin, growth hormones.

Course Outcomes:

At the completion of the course, the student will be able to:

1. To experience the hands-on training on laboratory techniques of genetic engineering
2. To acquire the basic acknowledge of the processes employed in the industries engaged in production of biomolecules

Assignments (any one)

1. Project (500 words) highlighting recent advancements.
2. Presentation highlighting recent advancements.
3. Analytical MCQ based questions
4. Biological Crosswords
5. Charts
6. 500 words answer to analytical questions
7. Outreach activities promoting awareness of physiological and immunological diseases and disorders.
8. Surveys on health indices, disease spread in family, neighbours, communities.

P17: Theory based practical

Total Credits: 04

Practical for Population and Evolutionary Genetics

1. Models to demonstrate the processes of evolutionary forces
2. Demonstration of Hardy–Weinberg law through modeling and observation from nature
3. To demonstrate adaptations through museum specimens
4. Transmission of characters in culture *Drosophila* population

Practical for Genetic Engineering

1. Isolation of plasmid DNA from *E. coli* & Agarose gel electrophoresis.
2. Isolation of genomic DNA from *E. coli.*
3. Extraction of genomic DNA from Yeast
4. Restriction digestion of DNA.
5. Ligation.
6. Transformation in *E.coli* and selection of recombinants. (Blue-white selection method).
7. Transformation of Yeast cell using Lithium acetate
8. DNA/ RNA Quantification
9. PCR
10. Isolation & identification of *Rhizobium* from root nodules.
11. Instrumentation
12. Industrial visit

P18X: Cancer Genetics

Total Credits: 04 **Teaching Hours: 60**

Course objectives

- To distinguish between different types of cancers, their cell lines and their properties
- To study cancer and tumour inducing cell transformation
- To learn about cancer diagnosis by using genetic markers

Unit I

15

Cancer: molecular basis

Cancer: history, types (Carcinoma, Lymphoma and Malignancy)
Genetics of cancer
Tumorigenesis and Metastasis
Proto oncogene, oncogenes: tumour suppressor gene, DNA repair gene
DNA repair mechanism

Unit II

15

Cancer diagnostic

Tumour specific marker, DNA markers, Single nucleotide polymorphism (SNP)
Cytogenetics of cancer, karyotype nomenclature
Somatic mutation theory of cancer
Various types of chromosomal aberrations in cancers
Philadelphia chromosome, Role of mismatch repair in cancer

Unit III

15

Cancer and environment

Occupational and environmental carcinogenesis
Epigenetic modification and genomic instability
Population screening of cancer
Breast cancer and prostate cancer–case studies

Unit IV

15

Cancer diagnostics: biochemical, histological and radiological methods.
Cancer therapy: Chemotherapy, radiotherapy, Immune therapy (Tumor necrosis factor, interleukins, cytokines, interferons, vaccines, monoclonal antibodies).

Course Outcomes:

At the completion of the course, the student will be able to:

- Understand the screening of cancer
- Understand the diagnosis of cancer
- Understand the treatment through Chemotherapy, radiotherapy, Immune therapy

Suggested Reading

1. Genetics and Medicine – M.W Thompson et al
2. Clinical Genetics – A. Sorsby
3. Bunz, Fred , Principles of Cancer Genetics., 2015, 2nd edition, Springer
4. Emery's Elements of Medical Genetics – R. F. Mueller and I.D Yound
5. Robert Weinberg, The Biology of Cancer, 2013, 2nd Edition –. Edition– 2nd

Assignments (any one)

1. Project (500 words) highlighting recent advancements.
2. Presentation highlighting recent advancements.
3. Analytical MCQ based questions
4. Biological Crosswords
5. Charts
6. 500 words answer to analytical questions

P18Y: Human Genetics

Total Credits: 04 **Teaching Hours: 60**

Course objectives

1. To understand how to Construct and interpret pedigree charts
2. To use and interpret human chromosome and karyotype nomenclature
3. To detect different types of de novo mutations
4. To understand the mechanisms and transmission of various genetic and epigenetic disorders.
5. To understand what is meant by personalized or precision medicine
6. To understand the importance and role of Genetic counselling.

