

# MSc in Molecular Life Sciences - Course Contents

## First Semester

### **Cells and genomes**

Universal features of cells, diversity of genomes

### **Cell as a unit of life and functional morphology of the cell**

Cell membranes, mitochondria, lysosomes and peroxisomes, endoplasmic reticulum, Golgi apparatus, nucleus and associated structures, cytoskeleton and molecular motors

### **Biomolecules and transport across biological membranes**

Molecular architecture of living matter: Nucleic acids, proteins, lipids and carbohydrates. Structure and composition of biological membranes; Fluid Mosaic model; transport across biological membranes, kinetics and mechanisms of transport,  $\text{Na}^+/\text{K}^+$ /ATPase pump,  $\text{Ca}^{++}$ /ATPase,  $\text{H}^+$ /ATPase, gap junctions and group translocation

### **Cell to cell communications and Cell signaling**

#### **Neural communication**

Generation and transmission of nerve impulses, Neurotransmitters, Synapses and neuromuscular junction

#### **Communication via chemical messengers**

Peptide and steroid hormones, biogenic amines, eicosanoids and growth factors

Endocrine, paracrine and autocrine effects

Signaling through G-protein coupled cell-surface receptors

Signaling through enzyme-linked cell surface receptors

Signaling through cytoplasmic and nuclear receptors

Signaling in plants

### **Energy homeostasis in the cell**

Enzymes : Biological catalysis, kinetics, regulatory enzymes; Bioenergetics and metabolism : Bioenergetics and thermodynamics, Phosphoryl group transfer and ATP, the concept of free energy and biological oxidation-reduction reactions (the redox potential); Intermediary metabolism and its regulation : Carbohydrate metabolism, lipid metabolism and protein metabolism ; Oxidative Phosphorylation; Hormonal regulation and integration of mammalian metabolism :

### **Cell division, cell cycle and programmed cell death**

An overview of the cell cycle, Components of the cell cycle control system, M phase

Mitosis and meiosis, Cytokinesis, Intracellular control of cell cycle events

Programmed cell death

Extracellular control of cell division, cell growth and apoptosis

**Cell in its social context**

Cell junctions, Cell adhesion molecules and cell-cell adhesion

Extracellular matrix

Integrins

**Isolating and visualizing cells**

Isolation of cells from tissues

Light and phase contrast microscopy in visualising cells

Locating specific molecules within a cell using antibodies and fluorescence

(Practical demonstration)

**Two of the following Optional Modules (details listed at the end of this document)**

**Developmental and Reproductive biology**

**Plant development**

**Enzymology**

## **Second Semester**

### **Biological Information storage, processing and transfer in the cell**

DNA Replication: Enzymology of DNA replication, accuracy and fidelity of replication, DNA damage and repair mechanisms. Transcription in prokaryotes and eukaryotes; Eukaryotic transcription factors and their role on regulation on gene expression; tissue specific transcription factors; the role of chromosome structure, remodeling, acetylation/deacetylation and methylation of histone proteins on gene transcription and mechanisms of genomic imprinting.

### **Molecular basis of abnormal cell growth and metastasis**

#### **Protein, DNA and RNA based techniques**

#### **Bioinformatics**

#### **Implication of genomics and proteomics on health and Agriculture**

#### **Research methodology and biostatistics**

Hypothesis driven and inductive research

Null hypothesis, Statistical significance

Literature review

General and specific objectives

Validation and quality assurance of methodology

Analysis of numerical data - parametric and non parametric tests

descriptive statistics, comparison of two groups, comparison of three groups or more

regression and correlation

#### **Ethical issues in scientific research and ethical, legal and social implications of genetic, genomic and reproductive technologies**

Ethical issues in animal and human experimentation, Informed consent and confidentiality

Ethical, legal and social implications of genetic research, genetic testing, assisted reproductive technology, reproductive and therapeutic cloning

## **Optional Modules**

### **Developmental and Reproductive biology**

Gametogenesis  
Fertilization and implantation  
Sex determination and sexual differentiation  
Reproductive messengers  
Reproductive maturation  
Follicular development, ovulation and the corpus luteum  
Neuroendocrine regulation and function of the male and female reproductive systems  
Pregnancy, parturition and labour, lactation  
Reproductive senescence  
Universal mechanisms of animal development  
Basic anatomical features, Regulatory genes and lessons from mutations  
Positional value, Assymmetric cell division  
Regulation of development: morphogens, sequential induction, intrinsic and extracellular inhibitors

### **Enzymology:**

General mechanisms of enzyme action  
Competitive and non-competitive inhibition  
Enzyme kinetics  
Classification of enzymes  
Classification of co-factors  
Detail mechanism of enzyme action of selected enzymes  
Enzyme assays  
Purification of enzymes  
Sequencing of enzymes  
Allosterases, Industrial enzymes, Isozymes  
Clinical enzymology  
Multi enzyme complexes  
Proteolytic activation, Covalent modification

### **Plant Development:**

An introduction to flowering plant  
Flowering plant life cycle  
Cellular level development  
Mechanisms controlling cell fate  
Cell intrinsic information – genetic involvement  
Cell extrinsic information – Different genes involved in the development under different conditions  
Coordination of development: Effects of different genes during the transition from embryonic to post-embryonic development