

**DEPARTMENT OF BIOCHEMISTRY AND  
MOLECULAR BIOLOGY**

**UNIVERSITY OF DHAKA**

Syllabus for M. Phil & Ph. D, Part I in Biochemistry and Molecular Biology

Session .....

The course BMB-PG 01 is a compulsory and the students will choose any one or two course equivalent to 4 Credits. Each credit will be of 100 marks and will comprise of 60 lecture hours.

**The theory courses are as follows:**

BMB-PG 01: Molecular Biology	4 Credits
BMB-PG 02: Bioinformatics	2 Credits
BMB-PG 03: Biochemistry of Drugs	4 Credits
BMB-PG 04: Molecular Diagnostics and DNA forensic Sciences.	4 Credits
BMB-PG 05: Agricultural Biochemistry	2 Credits
BMB-PG 06: Environmental Biochemistry	2 Credits
BMB-PG 07: Clinical Immunology and Immuno diagnostics	4 Credits
BMB-PG 08: Advanced Nutrition and Nutritional Biochemistry	4 Credits
BMB-PG 09: Biochemistry of Natural Product	2 Credits
BMB-PG 10: Viva-voce	4 Credits

Examination rules and procedures are explained in the admission rules [The students will have to pass the theory papers by securing a minimum of 50% of the total marks; they must pass the oral (Viva-voce) examination separately by obtaining at least 50% marks].

## **BMB PG-01: Molecular Biology**

**4 Credits**

**Chemistry and structure of DNA:** Classification and composition of nucleic acids, concept of gene, allele, genotype and phenotype, Watson-Crick model of DNA,  $T_m$  value  $C_{ot}$  value, nucleic acid hybridizations, sequence complexity; DNA packaging.

### **Gene expression concept:**

- (i) DNA replication – models of replication, DNA replication in prokaryotes and eukaryotes, regulation of replication; DNA damage repair.
- (ii) Transcription – types of RNAs, prokaryotes and eukaryotes transcriptions, RNA processing, control of RNA synthesis; concept of operon.
- (iii) Translation – ribosome structure, genetic code, codon-anticodon interactions, protein synthesis, control of translation, post-translational modification of proteins; polysomes.

**Recombinant DNA technology:** Cloning vectors, restriction endonuclease, DNA cloning, expression cloning, genomic and cDNA library preparation. Application of recombinant technology in food, agriculture, industry and medical field. Gene therapy.

**Molecular biology techniques:** PCR, real-time PCR, gel electrophoresis, blotting and probing, RFLP, AFLP, RAPD, DNA sequencing, DNA microarray (preparation of slides, hybridization, interpretation and application).

**Cytogenetics:** Chromosome structure, karyotype, chromosome aberrations and diseases, mutation, mobile genetic elements, genetic basis of dominant and recessive disorder, sex determination.

**Gene regulation by small RNAs:** Small RNAs and posttranscriptional gene silencing (PGTS) – small RNAs, their biogenesis, mechanism of action and gene regulation, their roles in diseases; epigenetic control of gene expression.

**Genomics:** Brief mention about human genome project. Physical mapping, sequence analysis and annotations; comparative homologies, evolutionary changes and single nucleotide polymorphisms (SNPs). Familiarization with biological databases, retrieval of desired data from database and their analysis.

**Proteomics:** Area and scope, experimental approaches to proteomics: 2D gel electrophoresis; fundamentals of mass spectrometry; functional characterization of proteins - differential display, phage display, use of GFP to visualize proteins in live tissues. Roles of proteomics in disease.