Unit I

15

Traits and their inheritance

Pedigrees: symbols and construction through family histories
Monogenic traits: autosomal inheritance; sex-linked inheritance; sex-limited and sex-influenced traits; Y-linked traits
Maternal inheritance

Unit II

15

Cytogenetics

Chromosome structure
Karyotyping and Idiogram
Bandings: G, C, R, Q;
Chromosomal abnormalities: numerical, structural
Lyon's hypothesis
De novo mutations, somatic and germline mosaicism
Somatic cell hybridization (use of somatic cell hybrids in gene mapping)
Gene mapping: physical and genetic

Unit III

15

Human diseases

Inborn errors of Metabolism
Monogenic disorder and multifactorial diseases
Genome imprinting and mitochondrial syndromes
Genetic basis of infertility
Triplet repeat disorder
Animal model of human diseases

Unit IV

15

Genetic and society

Eugenics, euthenics and euphenics
Prenatal genetic testing: concept, ethical and legal implications
Risk assessment and management of genetic disorders
Genetic counselling (Overview of genetic counseling, components of genetic counseling, information gathering and construction of pedigrees and their interpretation)

Course Outcomes:

At the completion of the course, the student will be able to:

1. It offers knowledge and about the various aspects and concepts of Human genetics and related genetic disorders.
2. The course provides suitable platform to use different genetic tools for the proper detection and diagnosis of both common and complex genetic disorders.
3. The course also stresses upon the use of genetic concepts for generating awareness among general public.
4. The students can conduct surveys regarding the identification of various genetic disorders.

Suggested Reading

1. Rooney and Czepulkowski: Human Cytogenetics: A practical approach (Vol. I & II) IRL Press 1992
2. Mueller and Young Churchill: Emery's Elements of medical genetics; 1998
3. Verma and Babu: Human Chromosomes. Manual of Basic techniques Pergamon 1989
4. Genetics : From Gene to Genome by Leland H. Hartwell, Michael L. Goldberg, Janice A. Fischer, Leroy Hood
5. Concepts of Genetics Klug W. S. and Cummings M. R Prentice-Hall
6. Genetics-a Conceptual Approach Pierce B. A. Freeman
7. An Introduction to Genetic Analysis Griffith A. F. et al Freeman
8. Principles of Genetics Snustad D. P. and Simmons M. J. John Wiley & Sons. 6. Genetics Strickberger M. W. Prentice-Hall
9. Human Molecular Genetics by Tom Strachen , 4th Edition, Garland Science, 2010
10. Principles and Practice of Medical Genetics by Rimion et al., Vol-I-III, Churchill, 2002
11. Genetic Couselling: a psychological approach by Christine Evans, Cambridge University Press, 2006
12. Introduction to Risk Calculation in Genetic Counselling by Young, 3rd Edition, Oxford, 2007.
13. Susan Schmerler, Lessons learned: Risk Management issues in Genetic Counseling, Springer, 2008. 5. M. Fox., A guide to Genetic Counseling, 2nd Edition, Elsevier, 2010.
14. Janice L. Berliner, Ethical Dilemas in Genetics & genetic counseling, Oxford University Press, 2014.

Assignments (any one)

1. Project (500 words) highlighting recent advancements.
2. Presentation highlighting recent advancements.
3. Analytical MCQ based questions
4. Biological Crosswords
5. Charts
6. 500 words answer to analytical questions
7. Outreach activities promoting awareness of genetic diseases and genetic counseling.
8. Surveys on health indices, disease spread in family, neighbours, communities.

P19X: Toxicogenomics

Total Credits: 04 **Teaching Hours: 60**

Course objectives

- To provide theoretical and applied knowledge on the effects of chemical substances on human health.
- To equip the students with toxicological analysis and the signs and symptoms of important toxic syndromes.
- To learn and apply toxicity tests for terrestrial and aquatic animals.
- To enable students develop deep understandings of Expression Profile Toolbox and their applications in toxicogenomics.
- To learn how the chemical exposure affects gene expression.
- To learn how to design experiments, collect samples, perform data analysis and create database.

