Molecular Life Sciences

First Semester

Learning outcome, course content, references and general format of assessment for each course unit are indicated below. Based on the advances in the field these will be updated whenever appropriate.

Course Unit MLS5010: Life & Biomolecules – 2 Credits
(Lectures – 15 h, Practical classes / Assignments/ Tutorials - 30 h)

Learning outcome:
At the end of this course unit student will be able to

- Give an overview of life process, cells and genomes
- Correlate structure, chemical properties and function of biomolecules
- Isolate lipids from animal or plant tissue
- Detect carbohydrates, lipids and proteins in a given sample
- Detect DNA and RNA in a given sample

Course content:

Overview of Life
Cells and Genomes: Universal features of cells**,** tree of life, chromosomes and genomes, genes and alleles, general structure of an eukaryotic gene, overview of Mendellian inheritance, diversity of genomes (eukaryotic, prokaryotic and viral)
Biomolecules: Molecular architecture of living matter:
Carbohydrates: Structure, chemical properties and biological importance of monosaccharides, disaccharides, polysaccharides**,** glycolipids and glycoproteins; reducing properties of sugars
Lipids: Structure, chemical properties and biological importance of triglycerides, fatty acids and other derived lipids (mono and diacylglycerols, alcohols) compound lipids (phospholipids, sphingolipids, glycolipids etc), sterols (cholesterol, vitamin D, steroid hormones etc), miscellaneous (carotenoids, Vitamin E, K etc.)
Proteins: Amino acids – structure, classification, stereoisomerism, isoelectic point, biological importance etc; primary, secondary, tertiary and quaternary structures of proteins; biological functions
Nucleic Acids: DNA and RNA: purine and pyrimidine bases, deoxyribose sugar, ribose sugar, nucleosides and nucleotides, base pairing; Overview of DNA timeline (establishment of DNA as hereditary material), DNA double helix, backbone, helix axis etc; property of semiconservative replication; unusual structures of DNA; An overview of RNA, mRNA, ribosomal RNA and tRNA (detail studies including other RNAs in 2nd semester)
Detection of biomolecules
Spectrophotometry (Beer Lambert Law, structure of spectrophotometer, applications of spectrophotometers)
Lipid extraction methods

References:
Lehninger Principles of Biochemistry, David L. Nelson, Michael M. Cox, W.H. Freeman and Company, New York
Molecular Biology of the Cell, Bruce Alberts et al, Garland Scince, New York, USA

Genomes 4, T A Brown, Garland Science, USA

Evaluation Procedure:
By continuous assessments contributing 30% and end of course assessment contributing 70% of the final mark for the course
Continuous assessment will comprise of a class test (15%), assignments (10%) and practical reports (05%)
End of course assessment will comprise of a written paper (70%)

Course Unit MLS5020: Cell Biology – 2 credits
(Lectures –15 h, Practical classes / Assignments/ Tutorials –30 h)

Learning outcome:
At the end of this course unit student will be able to

- Describe structure, function and organisation of cells
- Correlate how cells behave in social context to organise into tissues
- Compare and contrast animal and plant cells/tissues with respect to the above
- Isolate cells from a tissue, visualise cells and isolate cellular components
- Identify C3 and C4 plants using leaf anatomy

Course content:

Cell as a unit of life
Functional morphology of the animal cell: Structure and functions of following cellular compartments**:** mitochondria, lysosomes, peroxisomes, endoplasmic reticulum, Golgi apparatus, nucleus and associated structures
Cells in Social Context:
Cell adhesion molecules: Structure, types, function of cadherins, integrins, selectins, immunoglobulin like cell adhesion molecules; consequences of genetic deficiency
Cell junctions: Structure, components and functions of tight junctions, anchoring junctions, gap junctions and signal relaying junctions
Extra cellular matrix: Function of extracellular matrix, extracellular matrix molecules (collagens, elastic fibers, proteoglycans, glycosaminoglycan (GAG), adhesive glycoproteins), matrix receptors and co-receptor, basal lamina, degradation of extracellular matrix
Cytoskeleton and molecular motors: Structure, properties and functions of microtubules, intermediate filaments, actin filaments; regulation of cytoskeletal filaments; cytoskeleton and cell behaviour; actin based and microtubules based motor protein, effect of ATP hydrolysis on motor proteins
Isolation and visualization of animal cells: Light and phase contrast microscopy in visualising cells; locating specific molecules within a cell using antibodies and fluorescence
Isolation of cellular components from animal tissue: Centrifugation (theory of centrifugal force, types of centrifuges, types of rotors, applications of centrifugation); isolation of cellular components by differential centrifugation
Plant cell: Specific structures of plant cells, plant stem cells and their differentiation, role of cell wall in cell differentiation; C3, C4 and CAM plants, photorespiration, C3 and C4 photosynthesis,

