Syllabus

M.Sc. ANIMAL BIOLOGY & BIOTECHNOLOGY

2016-2017

Department of Animal Biology
School of Life Sciences
University of Hyderabad
Hyderabad - 500 046

M. Sc. ANIMAL BIOLOGY & BIOTECHNOLOGY

(Course Structure)

<table>
<tr><th>I Semester</th><th>II Semester</th><th>III Semester</th><th>IV Semester</th></tr>
<tr><td>AB 401
Genetics (3)*,•</td><td>AB 451 (New)
Animal Physiology (3)</td><td>AB 501 (New)
Endocrinology and Reproductive Biology(3)</td><td rowspan="5">2 Elective Courses only (2 credits each)

AB 571
Neurobiology
AB 572
Vaccinology
AB 573
Cancer and Cancer Stem Cell Biology
AB 574(New)
Chronobiology
AB 575 (New)
Signal Transduction
AB 576 (New)
Gene Regulatory Networks: Cell Identity and Functions

AB 551
Project Work (12)
(including seminars)</td></tr>
<tr><td>AB 402
Microbiology (3)*</td><td>AB 452
Developmental Biology (3)</td><td>AB 502
Stem Cell Biology (3)</td></tr>
<tr><td>AB 403
Biochemistry (3)</td><td>AB 453
Enzymology & Intermediary Metabolism (3)</td><td>AB 503 (New)
Immunobiology (3)</td></tr>
<tr><td rowspan="2">AB 404
Cell & Molecular Biology-I (4)</td><td rowspan="2">AB 454
Molecular Biology-II & Gene Manipulation (4)*</td><td>2 Elective Courses only (2 credits each)
AB 521
Oxidative Stress and Antioxidants in Health & Disease</td></tr>
<tr><td>AB 522
Infection Biology
AB 523
Aquaculture: Nutraceutical & Pharmaceutical Application
AB 524
Epigenetics and Nuclear Dynamics</td></tr>
<tr><td>AB 405
Lab course (6) (including Computational Biology)</td><td>AB 455
Lab course (6)</td><td>AB 504
Lab course (6)</td></tr>
<tr><td>19 Credits</td><td>19 Credits</td><td>19 Credits</td><td>16 Credits</td></tr>
<tr><td colspan="4">Total Credits = 73 (Seventy three); One credit is equivalent to 25 marks</td></tr>
</table>

1. Some of the core and elective courses are given as common courses taken by students from the Departments of Biochemistry, Plant Sciences and Biotechnology.
2. Common courses offered by Plant Sciences* and Biochemistry• are listed in the table.
3. In Semester III and IV, two Electives (one compulsorily from the Department) are to be taken by the students.

GENETICS
(AB 401)

1. Mendelian Genetics and analysis: Extension of Mendelian analysis
2. Chromosomal basis of inheritance
3. Chromosome characteristics
4. Chromosome structure, Euchromatin and Heterochromatin, Coding and Non-coding sequences, Transposons.
5. Genetic Recombination in Eukaryotes
6. Linkage and Crossing Over, Chromosome mapping, Tetrad analysis and Gene conversion
7. Mutations and mutagenesis –Detection, Molecular basis and Applications
8. Chromosomal changes: Number variation – Euploidy (auto and allopolyploidy), aneuploidy. Structural variations – Déficiences, duplications, inversions, translocations.
9. Interaction of Genotype and Environment: Twin studies, genetic environment, non-genetic environment, phenocopies, penetrance and expressivity
10. Gene expression regulation during differentiation and growth
11. Heterochromatization in human beings and other mammals, dosage compensation, mechanism, sex chromatin, position effect
12. Quantitative inheritance
13. Continuous traits – multigenic variability, dominance – additivity, norms of reaction
14. Non-Mendelian Inheritance
15. Plastid mutations – Nature and mode of transmission
16. Mitochondrial traits – Nature and mode of transmission and Applications
17. Population Genetics: Genotype and allelic frequencies, the Hardy-Weinberg equilibrium, non-random mating, consequences of homozygosity, factors affecting gene frequencies, heterosis, mutation – effect on allele frequencies, migration and genetic drift
18. Developmental Genetics
19. Model system *Drosophila*, Genetic screen, Pattern formation, Maternal effect, Homoetic transformations.

Suggested reading:

1. Griffiths A.J. F., Miller, J. H., Suzuki, D. T., Lewontin, R. C and Gelbart, W. M. An Introduction to Genetic Analysis, W. H. Freeman & Company.
2. Strickberger, M.W. Genetics, Macmillan Publishing Co.
3. Gardner, E.J., Simmons, M.J. and Snustad, D.P. Principles of Genetics, John Wiley & Sons.

MICROBIOLOGY
(AB 402)

1. Beginnings of microbiology: Discovery, Evolution of microbiology as a discipline
2. Importance of microorganisms in environment and industry
3. Nutritional requirements of microorganisms: Nutritional types, Requirements,
4. Uptake of nutrients, Design and types of nutrient media
5. Diversity of microorganisms: Culture techniques, Overview of bacterial systematics
6. Microbial growth: Principles, Kinetics and Methods of measuring growth, Batch and continuous growth, Synchronous culture, Diauxic growth
7. Structure function relation in bacterial cell – Cell wall, Cell membrane
8. Bacterial responses to chemical signaling
9. Overview of Plant-microbe interactions : Symbiotic nitrogen fixation, Mycorrhizae, Plant pathogens
10. Infection and disease – Host parasite relationship – Establishment of disease
11. Physical and chemical control of microorganisms
12. Chemotherapeutic agents and antibiotics
13. Foundations of virology – structure and replication, nomenclature and classification, detection, inhibition, viral vaccines, viroids, and prions

Suggested reading:

1. Prescott L**,** Harley J and Klein D. Microbiology. McGraw Hill Publishers.
2. Tortora G.J. Funke B.R. and Case C.L. Microbiology: An Introduction. Benjamin-Cummins Publishing Co.,
3. Pelzer, M. J. Chan, E.C.S. and Kreig, N. R. McGraw-Hill Publishing Co.

BIOCHEMISTRY
(AB 403)

1. Review of basic concepts of solution chemistry- acid, base, ionic strength, principles of thermodynamics: chemical potential, free energy, entropy, enthalpy, heat capacity; dimensions of atoms, bonds, and molecules; covalent and non-covalent bonds.
2. Dihedral angles, steric conflict, potential energy.
3. Classes of organic compounds and functional groups.
4. Amino acids and peptides: chemical reactions and physical properties.
5. Proteins and enzymes: secondary structures- helices, beta sheets, loops, turns, conformational map, tertiary structure, quaternary structure.
6. Glycobiology (glycomics): sugars and polysaccharides: chemistry, classification, and function; glycoproteins: structure and function.
7. Nucleic acids: nucleotides, single and double-stranded structures, uncoiling.
8. Ribonucleoprotein and ribozyme.
9. Lipids (lipidomics): fatty acids - saturated, unsaturated, and eicosanoids; phospho- and spingolipids- structure, classification, lipoprotein, liposomes.
10. Brief discussion of EM, AFM, crystallography, and NMR.