Unit I

15

General Toxicology

Exposure of toxicants
Toxicants exposure: frequency, duration and routes
Dose-response relationship
Toxicity Tests : acute, subacute, chronic and subchronic
Confounding factors in chemical toxicity**:** Environment, Route of administration and exposure time
Life Stages, Species Differences
Toxic effects on different physiological systems

Unit II

15

Statistical Methods and Data Analysis

Experiment Design
Random Sampling
Observational Studies versus Controlled Experiments
Completely Randomized versus Randomized Block Designs
Exploratory Data Analysis
Statistical Inference
Type I and Type II Errors
Parametric Versus Nonparametric Tests
Data Transformation
Analysis of Variance
Confounding Variables and Data Interpretation

Unit III

15

Use of microarray in Toxicogenomics

The Expression Profile Toolbox
Background on Microarrays
Spotted cDNA Microarrays
Affymetrix Oligonucleotide Microarrays
Inkjet Oligonucleotide Microarrays
Microarray Platform Error Model
Microarray Manufacture

Scanners
Real-Time and Quantitative PCR

Unit IV

15

Genes and Toxicity
Relationships between Toxicology and Gene Expression
Using Genetically Altered animals (one rodent and one non-rodent) in Toxicogenomic
Analysis of Chemical Exposure
Introduction to High-Throughput Protein Expression
Toxicogenomics Resources
(Toxicology Information/Links, Annotation, Pathways,
Genomic Analyses (Sequence), Gene Expression Data Bases/Lims, Gene Expression Analysis)
Databases for Toxicogenomics: Database Mining
Case Study: Occupational exposure of chromium in Leather Industry of Uttar Pradesh

Course Outcomes:
At the completion of the course, the student will be able to:

- examine the application how toxicants disrupt normal cellular processes of genomics, proteomics, and metabolomics data
- use clinical and laboratory findings in the treatment of acute toxic exposures
- understand mechanisms of systemic and organ toxicity induced by toxicants; and learn how to analyse and interpret complex data sets in toxicological research
- perform case studies on “occupational exposure of chromium in Leather Industry of Uttar Pradesh”.

Suggested Readings

1. Hamadeh H.K., Afshari C.A. (2004). Toxicogenomics: principles and applications. John Wiley & Sons, Inc.
2. Christer Hogstrand, Pete Kille. (2008) Comparative Toxicogenomics. Elsevier.
3. Jürgen Borlak (2005). Handbook of toxicogenomics strategies and applications. John Wiley & Sons, Inc.
4. Michael E. Burczynski (2000). An Introduction to Toxicogenomics. CRC Press.
5. Sharma PD (2018). Environmental Biology and Toxicology. Rastogi Publications
6. Klaassen, C. & Watkins, J. (2005) Casarett & Doull's Essentials of Toxicology, 3rd edition. Lange Publications
7. Ernest Hodgson (2010) A Textbook of Modern Toxicology. John Wiley & Sons, Inc.
8. Beddows, C. (2017) Comprehensive Toxicology. Elsevier

Assignments (any one)

1. Project (500 words) highlighting recent advancements.
2. Presentation highlighting recent advancements.
3. Analytical MCQ based questions
4. Biological Crosswords
5. Charts
6. 500 words answer to analytical questions

P19Y: Biophysics

Total Credits: 04 **Teaching Hours: 60**

Course objectives

The objective of this course is to:

- Understand the principles of physical sciences employed in biological systems.
- Make the students capable to simulate the organs and physiological mechanism design research and industrial projects to solve the problems of biological complexity and resolve various health & environmental issues.
- make the students apply physical principles and techniques to different problems in biology.
- set the goal to create future expertise in the field of Biophysics that are trained and excited to work on various important medical & health problems

Unit I

15

Physics in Biological Systems

Laws of thermodynamics, activation energy
Open and non-equilibrium systems
Concept of free energy, Gibbs Helmholtz equation, Entropy, Enthalpy
Thermodynamics of passive and active transport, glycolytic oscillations, biological clocks

Unit II

15

Bioenergetics

Concept of energy coupling in biological processors
Energy requirements in cell metabolism, structure and role of mitochondria, high energy phosphate bond, Energy currency of cell (ATP), Electron-transport chain, Oxidative Phosphorylation including chemiosmotic hypothesis
Thermodynamic analysis of TCA cycle and oxidative phosphorylation

Unit III

15

Mechanism of organisation

Cooperative transitions

- Helix coil transition
- Stretching of macromolecules
- Protein folding
- Unzipping of DNA

Chemical forces

- Chemical potential and Chemical reactions
- Electrophoresis
- Self-assembly, micelles, cell membranes

Machines in membranes

- Electro-osmotic effects

- Ion pumping

Nerve Impulses
- Action Potentials
- Ion channels

Homeostasis and organismic theory: Body-weight regulation, Neuroendocrine homeostasis**,** Social homeostasis