identification of different cell types using cross sections of stems and leaves, identification of C3 and C4 plants using leaf anatomy

References:
Molecular Biology of the Cell, Bruce Alberts *et al.*, Garland Science, New York, USA
Lewin's Cells. Editors: L. Cassimeris, V.R Lingappa, G Plopper, Jones and Bartlett Publishers
Plant Cell Biology, Brian E S Gunning and Martin W Steer, Jones and Bartlett Publishers
Journal articles recommended

Evaluation procedure:
By continuous assessments contributing 30% and end of course assessment contributing 70% of the final mark for the course
Continuous assessment will comprise of a class test (15%), assignments (10%) and practical reports (05%)
End of course assessment will comprise of a written paper (70%)

Course Unit MLS5030: Biological membranes, transport across membranes and cell signalling - 2 Credits
(Lectures – 15 h, Practical classes/ Assignments/Tutorials – 30 h)

Learning outcome:
At the end of this course unit student will be able to

- Correlate components, structure and properties of biological membranes
- Distinguish between different biological membranes
- Compare and contrast transport mechanisms across biological membranes
- Describe the neural communication and underlying cellular events
- Compare and contrast signalling pathways used by chemical messengers
- Outline the principles of different methods used for hormone assays

Course content:

Biological membranes
Structure and composition of biological membranes: Constituents of biological membranes and their properties; membrane models- historical developments, fluid mosaic model, recent developments on membrane models; specialised areas of biological membranes (eg: lipid rafts), membrane curvature and healing of membranes
Transport across biological membranes: Kinetics and mechanisms of transport, simple diffusion, facilitated diffusion via ion channels and transporters, active transport, Na^+/K^+/ATPase pump, Ca^{++}/ATPase, H^+/ATPase; ABC transporters; endocytosis and exocytosis

Cell to cell communications and cell signalling
Neural communication: Overview of the nervous system, generation and transmission of nerve impulses, neurotransmitters, synapses and neuromuscular junction, excitation contraction coupling
Communication via chemical messengers: Endocrine system, peptide and steroid hormones, biogenic amines, eicosanoids and growth factors; endocrine, paracrine and autocrine effects;

signalling through voltage gated and ligand gated ion channels; signalling through receptor enzymes- tyrosine kinase and serine threonine kinase receptors; PI-3 kinases in signalling; signalling through enzyme-linked cell surface receptors- JAK-STAT pathway; MAPkinase cascade; signalling through G-protein coupled cell-surface receptors; monomeric G proteins in cell signalling; scaffold proteins, signalling through cytoplasmic and nuclear receptors; signalling mechanism in vision, olfaction, perception of taste; signalling in plants;
assaying for signalling molecules with a hormone assay as an example

References:
Lehninger Principles of Biochemistry, David L. Nelson, Michael M. Cox ,
W.H. Freeman and Company, New York
Molecular Biology of the Cell, Bruce Alberts et al, Garland Science, New York, USA
Text book of Biochemistry with Clinical Correlations – Devlin
Ganong's Review of Medical Physiology, K E Barrett et al,

Evaluation procedure:
By continuous assessments contributing 30% and end of course assessment contributing 70% of the final mark for the course
Continuous assessment will comprise of a class test (15%), assignments (10%) and practical reports (5%)
End of course assessment will comprise of a written paper (70%)

Course Unit MLS5040: Enzymology and Energy Homeostasis 3 credits
(Lectures - 30 h, Practical classes / Assignments/Tutorials– 30 h)