Suggested reading:

1. Voet V and Voet J.G. Biochemistry. John Wiley Publishers.
2. Lehninger A.L. Principles of Biochemistry. W.H Freeman and Company.
3. Stryer L. Biochemistry. W.H. Freeman and Company.

CELL & MOLECULAR BIOLOGY - I
(AB 404)

Part A - Cell Biology

1. Comparison of prokaryotic and eukaryotic cells
2. General methods in cell biology
3. Ultrastructure of plasma membrane
4. Cytoskeletal elements
5. Mitochondria- structure, biogenesis and evolution
6. Mitochondria and male sterility
7. Chloroplast –structure, organization, biogenesis, genome and genetic manipulation
8. Lysosomes- biogenesis, pathophysiology
9. Peroxisomes, glyoxysomes
10. Plant cell wall
11. Cell growth and division (mitosis, meiosis and cell differentiation)
12. Biosynthetic process in ER and Golgi apparatus
13. Vesicular Traffic from ER through Golgi apparatus
14. Trans-Golgi Network, endocytosis and exocytosis
15. Programmed Cell Death

Suggested reading:

1. Alberts B, Bray D, Lewis J, Raff M, Roberts K, and Watson J.D. Molecular Biology of the Cell. Garland Science.
2. Pollard T.D., Earnshaw W.C, Schwartz J.L. Cell Biology. Elsevier Publishing Co.

PART B- MOLECULAR BIOLOGY

1. **Genetic material**: a) Classical experiments - Evidence of DNA as genetic material. b) RNA viruses –RNA as genetic material. c)Fine structure of gene - Benzers classical studies on rII locus.

2. **Organization of genome in prokaryotic and eukaryotic cells.** a) Differences between prokaryotic and eukaryotic gene organization: concept of the operon; split genes in eukaryotes. b) Supercoiling of DNA - general concepts and role of topoisomerases. c) Eukaryotic DNA: Chromatin and nucleoid structure-role of histones, denaturation-renaturation kinetics, repetitive DNA, satellite DNA. d) Extrachromosomal DNA: Plasmids, transposons, insertion elements, mitochondrial and chloroplast DNA. e) Horizontal transfer of bacterial genome-Construction of genetic maps.

3. **Replication of DNA.** a) Semi-conservative theory of Meselson and Stahl.

   b) Semiconservative and discontinuous mechanism of DNA replication –

leading, lagging strand, Okazaki fragments

c) Prokaryotic replication – origin of replication *oriC*, enzymatic machinery including the role of topoisomerases, helicases, DNA polymerases, primases, ligases etc.

d) Replication of bacterial viruses – detailed study of the replication of bacteriophage λ, Φx174, M13 – rolling mechanism of replication,

e) Eukaryotic DNA replication – eukaryotic DNA polymerases, replication of linear DNA – role of telomerases.

4. **Recombination at the molecular level.** Crossing over during cell division- breakage and rejoining of intact DNA molecules, Holliday model of homologous recombination – events at the molecular level; role of recA, recBC and chi sequences, Site- specific recombination – eg. bacteriophage λ; FLP/FRT and Cre/Lox recombination.

5. **Mutation and repair of DNA.** Nature of mutations, mutagens – chemical, UV radiations etc., DNA repair – Nucleotide excision repair; Mismatch correction; SOS repair; Photoreactivation.

Suggested reading:

1. Lewin B. Genes. Jones & Bartlett Publishers.
2. Alberts B, Bray D, Lewis J, Raff M, Roberts K, and Watson J.D. Molecular Biology of the Cell. Garland Science
3. Watson J.D, Baker T.A, Bell S.P, Gann A, Levine M and Losick R. Molecular Biology of the Gene. . Benjamin-Cummins Publishing Co.,
4. Freifelder D. Molecular Biology. Narosa Publishing House.

ANIMAL PHYSIOLOGY
AB 451 (New)

1. **Introduction to Animal Physiology:** The various physiological organ-systems and their importance to the integrative functions of the animal body. The concept of homeostasis, including set point, negative and positive feedback loops, and compensatory responses.Body fluid and its dynamics. Transport of through biological membranes.
2. **Blood and Circulation**: Composition of blood, structure & functioning of its constitutes. Blood coagulation and anti-coagulants. Hemoglobin and its polymorphism. Anaemias. Sreticule-endothelial System. Body defense mechanism and immunogenesis. Structure and functions of the cardiovascular system, including the mechanical and electrical properties of cardiac muscle function. Excitation-contraction coupling in cardiac muscle. Reflex regulation of blood pressure.
3. **Respiration:** Structure and functions of the respiratory system, including lung volumes, gas exchange, and gas transport in blood. Regulation of ventilation. Structure and functions of smooth muscle, including excitation-contraction coupling in smooth muscle.Work and exercise physiology.Respiration in birds.
4. **Digestion:** Structure, function and physiology of digestive system. Control of motility and secretion of alimentary canal and reflexes in the control of digestive functions. Control of rumen motility. Digestion in ruminant and monogastric animals. Absorption from rumen and the digestive tract. Manipulation of rumen microflora to enhance fibre digestion and microbial protein synthesis. Nitrogen recycling and rumen bypass mechanisms. Post-ruminal digestion. Physiology of rumen disorders**.**
5. **Excretion:** Structure and functions of the kidney nephrons, including glomerular filtration, tubular reabsorption, tubular secretion, and excretion. Transport of water, ions, and organic molecular across the tubular epithelia.Hormonal and renal regulation of body fluids and electrolyte balance. Physiology of micturition. Uremia and other renal disorders.
6. **Muscle Physiology:** Muscle types and their intra-cellular contractile mechanisms. Electrophysiology of muscles. Neuromuscular junction. Excitation contraction coupling, its biochemical and ionic mechanisms. Molecular basis of muscle contraction. Rigor mortis.
7. **Nervous System:** Neurone structure and fuction, Transmission of nerve impulse, Introduction to Central and Peripheral Nervous System.
8. **Sensory Physiology:** Basic principles of sensory physiology. Vision physiology (Photoreception). Hearing physiology. Auditory physiology. Chemoreception and mechanoreception.