Unit IV

15

Physical Techniques and related biology
- Optical Techniques: Microscopy, X-ray diffraction, light and neutron scattering
- Hydrodynamic Technique: Centrifugation
- Absorption & Fluorescence Spectroscopy: Colorimeter, Spectrophotometer & Nuclear Magnetic Resonance (NMR)
- Physico-chemical & Electroanalytical techniques: Chromatography, Electrophoresis
- Radiologic technique: Tomography
- Patch clamp technique

Course Outcomes:
At the completion of the course, the student will be able to:
- understand the physical basis of physiology and the organs system.
- understand the design of various prosthetic, ocular and auditory machines
- identify and differentiate working principle, instrumentation and applications of selected bio-analytical instruments

Suggested Reading
1. Biological Physics by Philip Nelson
2. Biophysics by W Hoope Edtr., Springer - Verlag New York
3. Molecular Biophysics by R B Setlaw & EC Pollard, Addison Wesley Reading MA.
4. Biophysics by Volkensyteinl M V.
5. Molecular Biology of the cell by Watson et al.
6. Biophysics by C Sybesma.
7. Biophysical Chemistry Vol. 1,2 & 3 by C R Cantor & P R Sachimmel.
8. Physical Chemistry of Nucleic Acid by V A Bloomfield.
9. Physical Biochemistry by K E Van Holde.
10. Biological Spectroscopy by J Campbell.
11. Intermediate Physics for Medicine and Biology by R K Hobble.

Assignments (any one)
1. Project (500 words) highlighting recent advancements.
2. Presentation highlighting correlations
3. Analytical MCQ based questions
4. Biological Crosswords
5. Charts
6. 500 words answer to analytical question

Research Methodology

Total Credits: 04 **Teaching Hours: 60**

Course objectives

The objective of this course is to make students:

- learn and imply good laboratory practices as they are essential ingredient of a quality system
- learn the techniques and working of various equipments used for research purpose
- study the basics and application of Biostatistics
- know the principle and working of instruments in a biology laboratory

Unit-I

15

Techniques and methods in Histology and Histochemistry

Good Laboratory Practices
Basic Laboratory Methods: Preparation of Reagents, Chemicals & Buffers
Fixation and preservation techniques
Tissue sectioning techniques: Microtomy, Cryosectioning
Dehydration and mounting
Histochemical techniques to demonstrate carbohydrate, lipid, collagen, nucleic acid and nerve cell

Unit-II

15

Techniques and Instrumentation I

Microscope (Compound, Fluorescence, Phase contrast, Transmission, Confocal)
pH meter
Centrifuges (Ultra and Refrigerated)
Colorimeter and Spectrophotometer
HPLC
ELISA
Radioactive tracer
FISH

Unit-III

15

Techniques and Instrumentation II

Gel Electrophoretic apparatus
Gel documentation system
Transilluminator
Thermocycler
SDS PAGE
Southern blotting
Western blotting

Unit-IV

15

Biostatistics

Designing of experiments
Null hypothesis, probability
Correlation, regression
Distribution and measurement of central tendency
Chi Square test

Student t test
F- test (one way ANOVA, two way ANOVA)
Usage of statistical software (SPSS)

Student learning outcomes:
After successfully completing this course, students will be able to:

- Understand and ensure uniformity, consistency, reliability and reproducibility of his experimental data
- Understand the principles and applications of basic laboratory methods and instruments
- Imply appropriate tools and techniques to solve the problems and figure out the downstream events in biological sciences

Suggested readings:

- Seiler, J.P. (2005). Good Laboratory Practice: the Why and the How. Springer
- Webster, J. G. (2004). Bioinstrumentation. John Wiley & Sons Incorporated
- Enderle, J. (2005). Bioinstrumentation. In Introduction to Biomedical Engineering (pp. 403-504). Academic Press
- Reilly, M.J. (2016) Bioinstrumentation. CBS Publishers & Distributor
- Ross, M.H. and Reith, E.J. (1995). Histology A Text and Atlas. Harper International Edition
- Kiernan j.A. (2015) Histological and Histochemical Methods: Theory and Practice. Pergamon Press
- Sundar Rao P.S.S. and Richard J. (2012). Introduction to Biostatistics and Research Methods. PHI Learning Private Limited
- Sokal R.R. and Rohlf F.J. (2009). Introduction to Biostatistics. Dover Publications.

Semester VIII

P20: Major Project

Total Credits: 24

Course objectives

Students who complete a Major Project will:

• apply fundamental and disciplinary concepts and methods in ways appropriate to their principal areas of study

• demonstrate skill and knowledge of current.