Learning outcome:
At the end of this course unit student will be able to

- Describe chemical and physical properties of an enzyme
- Explain the principle of enzyme catalyzed reactions
- Give an outline of enzyme activation, inhibition, induction, repression and inactivation
- Analyse and interpret results from an enzyme kinetic experiment
- Explain the functions of regulatory enzymes and its mechanism of regulation
- Outline uses and applications of enzymes
- Appraise bioenergetics and thermodynamics
- Describe the mechanism and regulation of oxidative phosphorylation

Course content:

Enzymology
Enzymes:
Biological catalysis; regulatory enzymes; basic principles of enzyme catalyzed reactions; enzyme kinetics; enzyme activation, inhibition, induction, repression and inactivation (proteolytic activation, covalent modification, allosteric modification, etc.); classification of enzymes and isoenzymes; multi enzyme complexes, protective enzymes; basic principles of enzyme assay methods

Applications of Enzymes: Application of enzymes in industries; medical applications of enzymes: use of enzyme levels as markers of tissue damage, enzymes as therapeutic targets; immobilized enzymes; purification of enzymes
Energy Homeostasis Bioenergetics & Oxidative phosphorylation – Bioenergetics and thermodynamics, phosphoryl group transfer and ATP, the concept of free energy and biological oxidation-reduction reactions (the redox potential); oxidative phosphorylation

References:
Lehninger Principles of Biochemistry, David L. Nelson, Michael M. Cox,W.H. Freeman and Company, New York.
Enzyme kinetics and Mechanism, Paul F. Cook and W.W. Cleland, Garland Science
Enzymes in Industry: Production and Applications, Wolfgang Aehle (Editor), Wiley-VCH
Industrial Enzymes, Structure, Function and Applications, Polaina, Julio, MacCabe, Andrew P. (Editors), Springer
Immobilization of Enzymes and Cells, Guisán, José M. (Editor), Springer
Enzymes in Food Processing, A volume in Food Science and Technology Tilak Nagodawithana, Gerald Reed and Steve Taylor, Elsevier Enzymes in farm animal nutrition, Bedford, M. R., Partridge, G. G. (Editors), CABI Books
Hand Book of Food Enzymology, J.R. Witaker, A.G.J. Voragen Voages and D.W.S. Wong, Marcel Dekker, New York
Journal articles recommended

Evaluation procedure:
By continuous assessments contributing 30% and end of course assessment contributing 70% of the final mark for the course
Continuous assessment will comprise of a class test (15%), assignments (5%) and practical reports (10%)
End of course assessment will comprise of a written paper (70%)

Course Unit MLS5050: Metabolism – 3 credits
(Lectures - 30 h, Assignments/Tutorials– 30 h)

Learning Outcome:
At the end of this course unit student will be able to

- Analyse the role of anabolic and catabolic pathways with respect to carbohydrates, lipids and proteins in health and disease
- Discuss how the above are regulated and inter-related
- Describe anabolism and catabolism of haemoglobin and nucleic acids and their regulation in health and disease

Course content:

Intermediary metabolism and its regulation:
Carbohydrate metabolism - glycolysis, TCA cycle, pentose phosphate pathway, glycogen metabolism, gluconeogenesis, fructose and galactose metabolism; **Lipid metabolism**- Fatty acid oxidation, Fatty acid synthesis, cholesterol metabolism, ketone body metabolism, lipoprotein

metabolism; **Protein metabolism** - Protein catabolism, (protein turnover, enzymes participating in protein degradation, chemical signals for protein turnover, general catabolism of amino acids (transamination, deamination, Decarboxylation & their biological and clinical importance), urea cycle, catabolism of specific groups of amino acids (sulphur containing, aromatic and branched chain amino acids)
Metabolic interrelations and its regulation
Metabolism of other important compounds: Haemoglobin metabolism, nucleotide metabolism etc.
Overview of derangements of above pathways leading to diseases

References:
Lehninger Principles of Biochemistry, David L. Nelson, Michael M. Cox , W.H. Freeman and Company, New York –
Lippincott's Biochemistry, Dennis R Ferrier, Lippincot, Williams and Wilkins, New York
Text book of Biochemistry with Clinical Correlations –Thomas Devlin, John Wiley and Sons
Journal articles recommended