Suggested reading:

1. Schmidt-Nielsen, Animal Physiology, Cambridge University Press.
2. Christopher D. Moyes and Patricia M. Schulte, Principles of Animal Physiology, Pearson Press.
3. Arthur C. Guyton and John E. Hall, Textbook of Medical Physiology, W.B. Saunders Company.
4. William S. Hoar, General and Comparative Animal Physiolog, Prentice Hall, India
5. Animal Physiology, Richard W, Gordon A and Margaret A. Sinauer Associates, USA

DEVELOPMENTAL BIOLOGY
(AB 452)

1. **Basic concepts of development:** Potency, commitment, specification (autonomous, regulative and syncytial), induction, competence, determination and differentiation, morphogenetic gradients, cell fate and cell lineages, genomic equivalence and the cytoplasmic determinants, imprinting.
2. **Gametogenesis and Fertilization:** Production and structure of gametes, cell surface molecules in sperm egg recognition in animals, acrosome reaction, fast and slow block to polyspermy, zygote formation.
3. **Cleavage and Early embryonic development:** Patterns and molecular mechanism of cleavage, blastula formation, gastrulation patterns, concept and functions of primary organizer, neural induction, differential gene expression during formation of germ layers.
4. **Neurulation:** Formation and differentiation of neural tube, differentiation of neurons, specification and regionalization of neural crest cells and their derivatives.
5. **Morphogenesis and organogenesis in animals:** Axes and pattern formation in *Drosophila*, amphibia and chick, derivatives of ectoderm, mesoderm and endoderm. Organogenesis- vulva formation in *Caenorhabditis elegans*; eye lens formation, formation of somite, limb development.
6. **Sex determination:** Chromosomal sex determination- mammals and *Drosophila*. Environmental sex determination.
7. **Postembryonic development & Aging and senescence:** Amphibian metamorphosis, metamorphosis in insects, regeneration in – flatworms, Hydra, Salamader limbs and mammalian liver. Biology of aging and senescence, Programmed cell death.
8. **Brief overview of:** Development in Health and Disease including birth defects, Development and the Environment (biotic, abiotic, and symbiotic regulation), Development and Evolution (developmental mechanisms of evolutionary change).

Suggested reading

1. Gilbert S.F. Developmental Biology, 10th Edition, Sinauer Associates, Inc., Publishers Sunderland, Massachusetts, USA.
2. Slack J. M. W. Essential Developmental Biology, Wiley-Blackwell.
3. T. Subramonium (2013) Molecular Developmental Biology, ISBN.

SEMESTER II

ENZYMOLOGY & INTERMEDIARY METABOLISM (AB 453)

1. **Enzymes:** Nomenclature, structure, isoenzymes, Structure-function relationship. Solubility, denaturation inactivation, stabilization
2. **Enzyme kinetics**: Michaelis-Menten equation, significance of Km, kinetic parameters, substrate co-operativity.
3. **Enzyme catalysis**: Measurement of enzyme activity; Enzyme Units; Specific activity; factors influencing enzyme activity.
4. **Enzyme inhibition:** Competitive, noncompetitive, uncompetitive and irreversible. Regulation of enzyme activity – allosteric and irreversible.
5. **Carbohydrate metabolism:** Glycolysis, TCA cycle, glycogenesis, glycogenolysis, pentose phosphate shunt pathway.
6. **Metabolic pathways and bioenergetics**: Electron transport and oxidative phosphorylation.
7. **Amino acid metabolism:** Transamination reaction, oxidative deamination, urea cycle, glucose-alanine cycle. Anabolic reactions involving incorporation of nitrogen into biological systems and amino acid synthesis from metabolic intermediates.
8. **Lipid metabolism:** Oxidation of fatty acids, biosynthesis of fatty acids and cholesterol, oxygenation of PUFAs- COX and LOX pathways.
9. **Nucleic acid metabolism:** *De novo* synthesis of purine and pyrimidines, salvage pathways.
10. **Anaplerotic reactions**: Interaction of metabolic pathways, metabolic flux.
11. **Inherited disorders of metabolism**
12. **Metabolism of drugs**: Phase I and Phase II detoxification systems.

Suggested reading:

1. Voet V and Voet J.G. Biochemistry. John Wiley Publishers.
2. Lehninger A.L. Principles of Biochemistry. W.H Freeman and Company.
3. Stryer L. Biochemistry. W.H. Freeman and Company.
4. Biochemistry of Rawn David J., Neil Patterson Publishers
5. Medical Biochemistry by N.V. Bhagavan, Harcourt Academic Press

MOLECULAR BIOLOGY- II & GENE MANIPULATION (AB 454)

Part A – MOLECULAR BIOLOGY II

1. **Prokaryotic Transcription**: a) Transcription unit – start site, upstream promoter regions, terminator, b) Structure and function of RNA polymerases, sigma factors, c) mechanism of transcription-initiation, elongation and termination – Rho-dependant and independent termination d) Promoter polymerase interactions –DNA foot printing techniques, e) Promoters-Constitutive and Inducible promoters, other regulatory elements - upstream activating sequences (UAS), anti-termination, f) inhibitors of transcription.
2. **Operon concept:** Operon concept – inducible and repressible operons. Eg. lac, trp, ara, and his operons; global nutrient (carbon, nitrogen) status sensing mechanisms – link to gene expression. Bacterial small RNA (sRNA) and its role in regulation of gene expression.
3. **Eukaryotic transcription:** a) RNA polymerases I, II, III - structure and assembly; b) Basal transcription apparatus for the three polymerases with specific promoters and transcription factors, c) Other regulatory elements – enhancers, silencers, response elements, d) Transcriptional factors – general features, motifs - zinc fingers, leucine zippers, helix-turn helix, homeodomains etc.
4. **Gene splicing & post-transcriptional modifications**: a) Splicing – mechanism, catalytic role of RNA, b) Group I, II and nuclear introns, nuclear splicing and role of snRNA, tRNA splicing, c) modification of mRNA - 5' cap formation, 3' polyadenylation; RNA editing. RNA interference (RNAi)-mechanism and significance.
5. **Translation:** a) Genetic code – universality and degeneracy, Wobble hypothesis, Chemical synthesis of the gene by Khorana, b) Translation machinery – ribosomes; charging of tRNA molecules and formation of aminoacyl tRNA; mechanim - initiation, elongation and termination, c) post-translational modifications of proteins – glycosylation, amidation, lipidation, processing of pre-proteins etc., d) Transport of proteins and molecular chaperones; Protein stability; Protein turnover and degradation, e) Inhibitors of protein translation.

Suggested reading:

1. Lewin B. Genes. Jones & Bartlett Publishers.
2. Alberts B, Bray D, Lewis J, Raff M, Roberts K, and Watson J.D. Molecular Biology of the Cell. Garland Science.
3. Watson J.D, Baker T.A, Bell S.P, Gann A, Levine M and Losick R. Molecular Biology of the Gene. . Benjamin-Cummins Publishing Co.,
4. Freifelder D. Molecular Biology. Narosa Publishing House.