## **BMB PG-02: Bioinformatics**

**2 Credits**

### **1. Introduction to bioinformatics database:**

- a) Organization of the databases
- b) Accessing Bioinformatics database

- c) Retrieval of desired data
  - d) Types of Biological data
  - e) Familiarization with databases (NCBI, ENSEMBL ect)
- 2. Example and use of Bioinformatics in molecular biology and biotechnology:**
- a) BLAST : Application and interpretation of BLAST program for homology searching
  - b) Clustal W: Application of Multiple sequence alignment via clustal W program
  - c) Codon optimization: Codon usage pattern in different species, Relative Condon frequencies, Codon usage barriers, Condon optimization for the synthesis of recombinant proteins.
- 3. Basic algorithms and their uses in bioinformatics:** Application of hidden markov model (HMM) in designing various bioinformatics tools
- 4. Evolutionary Bioinformatics**
- a) Building and interpretation of Phylogenetic trees
  - b) Calculating Substitution rate (Jukes Cantor model and Kimura's two parameter model)
  - c) Construction of distance matrix from the pairwise evolutionary distances
  - d) Non-synonimous vs synonymous substitution ratio (Ka/Ks) in Protein/Gene evolution
  - e) Identification of horizontally transferred genes in bacterial genomes
  - f) Use of Mega4 package for detail evolutionary analysis
  - g) Molecular Clock hypothesis
- 5. Structural bioinformatics:**
- a) Importance of the structures of biomolecules in biological functions
  - b) Analyzing RNA secondary structures: Basic concept of stem loop RNA secondary structure, minimum free energy (MFE) calculation.
  - c) Analyzing protein secondary and tertiary structures: Concept of protein folding, Prediction of protein 3-d structure via homology modelling and de-novo modelling, Prediction of conserved domains via structure-function analysis.
  - d) Identification of hydrophobic regions in proteins: Concept of hydrophobicity index of amino acids, Prediction of hydrophobic trans-membrane domain via sliding window algorithm
- 6. Immunoinformatics:**
- a) Basic mechanism of antigen presentation
  - b) Familiarization with immunoinformatics websites and tools

- c) Identification of immunogenic epitopes by computational methods for designing vaccines
- d) Identification of the proteasomal cleavage sites
- e) Analysis of HLA-epitope interaction

**7. Analysis of microarray data**

- a) Microarray: Basic principle
- b) Gene chips
- c) Handling processed microarray data
- d) Clustering of genes based on their expression level
- e) Pathway analysis and building gene/protein regulatory network

**8. Computational proteomics**

- a) Overview on LC-MS/MS
- b) Peptide mass finger printing
- c) Application of Stable isotope labelling of amino acid in cell culture (SILAC) technology for quantitative proteomics

**BMB-PG 03: Biochemistry of Drugs**

**4 Credits**

**1. Introduction**

- (a) Drugs – basic features
- (b) Broad classification with specific examples

**2. Some selected groups of drugs**

- (a) Cardiovascular drugs
- (b) Immunosuppressive drugs & Immunotherapy
- (c) Antimicrobials e.g. Penicillin-Cephalosporin groups, Aminoglycosides, Tetracyclines etc.
- (d) Locally acting drugs e.g. Gastric antacids, Antiseptics, Disinfectants.
- (e) Enzymes inhibitors that act as drugs

**3. Pharmacokinetics**

- (a) Drug absorption
- (b) Drug distribution, bio-availability, half-life.
- (c) Drug metabolism and its various aspects, factors affecting drug metabolism, methods of studying drug metabolism.
- (d) Drug excretion

4. **Molecular mechanism of drug action**
  - (a) Basic aspects
  - (b) Structure – activity relationship of drugs like, Antihistamines, Sulfa drugs and Psychiatric & antidepressants.
  - (c) Drug receptors (e.g. ion channel receptors, G-protein coupled receptors, etc.) and their characteristics.
  - (d) Non-receptor mediated drugs.
  - (e) Agonists-antagonists with emphasis on drug and receptor interaction, drug-drug and drug-metabolite interaction. Drug resistance and its implication.
  - (f) Drug toxicity and its effect, evaluation in lower animals, drug allergy & tests for its prediction, design of toxicity tests, antidote.
  
5. **Drug design**
  - (a) Basic concepts; physico-chemical factors in designing of a drug e.g. thermodynamic, electrostatic & steric factors, topology, molecular interaction and kinetics
  
  - (b) Molecular methods in drug design and development - targeting and pharmacogenomics.