Evaluation procedure:
By continuous assessments contributing 30% and end of course assessment contributing 70% of the final mark for the course
Continuous assessment will comprise of a class test (15%) and assignments (15%)
End of course assessment will comprise of a written paper (70%)

Course Unit MLS5060: Molecular Techniques I: 3 credits- Lectures 15 h, Practical classes -60 h

Learning outcome:
At the end of this course unit students will be able to

- Explain the principles behind the basic molecular biological techniques for DNA manipulation
- Use basic laboratory instruments in experiments
- Use appropriate enzymes in manipulation of DNA
- Apply hybridization techniques in the experiments
- Describe different electrophoresis methods used in the separation of nucleic acids
- Design PCR primers and PCR amplification assays and interpret results.
- Organize experimental procedures to minimize or prevent PCR contaminations.

Course content:
Molecular biological and biochemical instrumentation; microbiological (sterile) techniques; preparation of molecular biological reagents; pH and pKa – theory and practice; extraction and quantification of nucleic acids; nucleic acid manipulating enzymes and their uses (restriction endonucleases, DNA polymerases, reverse transcriptase, alkaline phosphatases, polynucleotide kinase, terminal transferase, DNAse, RNAse); immobilization of nucleic acids; nucleic acid labeling, DNA probes and hybridization of nucleic acids; electrophoresis (agarose gels, polyacrylamide gels, 2D-electrophoresis, PFGE etc.); polymerase chain reaction - primer designing, PCR, optimization, - prevention of nonspecific amplicons and contamination

References:
Calculations for Molecular Biology and Biotechnology by Frank Stephenson, Elsevier

DNA Probes by George H. Keller and Mark M. Manak, Macmillan
PCR Protocols by Daniel J. Park, Springer
Molecular Biology Techniques, A Classroom Laboratory Manual by Heather Miller D. Scott Witherow Sue Carson, Elsevier
Genetic Engineering by Smita Rastogi and Neelam Pathak, Oxford University Press

Evaluation procedure:
By continuous assessments contributing 30% and end of course assessment contributing 70% of the final mark for the course
Continuous assessment will comprise of a class test (10%) and practical reports (20%)
End of course assessment will comprise of a written paper (40%) and a practical test (30%)

Second Semester

Course Unit MLS5070: Molecular Biology – 4 credits (Lectures – 30 h, Assignments / Tutorials – 60 h)

Learning outcome:

At the end of this course unit student will be able to

- Describe historical developments identifying DNA as genetic material, elucidation of structure of DNA and confirmation of semi-conservative replication
- Compare and contrast the mechanism and enzymes involved in DNA replication and repair in prokaryotes and eukaryotes
- Compare and contrasts the mechanism and regulation of transcription in prokaryotes and eukaryotes
- Discuss tissue specificity of gene expression and its regulation
- Illustrate the process of translation, post translational modifications, protein sorting and their regulation
- Categorise types of RNA, their synthesis, functions and regulation

Course content

Historical aspects of DNA
Historical developments leading to identification of DNA as genetic material, elucidation of double helical structure of DNA and confirmation of semi-conservative replication

Biological information storage, processing and transfer in the cell
DNA replication: DNA replication in prokaryotes; enzymology of DNA replication – discovery, structure and function of DNA polymerases, DNA ligase, primase etc; accuracy and fidelity of replication, replication origin, replication fork, replisome, associated proteins; initiation, elongation and termination of DNA replication; DNA replication in eukaryotes and its regulation; eukaryotic DNA polymerases and components of the replisome.
DNA Repair: DNA damage – mechanisms and consequences; DNA repair mechanisms – base excision repair, nucleotide excision repair, mismatch repair, direct repair; repair of DNA double strand breaks: error prone repair, homologous recombination; differences and similarities between prokaryotic and eukaryotic DNA repair, DNA transposition

Transcription: Transcription in prokaryotes and eukaryotes; eukaryotic transcription factors and their role on regulation of gene expression; tissue specific transcription factors; the role of chromosome structure, remodeling, acetylation/decaetylation and methylation of histone proteins on gene transcription, mechanisms of genomic imprinting
Translation and post translational modifications: Prokaryotic and eukaryotic translation, alternate splicing, post translational modifications
Protein targeting and folding; Protein sorting and intracellular vesicular traffic: Mechanisms that enable transport between different cellular compartments and secretion from the cell
RNA - Non coding RNAs (eg: microRNA, small RNA, long non coding RNA): Biogenesis and their effects on information processing