Part B –GENE MANIPULATION

1. **Generation of DNA fragments:** Mechanical shearing, restriction endonucleases (REs) – classification, mechanism of action, use of REs for molecular cloning, PCR technology and its application in recombinant DNA technology, cDNA synthesis – strategies for isolation of full length cDNAs, chemical synthesis of a DNA fragment.
2. **Vectors used in molecular cloning:** a) Plasmids – general concepts, eg. pUC, pBlueScript, pGEM vectors; Expression vectors; pMal, GST-based, pET vectors, b) Bacteriophage λ vectors – λgt10, λgt11, λ ZAP and replacement vectors – EMBL, c) Phagemids - M13-derived vectors, d) cosmids - Artificial chromosome vectors (YACs; BACs), e) Other viral vectors: SV-40, vaccinia, baculovirus & retroviral vectors**.**
3. **Cloning strategies & Introduction of recombinant DNA into hosts:** a) Other enzymes used in cloning - DNA ligase, Klenow enzyme, T4 DNA polymerase, Polynucleotide kinase, Alkaline phosphatase, b) cloning strategies – basic concepts of cohesive and blunt end ligation; directional cloning, use of linkers and adaptors; c) Homopolymer tailing, d) T-vectors and cloning of PCR products, e) Introduction of recombinant DNA into suitable hosts - transformation, conjugation, transduction, transfection, particle bombardment techniques, f) Ti plasmids and Agrobacterium-mediated transformation; particle bombardment.
4. **Construction and screening of genomic libraries:** a) Construction of genomic and cDNA libraries – using for eg. λgt11, λ ZAP vectors, b) Screening: DNA probe-based screening - molecular hybridization techniques: Preparation of nucleic acid probes by nick translation, random primer labeling and end labeling, hybridization techniques for identification of clones with gene of interest, c) Screening by antibody-based methods: induction of protein expression, immunodetection using specific antibodies, radioactive and chemiluminescent methods of detection.
5. **Characterization of cloned genes:** a) Sequencing of DNA- Sanger's enzymatic method and Gilbert's chemical sequencing method; automated DNA sequencing, b) Identification of promoters and regulatory elements – promoter reporter fusions, c) Site directed mutagenesis.
6. **Expression of recombinant proteins.** a) Protein expression in *E. coli* as a host - Factors influencing the expression of recombinant proteins. Purification of recombinant proteins - His-tag, GST-tag, MBP-tag etc., commercially available *E. coli* hosts for expression of recombinant proteins, b) examples of alternate expression systems – yeast, baculovirus, mammalian systems and plants. Molecular Pharming.

Suggested reading:

1. Primrose S.B, Twymand R.M, and Old R.W. Principles of Gene Manipulation. Blackwell Science.
2. Sambrook J and Russell D. Molecular Cloning: A laboratory Manual. Cold Spring Harbor Laboratory Press.

SEMESTER III

ENDOCRINOLOGY AND REPRODUCTIVE BIOLOGY
AB 501 (New)

1. **Basic concepts:** Important discoveries in endocrinology, Hypothalamo-hypophyseal axis, Pituitary hormones and function.
2. **Endocrine glands - Classification of hormones, Structure and function of hormones:** Pancreas, Adrenal, Thyroid, Parathyroid, Thymus, Gatrointestinal hormones.
3. **Mechanism of action of hormones:** Protein, steroid and thyroid hormones.
4. **Gonadal development:** Genetic sex- gonadal sex- somatic sex, Sex determination and differentiation, Puberty.
5. **Structure and function of male reproductive system**: Testis, hormonal regulation of spermatogenesis and spermiogenesis, inhibin and androgen binding proteins; capacitation of spermatozoa.
6. **Structure and function of female reproductive system**: Ovary, influence of hormones on development of ovarian follicles and oogenesis, reproductive cycles: estrous and menstrual cycle, ovulation, atresia and corpus luteum formation; pregnancy and lactation; implantation and placentation.
7. **Contraception in males and females**: Hormonal and chemical, recent advances in contraception research.
8. **Artificial insemination techniques and their development**: Estrus synchronization; semen collection, evaluation, storage, assisted reproductive technology, i*n vitro* fertilization, ICSI and preservation of endangered species.
9. **Endocrine disorders and disruption:** Endocrine related disease and syndromes**,** Types of endocrine disruptors, site of action and metabolic effects.

Suggested reading:

1. Wilson J.D. Text Book of Endocrinology. Saunders Publishers.
2. Schatten H and Constanitinescu G.M. Comparative Reproductive Biology. Blackwell Publishers, UK
3. Joy K.P, Krishna A, and Haldar C. Comparative Endocrinology and Reproduction. Narosa Publishers, Delhi.
4. Nussey S and Whitehead S. Endocinology-An Integrated Approach, Oxford: BIOS Scientific Publishers.
5. Polonsky K. S, Larsen P.R and Kronenberg H.M. Williams Textbook of Endocrinology, Elsevier.

STEM CELL BIOLOGY
(AB 502)

1. **Introduction:** Cellular potency, lineage commitment, cellular development, differentiation, dedifferentiation & trans differentiation, Cell cycle control, Immortal DNA strand hypothesis, Asymmetric cell division, telomerases in relevance to stem cell development and differentiation.
2. **Somatic and Germ cell derived stem cells:** Germline stem cells and germ line-derived pluripotent cells, Stem cell niche, epithelial stem cells, mesenchymal stem cells, neural stem cells, haematopoitic stem cells, cardiac stem cells, Cancer stem cells, Markers, molecular and evolutionary mechanisms addressing origin and maintenance of cancer stem cells.
3. **Regulatory mechanisms in Embryonic and adult stem cells**: Core regulatory circuitry, DNA methylation, histone modifications, histone modifiers, chromatin remodelers, RNA PolII code, post transcriptional control of gene expression in ESC: role of miRNAs, LincRNAs and RNA binding proteins. Spatial organization of genome during ESC development and differentiation.
4. **Stem cell therapies:** Generation of induced pluripotent cells, and molecular mechanism of iPSCs reprogramming. Direct differentiation.
5. **Stem cell technologies:** Generation of chimeric animals and animal cloning; Pro-nuclear injection of blastocysts, transplantation of blastocystes into pseudo-pregnant mice and generation of chimeric and knockout animals. Potential application of transgenic animals: Reprogramming of the nuclei and generation cloned animals. Gene editing technologies - TALEN, CRISPR Cas9.
6. **Stem cell and progenitor cell assays:** Purification of tissue specific stem cells and transplantations. Hematopoietic progenitor cell analyses such as flow cytometry, dynabeads, colony forming assays and *in vitro* differentiation assays of lymphoid (B and T), myeloid lineages and other tissue lineages.
7. **Tissue engineering:** Soft tissue engineering (Breast and Urinary bladder), Hard tissue engineering (Bone and cartilage), Complex tissue engineering (Cardio vascular system and muscular joints).
8. **Methods & Bioinformatics resources related to Stem cells:** Next generation sequencing; DNA-seq, RNA-seq, ChIP-seq etc. Utility of genome browsers (UCSC), ENCODE & stemformatics.