**BMB-PG 04: Molecular Diagnostics and DNA forensic Sciences.**

**4 Credits**

## **DNA Forensic Sciences**

### **1. Molecular Diagnostics :**

- (a) Introduction to Molecular Diagnosis (MD) and Molecular Diagnostic Laboratory (MDL) appropriate clinical specimen for MD
- (b) Isolation and characterization of DNA/RNA from different clinical specimens: basic principle of DNA extraction by organic method, Chelex method, Spin columns, magnetic beads etc.
- (c) Overview of the application of molecular methods for diagnosis of genetic disorders, infectious diseases and cancer.
- (d) PCR in molecular diagnostics - conventional PCR and real time PCR, qualitative and quantitative PCR, PCR-ELISA
- (e) Molecular Diagnosis of Viral Disease: HBV, HCV, HCMV, HIV and HPV
- (f) Molecular Diagnosis of Bacterial Disease: MTB and STDs
- (g) Molecular Diagnosis of Cancer: Hematological cancer and solid cancer
- (h) Molecular HLA Typing: SSP, SSOP and SBT methods for typing HLA Class I & Class-II

## 2. Pharmacogenomics

- a) Introduction-promises, opportunities and limitations of pharmacogenomics, pharmacology and toxicology in the genomics era, germ line genomics, evolving landscapes in pharmacogenomics and personalized medicine, genetic polymorphisms of metabolic reaction, role of single nucleotide polymorphisms in pharmacogenomics, variability of pharmacogenetics polymorphisms within a population.
- b) Applications of pharmacogenomics in personalized medicine - Pharmacogenomics and the treatment of various diseases such as Alzheimer disease, cancer (eg. lung and breast cancer), asthma, alcoholism, cardiovascular diseases, pharmacogenomics and lipid-lowering agents, tobacco addiction, antibiotics.
- c) Pharmacogenomics tests currently in clinical use - genotypic techniques to identify new drugs, functional analysis to identify gene variants of UDP-glucuronosyltransferase, drug transporter genes eg, ABC genes, CYP450, CYP2D6, CYP2C19, CYP2C9, VKORC1 and their role in drug metabolism.

## 3. DNA technology in forensic sciences

- a) DNA Polymorphism - minisatellite sequences or Variable Number of Tandem Repeats (VNTRs) microsatellite sequences or Short Tandem Repeats (STRs) Biology and nomenclature of STR markers Single Nucleotide Polymorphism (SNPs)

SINEs and LINEs mitochondrial DNA variations Y-Chromosome STRs X-Chromosome STRs amelogenin: the sex typing marker

- b) DNA typing methods - DNA profile: Definition (DNA fingerprinting/DNA testing) Restriction Fragment Length polymorphism (RFLP) Single locus and multi-locus DNA typing Allele specific oligonucleotides (ASO) Polymerase Chain Reaction (PCR): an overview Analysis of minisatellites by PCR, STR analysis by PCR DNA detection methods - silver staining, fluorescent dyes capillary electrophoresis, principles and instrument platform for capillary electrophoresis e.g. 310/3100 genetic analyzer
- c) DNA Extraction and quantitation from forensic samples - DNA Extraction from liquid blood, soft tissues, bone, teeth, buccal cells, semen, blood stains, and semen stains etc. FTA Card, Differential extraction

DNA quantitation - spectrophotometry, fluorometry, Slot-blot, Real-time PCR

- d) Applications of DNA profiling - identity test parentage test sibship analysis kinship analysis identification of dead bodies resolving immigration and inheritance disputes.

**BMB-PG 05: Agricultural Biochemistry****2 Credits**

1. Responses to plant pathogenesis
  - a) Ways in which plant pathogenesis cause disease
  - b) Plant defense systems,
  - c) Genetic Basis of plant-pathogen interactions, biochemistry of plant defense reactions.
  - d) Systemic plant defense responses
  - e) Control of plant pathogen by genetic engineering.
  
2. Responses to Abiotic Stresses
  - a) Plant responses to abiotic stresses.
  - b) Stresses involving water deficit.
  - c) Osmotic adjustment and its role in tolerance to drought and salinity.
  - d) Impact of water deficit and salinity on transport across plant membranes.
  - e) Additional genes induced by water stress.
  - f) Freezing stress.
  - g) Flooding and oxygen deficit.
  - h) Oxidative stress.
  - i) Heat stress.
  
3. Molecular Physiology of Mineral Nutrient Acquisition, Transport, and Utilization.
  - a) Overview of essential mineral elements
  - b) Mechanisms and regulation of plant  $K^{\oplus}$  transport
  - c) Phosphorus nutrition and transport
  - d) The molecular physiology of micronutrient acquisition
  - e) Plant responses to mineral toxicity, plants as bioreactors.
  