References:
Genome 4, T A Brown, Garland Science, New York
Lehninger Principles of Biochemistry, David L. Nelson, Michael M. Cox,W.H. Freeman and Company, New York
Molecular Biology of the Cell, Bruce Alberts et al, Garland Science, New York
Molecular Cell Biology, Harvey Lodish, W. H. Freeman, New York
Journal articles recommended

Evaluation procedure:
By continuous assessments contributing 30% and end of course assessment contributing 70% of the final mark for the course
Continuous assessment will comprise of a class test (20%) and assignments (10%)
End of course assessment will comprise of a written paper (70%)

Course Unit MLS5080: Advance Cell Biology and Molecular Genetics of Cancer – 3 credits (Lectures – 30 h, Practical classes/ Assignments/ Tutorials – 30 h)

Learning outcome:
At the end of this course unit student will be able to

- Describe gametogenesis, fertilization and early development in the human
- Appraise the cell cycle and its regulation
- Illustrate apoptosis and underlying mechanisms
- Discuss types and properties of stem cells
- Illustrate the hallmarks of cancer and genetic basis of cancer

Course content:
Gametogenesis, fertilization and development of multicellular organisms: Human oogenesis and spermatogenesis, human fertilization, blastocyst, implantation, mechanisms that govern development of multicellular organisms
Cell division, cell cycle: Components of the cell cycle; cell cycle control system including cyclins, cyclin dependent kinases & APC; cell cycle check points, mitosis and meiosis, cytokinesis, intracellular control of cell cycle events
Apoptosis: Intrinsic, extrinsic and common pathways, initiator and executioner caspases, role of P53 in apoptosis, other pro-apoptic and anti apoptic genes/proteins, detection of apoptosis by microscopy and DNA fragmentation assays

Stem cells: Definition, special characteristics; embryonic stem cells, generation and cell potency; adult stem cells, types, sources, signalling pathways; induced pluripotent cells; regeneration, physiological, reparative, hypertrophy, epimorphosis, morphallaxix etc.; stem cell culture, uses of stem cells, ethical, legal and societal implications; cancer stem cells
Molecular genetics of cancer: Hallmarks of cancer, genes associated with cancer: proto-oncogenes, tumor suppressor genes, caretaker genes (DNA repair genes) – examples such as *BRCA1/BRCA2, P53, RB* etc, discovery, mutation spectra, mechanism of carcinogenesis, disease association, implications for screening, diagnosis and management

References:
Molecular Biology of the Cell, Bruce Alberts et al, Garland Science, New York
Essential Reproduction, Martin H Johnson, Wiley Blackwell
Journal articles recommended

Evaluation procedure:
By continuous assessment contributing 30% and end of course assessment contributing 70% of the final mark for the course
Continuous assessment will comprise of a class test (15%), assignments (10%) and practical reports (05%)
End of course assessment will comprise of a written paper (70%)

Course Unit MLS5090: Basic Bioinformatics: Credits 1 (Practical classes and assignments 30 h)

Learning outcome:
At the end of this course unit student will be able to

- Explain the principles underlying, perform appropriate bioinformatic analyses and interpret results on pairwise and multiple sequence comparison
- Carry out sequence based searches
- Predict protein sequences from DNA sequences
- Predict secondary and tertiary structure of proteins
- Infer phylogenetic relationships between organisms

Course content:

Basic Bioinformatics
Overview of historical aspects; basic sequen**c**e manipulations (complementing, reverse complementing, ORF, translation, restriction sites etc); sequence aligning (Dot matrix, local, global and multiple alignments); DNA and protein databases; searching DNA and protein sequences over databases; bioinformatical characterization of proteins; protein structure prediction and analysis; phylogenetic analysis

References:
Introduction to Bioinformatics Arthur M. Lesk, Oxford University
Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins – Andreas D., Baxevanis, B.F. Francis Ouellette, John Wiley & Sons
Resource materials provided on line