Suggested reading:

1. Lanza R, Gaerhart J, Hogan B, Melton R, Thomas D, Thomas J, and Wilmut S. Essentials of Stem Cell Biology. Elsevier Inc.
2. Stillman B, Stewart D and Grodzicker T, Control and Regulation of Stem Cells.
3. Tursen Kursad, Stem Cell Biology and Regenerative Medicine, Humana Press.

IMMUNOBIOLOGY
AB 503 (New)

1. **Cell, molecular and developmental biology of immune system:** Evolution of the immune system, development and survival of immune cells. Molecular mechanisms of immune recognitions, and effector responses against pathogens.
2. **Molecular components of Immune system:** Structure, function and generation of antigen receptors, regulation of immune responses, signal transduction, autoimmunity, tolerance.
3. **Innate immune system:** The effector mechanisms of innate immune system, pattern recognition, complement system, antimicrobial peptides, cytokine products in response to viral, bacterial and parasitic pathogens and antigen processing, and presentation.
4. **Adaptive immune system:** Antigen recognition, lymphocyte activation, humoral and cell mediated immunity, immunological memory, physiological and pathological aspects of inflammation.
5. **Immune Dysfunction:** Autoimmunity, immunodeficiency, allergy, hypersensitivity, alloantigens and transplantation rejections.
6. **Cancer immunology:** Tumor cell recognition, Mechanic insights of anti-tumor immunity, immunosuppressive mechanisms, inhibitory receptors, cancer vaccines, and new approaches for delivery of immunotherapies into tumors.

References:

1. Goldsby RA, Kindt TK, Osborne BA and Kuby J. Immunology, 7th Edition, W.H. Freeman and Company.
2. Janeway CA, Travers P, Walport M, and Shlomchik M. Immunobiology, 8th Edition, Garland Publishing.

OXIDATIVE STRESS AND ANTIOXIDANT DEFENSE IN HEALTH & DISEASE (AB 521)

1. **Chemistry of oxygen**
2. **Free radicals**-Definition, Oxy radicals – types, mechanism of formation, environmental factors in generation of free radicals
3. **Free radicals, oxidative stress and lipid peroxidation**
   - non-enzymatic-lipofusion (age pigments)
   - enzymatic
   - leukotrienes -mediators of allergy, asthma
   - prostaglandins – mediators of inflammation and cancer
4. **Oxidative stress: Role in physiological and pathological processes**
   - Inflammation & pathogen defenses
   - Reproduction, ovulation, fertilization, implantation, parturition
   - Brain development: Differentiation into type I & II neurons
   - Chronic respiratory disorders – asthma
   - Cardiovascular disease- atherosclerosis
   - Neurodegenerative disorders – stroke, Parkinson's, Alzheimer's
   - Diabetes
   - Cancer
   - Aging

Suggested reading:

1. Packer L and Helumt S. Oxidative Stress and Inflammatory Mechanisms in Obesity, Diabetes, and the Metabolic Syndrome. CRC Press.
2. Qureshi A.G and Parvez SH. Oxidative stress and neurodegenerative disorders Elsevier Publishers.
3. Singh. Oxidative Stress Disease and Cancer. World Scientific Publishing.
4. Surh Y.J and Packer L. Oxidative Stress, Inflammation, and Health. CRC Press.
5. Ozbenm T. Free Radicals, Oxidative Stress, and Antioxidants: Pathological and Physiological Significance. Springer Publishers.

INFECTION BIOLOGY
(AB 522)

1. **Overview and introduction to infection biology:** historic perspectives, Kochs hypothesis, General events in establishment of infection, infectious dose, lethal dose, infectious disease epidemiology, nosocomial infections, antisepsis, modes of disinfection/sterilization, modes of disease transmission, specific and non-specific defense responses.

2. **Bacteriology**
   a) The fundamental structure of bacteria, especially structures important for pathogenicity and virulence.
   b) Basic biology and host-pathogen interactions with reference to important infections due to Gram negative bacteria (pathogenic E. coli, Vibrio cholera, Salmonella, Yersinia pestis), Gram positive bacteria (Staphylococci, Streptococci), tuberculosis, zoonotic diseases: leptospirosis, Helicobacteri pylori and peptic ulcer.
   c) Importance of different virulence factors, e g. exotoxins, the endotoxin, secretion systems, the invasiveness, intracellular survival, antigenic variation and other mechanisms to avoid the immune system.
   d) Antibiotics and drug resistance: Principles for mechanisms of antibiotic action, bacteriostatic and bacteriocidal effect. Mechanisms of antibiotics resistance and its importance within the healthcare: MRSA, MDR and XDR in tuberculosis.

3. **Virology**
   a) Components and structures of virus particles; classification of viruses; DNA and RNA viruses.
   b) Host immune response to viral infections: Flu, HIV, polio, hepatitis etc
   c) Control measures: diagnosis, anti-viral therapy, vaccines

4. **Parasitic infections**
   a) Malaria, toxoplasmosis, leishmaniasis, trypanosomiasis etc.
   b) Immune evasion: adaptation of parasites for survival within the mammalian host.
   c) Mechanism of antigen export and antigen presentation in *Plasmodium* and *Toxoplasma*.
   d) Host immune responses to protozoan diseases and model systems to study immune activation during protozoan infections.

5. **Diagnostics**: Identification of the infecting bacteria by staining and culture technqiues, immuno assays including ELISA, Western blotting, agglutination etc. and molecular techniques using PCR, RT-PCR.