Evaluation procedure:

By continuous assessments contributing 50% and end of course assessment contributing 50% of the final mark for the course
Continuous assessment will comprise of class test (30%) practical assignments (20%)
End of course assessment will comprise of a written paper (50%)

Course Unit MLS5100: Molecular Techniques II – 3 credits (Lectures - 15 h, Practicals – 60 h

Learning outcome:
At the end of this course unit student will be able to

- Apply different PCR based molecular techniques to solve given problems requiring molecular analysis
- Use an appropriate post PCR experiment to detect a given nucleotide variant
- Use an appropriate experiment to confirm expression of a given gene
- Explain the methods of detection in Real Time PCR and uses of Real Time PCR
- Illustrate the principles of recombinant DNA technology and their applications
- Explain the basic principles behind DNA sequencing

Course content:
PCR based applications: nested PCR, multiplex PCR, RAPD, PCR-RFLP, AFLP, SSR, SSCP etc RT-PCR, real time PCR; Principles of Recombinant DNA technology; Principles of DNA sequencing

References:
Methods in Molecular Biology, PCR protocol John M S Bartlett, David Stirling, Volume 226, Humana Press Inc., Totowa
Resource materials provided on line

Evaluation procedure:
By continuous assessments contributing 30% and end of course assessment contributing 70% of the final mark for the course
Continuous assessment will comprise of a class test (10%) and practical reports (20%)
End of course assessment will comprise of a written paper (40%) and a practical test (30%)

Course Unit MLS5110: Guided independent study – 5 credits

Learning outcome:
At the end of this course unit student will be able to

- Carry out a comprehensive literature search
- Write a critical analysis on a given topic
- Design an appropriate experiment to solve a given problem
- Perform the experiment designed
- Interpret results and write a brief report

Course content:
Carrying out a literature search on a given topic

Writing a brief report critically analyzing available literature, designing and setting up of an appropriate experiment using one or more of the techniques learnt during the course to solve a specific problem given; analysis and interpretation of results generated and writing a brief report

Evaluation procedure:
At the end of each component with each component contributing 50% of the final mark for the course
Assessments will comprise of literature report (50%) and practical report (50%)
Specific criteria that will be evaluated will be informed at the beginning of the guided independent study.

Third Semester

Course Unit MLS6010: Selected applications in Molecular Genetics: Credits 2 (Lectures 15 h, practical classes and assignments 30 h)

Learning outcome:
At the end of this course student will be able to

- Describe how genetically modified organisms are produced
- Explain why genetically modified organisms are needed
- Discuss controversies regarding GMOs/ GMFs
- Illustrate the use of DNA in understanding evolution and population migration
- Apply DNA based techniques for individual identification

Course content
Genetically modified organisms - History of plant breeding; challenges in agriculture and food production; definition, need and currently available GMOs and GMFs; global status of GM crops, Uses of GMOs and GMFs; development of transgenic crops; GM foods: GM components (ingredients) in food production; labelling, consumer choice, regulation and testing of GMOs and GMFs
Population and Evolutionary genetics: –DNA variation: repetitive sequences, VNTR, STR etc, single nucleotide polymorphisms; genealogy, Hardy-Weinberg equilibrium, neutral model, linkage disequilibrium, evolution and migration of *Homo sapiens*, mtDNA and Y chromosomal DNA in the study of human migration
DNA identification of individuals

References:
Genomes 4, T A Brown, Garland Science
Introduction to Genetic Analysis, Anthony Griffiths et al, W. H. Freeman
Fundamentals of Forensic DNA Typing, Butler JM, Academic Press Publications, Elsevier
A guide to Forensic DNA Profiling, Editors: Jamieson A & Bader S. John Wiley & sons Ltd
Human Evolutionary Genetics, Jobling M, Hollox E, Kivisild T and Tyler-smith C. Garland Science
Journal articles recommended
Resource materials provided on line

Evaluation procedure:
By continuous assessments contributing 30% and end of course assessment contributing 70% of the final mark for the course

Continuous assessment will comprise of a class test (15%), assignments (10%) and practical reports (05%)
End of course assessment will comprise of a written paper (70%)

Course Unit MLS6020: Recent Advances in Molecular Life Sciences – 3 Credits (Lectures - 30 h, Assignments 30 h)

Learning outcome:
At the end of this course unit student will be able to

- Discuss latest developments in molecular biology and related fields
- Illustrate their uses and applications

Course content:
Lectures / review presentations / seminars on current topics including transcriptomics, proteomics, epigenetics and gene editing etc.

References: Recommended journal articles

Evaluation procedure:
By continuous assessments contributing 50% and end of course assessment contributing 50% of the final mark for the course
Continuous assessment will comprise of assignments (50%)
End of course assessment will comprise of a written paper (50%)

Course Unit MLS6030: Advance Molecular Techniques: 5 credits (Lectures - 30 h, Practical classes – 90 h

Learning outcome:
At the end of this course unit student will be able to

- Discuss the differences between different DNA libraries and their usages
- Identify the different recombinant DNA technologies and usage of different vector systems for applications in cloning
- Outline the applications available for screening the whole or part of the genome
- Propose an appropriate sequencing method to solve a given problem requiring molecular analysis
- Select appropriate methods for protein expression and purification
- Detect protein expression in a given biological sample

Course content
Recombinant DNA technology**:** Cloning phage vectors**,** construction of DNA libraries and their applications (cDNA and Genomic DNA libraries)**,** screening of DNA libraries**,** plasmid vectors**,** features of plasmid cloning vectors**,** expression vectors, shuttle vectors**,** cloning strategies using vectors (directional, TA cloning, TOPO cloning etc)**,** transformation strategies and selection of recombinants

Engineering protein coding sequences for expression and purification of proteins, protein expression, purification, characterization and crystallization; detection of protein expression: immunofluorescence and western blotting; global gene expression analysis – microarrays hands-on experiences on Sanger DNA sequencing; sequencing based fragment analysis and SNP analysis; next generation sequencing

References-

Genetic Engineering by Smita Rastogi and Neelam Pathak, Oxford University Press
Molecular cloning: A laboratory manual.Volumes 1, 2, and 3. By J. Sambrook, E. F. Fritsch, and T. Maniatis, CSHL Press
Gene Cloning and DNA Analysis: An Introduction,T. A. Brown, Wiley-Blackwell
Principles and Techniques of Biochemistry and Molecular Biology, Editors: Keith Wilson, John Walker, Cambridge University Press

Evaluation procedure:

By in course assessment contributing 30% and end of course assessment contributing 70% of the final mark for the course
Continuous assessment will comprise of a class test (10%) and practical reports (20%)
End of course assessment will comprise of a written paper (40%) and a practical test (30%)

Course Unit MLS6040: Optional Module on Molecular Medicine
(15 h lectures, 30 h assignments / practical classes)

Molecular Medicine:

Learning outcome:

At the end of this course unit student will be able to

- Compare and contrast the characteristics of different inheritance patterns
- Illustrate the genetic and molecular basis of selected human diseases
- Discuss the advances in diagnosis of human diseases based on genetic and/or molecular pathology
- Analyse the role of antioxidants in health and disease

Course content:

Historical aspects; chromosomal aberrations leading to diseases, autosomal dominant, autosomal recessive, sex linked recessive inheritance of monogenic diseases; polygenic diseases and genomic approach to complex diseases; diseases due to tri-nucleotide expansion with examples; applications of molecular techniques in disease diagnosis; recombinant technology in vaccine and therapeutic development; gene therapy, cell therapy and immunotherapy; pre natal and pre implantation diagnosis, epigenomics and its implications for molecular medicine; gene environment interaction; genome wide association studies; copy number variation and human health; systems biology and systems medicine; overview of pharmacogenetics and pharmacogenomics; antioxidants in health and disease (stem cells and cancer are covered under the core units)

References:

Introduction to Genetic Analysis, Anthony Griffiths et al, W. H. Freeman

Molecular Medicine- Genomics to Personalized Healthcare, R J Trent, Academic Press
Text Book of Biochemistry with Clinical Correlations, Thomas M Devlin, John Wiley and Sons Inc.
Journal articles recommended