Suggested reading:

1. Cole ST, Eisenach K.D, McMurray D.N and Jacobs W.R. Tuberculosis and the tubercle bacillus. ASM Press.

2. Hacker J.H and Heesemann J, Molecular infection biology: Interactions between microorganisms and cells. Wiley Blackwell Publishers.
3. Schaible U.E and Haas A, Intracellular Niches of Microbes: A Pathogens Guide Through the Host Cell by Modern Parasitology. Wiley Blackwell Publishers.
4. A textbook of Parasitology by F.E.G. Cox. Wiley Blackwell Publishers.
5. Frank SA, Immunology and Evolution of Infectious Disease. Princeton University Press.
6. J.D Smyth, Introduction to Animal Parasitology. Cambridge University Press.
7. Ahmed N, Dawson N, Smith C and Wood Ed. Biology of Disease. Taylor and Francis Group.
8. Sherman I.W. Malaria Parasite Biology, Pathogenesis and Protection. ASM Press.
9. Ajioka J.W and Soldati D. Toxoplasma Molecular and Cellular Biology. Horizon Bioscience.
10. Pommerville J.C. Alcamo's Fundamentals of Microbiology. Jones and Bartlett Publishers.
11. Salyers A. A and Whitt D.D. Microbiology-Diversity, Disease and Environment. Fitzgerald Sciences Publishers.

1. Reproductive endocrinology of fishes, Sex determination and differentiation: Genetic, environmental and hormonal regulation, Natural Sex change
2. Sex reversal in fishes and their applications, Production of monosex populations
3. Aquaculture and fish seed production: Hypophysiation, hCG injections and Linpe technique
4. Algae, shellfish, shrimp and prawn culture
5. Impacts of endocrine disrupters on aquaculture
6. Growth hormone transgenics and stem cell technology for betterment of aquaculture
7. Utilization of marine bacteria and fungi for pharmaceutical and nutraceutical industries: Special reference to production of agents for antibiotics (methicilin resistant bacteia), anti-oxidants (astaxanthin) and feed additives
8. Marine bio/fish resources and its applications in pharmaceutical and Nutraceutical industries
9. Fish meal and oil- products of marine algae
10. Fresh water and marine (oyster) pearl culture technology.

Suggested reading:

1. Ostrander G.K. The laboratory fish. Academic Press.
2. Dunham R.A. Aquaculture and Fisheries Biotechnology and Genetic Approaches. CABI Publishing, UK.
3. Zaborski O.R and Attaway D.H. Marine Biotechnology. Pharamaceutical and bioactive natural Products. Springer Science.

EPIGENETICS AND NUCLEAR DYNAMICS
(AB 524)

1. **Epigenetic reprogramming, Genomic imprinting**: Nuclear Cloning, Epigenetic Reprogramming, and Cellular Differentiation in Early Mammalian Development, Genomic Imprinting: Germ Line and Early Embryo.
2. **DNA & Histone modifications:** Reading the DNA Methylation Signal, Role of De Novo DNA Methyltransferase, The Rigidity and Plasticity of the Marks, Histone code hypothesis, Histone modifiers. Links between the DNA Replication Machinery and Epigenetic Gene regulation, Non-covalent Modification of Chromatin: chromatin remodelling and accessibility complexes,
3. **Regulatory roles of Non coding RNA**: miRNAs, LincRNAs, Chromatin RNA interactions. Role of XIST and AIR non-coding RNAs in Mammalian X–Chromosome Inactivation and An Imprinted cis–silencing at Kcnq1 locus respectively. nRNA Interference and Related Mechanisms, eRNAs.
4. **Structural organization cell nucleus:** Electron microscopic studies on nuclear organisation. Spatial organisation of euchromatin, heterochromatin. Concept of nuclear matrix. Chromosome territories, gene positioning. Fractal geometry of chromatin, Primary, secondary and tertiary structural organisation of chromatin, Spatial organisation of genes and regulatory elements.
5. **Functional organisation of the cell nucleus:** Chromatin movements, Nuclear bodies and its significance: RNA PolII transcription factories, Polycomb silencing bodies, PML bodies, splicing speckles, Cajal bodies and other nuclear domains. Gene clustering and long range chromatin interactions for transcriptional activation or silencing, Nucleolus, Telomere Clustering. Epigenetic regulation of higher order chromatin structure, chromatin insulators and its role in genome architecture. Gene regulation in 3-dimensions. Thermodynamics of nucleus. Phenomenon of molecular crowding effect
6. **Epigenomic methods and epigenetic perspective of diseases.**

Suggested reading:

1. Nuclear organization and function: Cold spring harbour symposia on quantitative biology Volume LXXV (2010). Cold Spring Harbor Laboratory Press
2. Allis D et al., Epigenetics: Cold Spring Harbor Laboratory Press,
3. Armstrong L. Epigenetics: Garland Science publishers

NEUROBIOLOGY
(AB 571)

1. **Introduction**: To cellular and molecular basis of nervous system and its uniqueness.
2. **Neural Development:**
   a) Turning embryonic stem cells into neurons
   b) Glial guided neuronal migration**,** path finding, and axon guidance
3. **The Macroscopic Organization of the Brain:**
   a) Functional anatomy of the brain
   b) Cellular heterogeneity of nervous system
   c) Blood Brain Barrier and its disorders
4. **Synaptic Transmission: Electrical and Chemical transmission**
   a) Membrane potentials (Resting and Action potentials)
   b) Ion channels and Voltage-gated channels
   c) Synapse formation
   d) Neurotransmitters (synthesis, storage and function)
   e) Disorders of synaptic transmission
5. **Cognitive Neuroscience:**
   a) Role of limbic system in cognition,
   b) Cellular and molecular basis for learning and memory
   c) Synaptic plasticity
6. **Special aspects of brain metabolism:**
   a) Brain specific genes, DNA, RNA and protein synthesis
   b) Amino acid transport
7. **Molecular aspects of neurological dysfunction and neurodegeneration:**
   a) Mechanism of apoptosis and special aspects of neurodegeneration.
   b) Neurodegenerative diseases: Alzheimer's Disease, Parkinson's Disease, Creutzfeldt-Jakob Disease (CJD), Amyotrophic Lateral Sclerosis (ALS), Epilepsy, Schizophrenia.
   c) Cerebrovascular Diseases: Stroke, Arteriosclerosis, Arterio Venous Malformations (AVMs), Aneurysms.

Suggested reading:

1. Kandel E, Schwartz J, Jessell T, Siegelbaum S and Hudspeth A. J. Principles of Neural Science 2000, Fourth Edition, McGraw-Hill Companies USA.
2. Siegel G.J, Agranoff B.W, Albers R.W and Molinoff P.B. Basic Neurochemistry. Raven Press.
3. Brady S, Siegel G and R. Wayne Albers. Basic neurochemistry: Molecular, Cellular and Medical Aspects. Seventh Edition: Raven Press.
4. Purves D, Augustine G.J, Fitzpatrick D, Hall W.C, Lamantia A.S and White L.E. Neuroscience Fourth Edition (2007). Sinauer Associates.

VACCINOLOGY
(AB 572)

1. Historical perspective work of Edward Jenner on smallpox and cowpox, Louis Pasteur's contribution to vaccinology.
2. Biology of vaccination-Basis of immunization, antigenicity and immunogenicity. Immune response-antigen presentation, cellular and humoral immune response.
3. Antigenic determinants-Structure of viruses, viral antigens and antigenic variation, bacterial antigens and virulence factors, parasitic antigens.
4. Classical categories of vaccines-killed live; adjuvants and vehicles-mineral oil compounds, liposomes, saponins, and biodegradable micro particles.
5. Modern categories of vaccines - multivalent vaccines, synthetic peptide vaccines, recombinant vaccines, DNA vaccines, combination vaccines.
6. Commercial preparation of vaccines, cell culture based vaccines, regulatory aspects of vaccination for humans and veterinary use.
7. Technical aspects of vaccination-routes of vaccination, schemes for vaccination - primary and boosters, storage of vaccines, risks of vaccination.
8. Examples of vaccination-success of small pox vaccine, hepatitis B vaccine, rabies vaccine, challenges in vaccination against HIV, malarial parasites etc.

Suggested reading:

1. Kaufmann S.H. E. Concepts in vaccine development. In Vaccines for the 21st Century: A Tool for Decision making by Institute of Medicine (U.S.). National Academies Press.
2. Brostoff J, Seaddin JK, Male D and Roitt IM. Clinical Immunology, Gower Medical Publishing.

SEMESTER IV – ELECTIVE

CANCER AND CANCER STEM CELL BIOLOGY
AB 573 (New)

1. **Introduction:** Epidemiology of cancer**,** Cancer types, Characteristics of cancer cells; Carcinogenesis: cancer initiation, promotion and progression, termination.Factors responsible for carcinogenesis: Physical, chemical and biological.
2. **Tumor Development:**Models, Tumor angiogenesis, Overview of invasion and metastasis, Cell-cell interactions in cancer, Invasion and the extracellular matrix, Specific cases of Prostate, Breast, Intestinal cancers
3. **Oncogenes and their role in Cancer:** Introduction to oncogenes, Mechanisms of oncogene activation (gene amplification), Mechanisms of oncogene activation (chromosomal translocations), Chromosomal translocations with dominant negative effects, Introduction to tumor suppressor genes.
4. **Cell-Cycle Regulation and Cancer:** Mutations affecting mitogenic signal transduction pathways, Cell Cycle Regulation - Mutations affecting the cell cycle, Loss of checkpoint control and genetic instability,Replicative senescence
5. **DNA Damage, Repair failure and Carcinogen Mechanisms:** Carcinogens, DNA damage and repair, Carcinogenesis: Chemical and physical agents, Carcinogenesis: Repair mechanisms, Aberrant repair and genetic instability, Genetic predisposition to cancer
6. **Tumor Immunology.** Tumor immunology [tumor antigens, cytokines, vaccine development , immunotherapy and its limitations, Tumor cell evasion of immune defenses.
7. **Biology of Cancer Stem cells:** self-renewing properties, disease prognosis and resistance to therapies
8. **Epigenetics, miRNAs in human cancer**
9. **Principles of chemotherapy and chemoprevention.**

Suggested reading:

1. Keinsmith L.J. Principles of Cancer Biology. Amazon Publishers.
2. Weinberg R.A. Biology of Cancer. Taylor and Francis Inc.
3. Alberts B, Bray D, Lewis J, Raff M, Roberts K, and Watson J.D. Molecular Biology of the Cell. Garland Science
4. Ruddon R.W. Cancer Biology: 4th Edition. Oxford University Press

CHRONOBIOLOGY
AB 574 (New)

1. **Introduction to 'chronobiology':** Different types of geophysical and biological cycles with examples of circadian rhythms. Characteristics of circadian rhythm: Free-run, Temperature and nutrition compensation, Zeitgeber Time (ZT) and Circadian Time (CT) and Entrainment. Photoperiodism.
2. **Entrainment, Masking, Zeitgebers for circadian clocks:** Key properties of a Zeitgeber. Photic and non-photic zeitgebers. Specialized photoreceptors.
3. **Phase response curves (PRC):** Quantification of biological rhythms - Average, amplitude, phase, and period. Brief introduction to various time series analysis including COSINOR
4. **Circadian pacemakers in various organisms with special reference to Suprachaismatic nucleus in mammals:** Multi-oscillatory organization: master and slave oscillators, morning and evening oscillators, Central pacemaker and peripheral clocks.
5. **Molecular mechanisms underlying clock functions in organisms from bacteria to mammals:** Autoregulatory transcriptional feedback loops; Circadian clock mutant types. Temporal expression pattern and Regulation of expression of clock genes.
6. **Clock's relationship to pathology**: Chronopharmacology, circadian dependence of drug pharmacokinetics. Chronotherapy: Application of chronotherapy in treatment of different types of cancer, chronopump, cardiovascular diseases, allergies and asthma, Jet lag, Shift work, sleep disorders, mood disorders, alertness and performance rhythms. Aging and pathophysiological circadian dysfunction

Suggested reading:

1. Dunlap J.C Loros J.J and DeCoursey P.J. Chronobiology: Biological timekeeping. Sinauer Associates.
2. Hrushesky W.J.M. Circadian cancer therapy.
3. Jagota A and Gupta P.D. Living Clocks
4. Palmer J.D, Brown Jr F.A and Edmunds Jr L.N. An introduction to biological rhythms. Academic Press

SEMESTER IV – ELECTIVE

SIGNAL TRANSDUCTION
AB 575 (New)

1. **Overview of Signal Transduction :** What is a cell signaling, different type of cellular communications, its effects on cell biology in broader perspective.
2. **Principles and Mechanisms of signaling Interactions:** Receptor and ligand mechanisms, autocrine and paracrine signaling, various signaling molecules and their interactions, upstream and downstream mechanisms.
3. **Role of Post-Translational Modifications in Signaling:** Various post translational modification mechanisms, agonist and antagonist mechanisms, dynamics of modifications and feedback mechanisms.
4. **Sub cellular Localization of Signaling Molecules:** Extracellular and Intra cellular signaling, sub cellular organelle communications.
5. Role of Lipids and Enzymes in Modifying Signaling
6. Signaling in Regulated Protein Degradation
7. Modular Architecture and Evolution of Signaling Proteins
8. Insights in Cell's Decision Making
9. Methods for Studying Signaling Proteins and Networks
10. Translational perspective in targeting signaling intermediates; lessons learned.

Suggested reading:

1. Hancock J.T. Cell Signaling. Oxford University Press.
2. Lim W, Mayer B, Pawson T. Cell Signaling, Principles and mechanisms. Garland Sciences.
3. Kraus G Biochemistry of Signal Transduction and Regulation. Willey-VCH Publications.