Evaluation procedure:
By in course assessment contributing 30% and end of course assessment contributing 70% of the final mark for the course
Continuous assessment will comprise of a class test (15%) and assignments (15%)
End of course assessment will comprise of a written paper (70%)

Course Unit MLS6050: Optional Module on Plant Molecular Biology:
(15 h lectures, 30 h assignments / practical classes)

Learning outcome:
At the end of this Module student will be able to

- Describe plant genome
- Explain tissue specific and stage specific regulation of plant genes
- Appraise the effect of environmental factors in gene regulation
- Discuss molecular markers used in marker assisted selection
- Illustrate methods used in genetic engineering of plants

Course content
Plant genome (nuclear, chloroplast and mitochondrial genome); regulation & tissue specific expression of plant genes; effect of cell intrinsic information (cell lineage and position) on cell fate; molecular biology of plant development (gene regulation of embryogenesis, leaf development, flower development, self-incompatibility); effect of cell intrinsic information on development in response to light, gravitrophism, thigmomorphogenesis, nutrients; molecular basis of stress responses (abiotic and biotic); molecular markers: marker assisted selection; gene mapping**;** Genetic engineering of plants: techniques for plant transformation, genetic modification in agriculture (taught under genetically modified organisms/ foods)

References:
Mechanisms in Plant Development by Ottoline Leyser and Stephen Day, Blackwell
Molecular Markers in Plants, Editor: Robert J. Henry, Wiley-Blackwell
Molecular Markers in Plant Genetics and Biotechnology by Domonique de Vienne, CRC Press
Plant Genotyping: The DNA Fingerprinting of Plants by Robert J. Henry, CABI Publishing
Plant Genes, Genomes and Genetics by Erich Grotewold, Joseph Chappell, Elizabeth A. Kellogg, Wiley-Blackwell

Evaluation procedure:
By continuous assessments contributing 30% and end of course assessment contributing 70% of the final mark for the course
Continuous assessment will comprise of a class test (15%) and assignments (15%)
End of course assessment will comprise of a written paper (70%)

Course Unit MLS6060: Research methodology, biostatistics and ethics in research – 3 credits (Lectures 30 h, Assignments / Tutorials 30 h)

Learning outcome:
At the end of this course unit student will be able to

- Write a research proposal
- Write an application for ethical approval for a study involving human subjects
- Use appropriate statistical tests to analyse results from biological experiments
- Discuss ethical, societal and legal implications of genetic research, genetic testing and genetic manipulations,
- Discuss ethical, societal and legal implications of reproductive and therapeutic cloning

Course content:
Formulating a research question; general and specific objectives; study designs; conducting a literature review; validation and quality assurance of methodology; descriptive statistics- presentation of data & numerical methods of describing data; Inferential statistics: sample/population concept, confidence intervals; formulating and testing a Hypothesis; tests of significance: parametric and non parametric; one sample tests, two sample tests, comparison of more than two groups; ethical issues in animal and human experimentation, informed consent and confidentiality; ethical, legal and social implications of genetic research, genetic testing, genetic manipulations, reproductive and therapeutic cloning

References:
Prevailing guidelines on research involving a) genetic data b) human subjects c) assisted reproductive technology and cloning from World Health Organization, UNESCO and Other International and National Bodies
Statistics at Square One, Swinscow TDV and Campbell M J, BMJ Publishing Group London, UK
Basic Statistics –Agarwal B. L. New Age International (p) Ltd, New Delhi

Evaluation procedure: Continuous assessments by assignments contributing 50% of the final mark and end of course assessment by written reports contributing to 50% of the final mark

Fourth Semester

Course Unit MLS6070: Research project – 15 credits (4th semester)

Learning outcome:
At the end of this course unit student will be able to

- Independently design a research project
- Implement the designed project
- Analyse results
- Discuss the findings
- Defend the study and its conclusions

Course content
Literature review & project proposal presentation, project implementation & data analysis writing and submission of the Dissertation for examination, defending the Dissertation

Evaluation procedure:
Literature review and project proposal presentation, final presentation, Dissertation examination, Viva Voce contributing to 20%, 20%, 50%, 10% of the final mark respectively

Viva Voce contributing to 20%, 20%, 50%, 10% of the final mark respectively