Gene Regulatory Networks: Cell Identity and Function
AB 576 (New)

1. **Regulatory components of networks:** Regulatory inputs of gene networks: extracellular signals, transcription factors, small RNAs and RNA binding proteins. Transcription factor-DNA interactions that control specific genes in large regulatory networks.
2. **Structural organization and properties of networks:** Architecture of networks based on expression data, and data from cis-regulatory analyses, interactions between regulatory components, positive and negative feedback loops and maintenance.
3. **Output of gene networks: structure and function relation:** Cellular responses, establishment cell identify and function
4. **Large-scale gene expression analyses:** High throughput approaches to evaluate the expression levels of transcription, biogenesis of small RNAs, protein expression and post-translational modifications.
5. **Computational analyses and mathematical models:** Quality assessment of high throughput data, read alignment, generation of count data, data normalization and presentation.
6. **Gene networks and dysfunction:** Perturbation of gene networks and their effect on cell fate, development and function, and development of drugs and therapeutic approaches.

Suggested reading:

Peter, I. S. and Davidson, E. H. Genomic Control Process, Development and Evolution. Academic Press/Elsevier

SYLLABUS FOR PRACTICALS

SEMESTER – I
(AB 405)

Module 1: Biochemical techniques

1. Introduction to good laboratory practices
2. Solutions and buffers
3. Spectral characterization of macromolecules:
   i. Spectrophotometry: Determination of absorption spectra and extinction – coefficient
   ii. Quantitation of protein and DNA by UV-Visible and Calorimetry
   iii. Hyperchromic effect and Tm determination
   iv. Spectrofluorimetry (demonstration)
4. Separation and Chromatographic techniques:
   i. Dialysis
   ii. Size exclusion,
   iii. Ion exchange
   ii. Affinity
5. Statistical analysis

Module 2: Genetic methods

1. Introduction to microscopy : Light, confocal, scanning and transmission microscope- demonstration
2. Chromosomal preparation:
   i. Squash preparation from *Drosophila melanogaster* salivary gland
   ii. Preparation of metaphase chromosomes from bone marrow/cell line
3. Drosophila Genetics :
   i. Law of segregation by making monohybrid cross involving sepia eye mutant and red eye
   ii. Law of independent assortment by making dihybrid crosses involving sepia eye and vestigial wing mutant and red eye and long wing
   iii. Linkage and crossing
   iv. Sex linkage by making reciprocal crosses involving red eye and white eye
4. Bacterial/Yeast Genetics:
   i. Mating type
   ii. Complementation

Module 3: Microbiological techniques

1. Preparation of culture media and sterilization methods
2. Staining of microorganisms: Gram's staining, Acid fast staining
3. Ubiquitous nature of microorganisms
4. Isolation of pure cultures by streak, spread and pour plate methods
5. Determination of bacterial growth curve
6. Biphasic bacterial growth curve
7. Antibiotic sensitivity testing
8. Biochemical characterization by assaying enzymes like catalase and amylase
9. Phage titration

SEMESTER – II
(AB 455)

Module 4: Isolation of organelles and macromolecules

1. Cell disruption techniques - Sonication, Homogenization and French press
2. Differential centrifugation for preparation of cellular fractions
3. Density gradient centrifugation for isolation of organelles
4. Isolation of macromolecules – DNA, proteins and lipids using liver tissue
5. Protein precipitation- Ammonium sulphate and TCA

Module 5: Protein purification and analysis

1. Chromatographic separation techniques
   i. gel permeation chromatography
   ii. Ion exchange chromatography - DEAE and CM cellulose
   iii. Affinity based-Ni and GST
   iv. HPLC
2. Enzyme kinetics
3. Analytical techniques
   i. Electrophoretic separation of protein by SDS-PAGE
   ii. Detection of glycoproteins
   iii. Western blotting
   iv. Analysis of total proteome by 2D electrophoresis (demonstration)
   v. MALDI-TOF, Q-TOF(demonstration)

Module 6: Immunological methods

1. Raising of polyclonal antibodies (demonstration)
2. Purification of antibodies
3. Double immunodiffussion and radial immunoduffusion
4. ELISA.

5. Flow-cytometry (demonstration)
6. Phagocytic activity of macrophages

SEMESTER – III
(AB 504)

Module 7: Histological techniques

1. Histology
   i. Tissue fixation, paraffin embedding and sectioning.
   ii. Hematoxylin-eosin staining
   iii. Light microscopy and microphotography (demonstration)
2. Immunocytochemistry
   i. Antibody staining and chromogen detection.
   ii. Immunoflourescence
3. *In situ* hybridization (demonstration)

Module 8: Genetic Engineering and Bioinformatics

1. Isolation of Genomic DNA from bacteria.
2. Plasmid DNA isolation and Cloning
3. Bacterial transformation and screening of recombinants
4. Genomic PCR and Restriction mapping
5. Southern / Northern hybridization (non-radioactive)
6. Isolation of total RNA, RT-PCR, Realtime PCR and microarray (demonstration)
7. Expression and purification of recombinant proteins in *E. coli*
8. Public domain databases: overview and retrieving of gene sequences
9. BLAST analysis of DNA and protein sequences
10. Analysis of genes: restriction sites, translation of DNA sequence etc
11. Primer designing
12. *In silico* prediction: signal peptide,transmembrane domains, nuclear export and import signals, mitochondria targeting signals, DNA binding domains, post translational modifications on proteins like phosphorylation and glycosylation

Module 9: Mammalian Cell Culture

1. Preparation of culture media
2. Establishment of primary cell culture: mouse splenocyte culture
3. Handling mammalian cell lines: thawing, culture maintenance and cryopreservation
4. Cell counting using hemocytometer
5. Cell viability and proliferation assays:
   i. Trypan blue exclusion test
   ii. MTT assay
   iii. Propidium Iodide staining
   iv. CFSC labeling
6. Mammalian cell transfection (transient)
7. Immunofluorescence detection to check transfection efficiency (using

fluorescence and confocal microscopes)

Suggested reading:

1. Holme D.J and Peck H. Analytical Biochemistry. Longman Scientific and technical Publishers.
2. Plummer D.T. An Introduction to Practical Biochemistry. Tata McGraw-Hill Publishing Company Limited.
3. Sambrook J and Russell D.W. Molecular Cloning, volumes 1,2 and 3 . Cold Spring Harbor Lab Press.
4. Wilson K and Walker J. Principles and techniques of Biochemistry and Molecular Biology. Cambridge University Press.
5. Harlow E and Lane D. Antibodies: A Laboratory Manual. Cold Spring Harbor Lab Press.

SEMESTER- IV
(AB 551)

Project Work:

M. Sc. students initiate research project in Semester III and the entire IV semester is utilized for completion of project work under the supervision of respective faculty. The project is written as a dissertation and presented orally for evaluation.