- 4. Crop improvement and yield enhancement - new edible uses of novel plant products: Uses and modifications of fatty acids & lipids, plants as sources of biodegradable plastics, plants as factories for chemical drug.**

**BMB-PG 06: Environmental Biochemistry****2 Credits**

- 1. Introduction to ecology and ecosystem:** Environmental pollution (water, soil and air), noise and thermal pollution, their sources and effects. Pollution due to arsenic, tannery, textile, lead and sulphur- rich coal.
- 2. Waste water (sewage and industrial effluents) treatments:** Anaerobic and aerobic treatment, conventional and advanced treatment technology, methanogenesis, methanogenic, acetogenic, and fermentative bacteria-technical process and conditions, emerging biotechnological processes in waste - water.

3. **Solid waste management:** Landfills, composting, earthworm treatment, recycling and processing of organic residues. Treatment of heavy metal wastes development of industrial waste treatment system. Anaerobic digestion of agroindustrial byproducts & wastes
4. **Bioremediations:** Biotransformation of toxic wastes to harmless products.
5. **Wasteland:** Uses and management, bioremediation and biore restoration of contaminated lands.
6. **Environmental genetics:** Degradative plasmids, release of genetically engineered microbes in environment. Environmentally friendly biofertilizers and biopesticides Biofuels and Biogas.
7. **Bioengineered foods:** Regulation and safety.
8. **Plant environment and agriculture.**

#### **BMB-PG 07: Clinical Immunology and Immuno diagnostics**

**4 Credits**

1. **Autoimmunity and autoimmune disease:** Pathogenesis, genetic susceptibility to autoimmunity; role of infection in autoimmunity pathogenic role of autoantibodies, control mechanisms, treatment, autoimmune diseases like; autoimmune diabetes, autoimmune hemolytic anemia, rheumatoid arthritis, pernicious anemia, hereditary angioneurotic edema etc; diagnostic and prognostic value of autoantibodies.
2. **Allergy and hypersensitivity:** Coombs and Gell classification.
  - a) **Type I -Immediate hypersensitivity:** Induction and effector mechanisms; allergens, atopy, IgE involvement; cytokine regulation of IgE production; immune response to inhaled allergens; role of mast cells, mediators and the reactions involved; genetic susceptibility and immunopathology; diagnosis; skin prick test; immunotherapy and new approaches for treatment.
  - b) **Type II- Antibody dependent cytotoxicity:** mechanism of tissue damage; reactions involving hemolytic diseases in newborn, autoimmune hemolytic anemia and hyper acute graft rejection; treatment.
  - c) **Type III- Immune complex mediated hypersensitivity:** types of immune complex diseases; inflammatory mechanisms involved; experimental models; persistence, deposition and detection of immune complexes.
  - d) **Type IV-Delayed hypersensitivity:** contact hypersensitivity; tuberculin-type and granulomatous hypersensitivity; cellular reactions and disease manifestation in delayed hypersensitivity.



3. **Transplantation immunology:** Immunology of allogenic transplantation; recognition of alloantigens, activation of alloreactive T cells; effector mechanisms of allograft rejection: hyperacute acute and chronic rejection, prevention and treatment: immunosuppression, inducing donor-specific tolerance or suppression; xenogeneic transplantation; blood transfusion; bone marrow transplantation: graft-versus-host disease.
4. **Tumor Immunology:** Immune surveillance, tumor antigens, tumor associated antigens, immune responses to tumors, immune evasion by tumors, immunodiagnosis, immunotherapy for tumors.
5. **Immunodeficiencies:** Primary (congenital) immunodeficiencies - B and T cell deficiencies- SCIDs, X-LA, selective IgA and IgG deficiencies, hyper IgM syndrome, common variable immunodeficiency, X-linked immunoproliferative disease, defective class I and II MHC expression, Wiskott-Aldrich syndrome, ataxia-telangiectasia, chronic granulomatous disease, leukocyte adhesion deficiency, defects in complement proteins, defects in phagocytosis; therapeutic approaches Acquired (secondary) immunodeficiency: HIV and AIDS, treatment and prevention.
6. **Immunoassays:** Enzyme immuno assays, MEIA for detection of anti-HCV, immunoassay for HIV envelope proteins, detection of HBsAg, IgM-anti-HBc, anti-HBe, immunoelectrophoresis, radioimmunoassay for hormones- insulin, hCG, etc. immunoturbidometry, microtiter-haemagglutination, detection and quantitation of immune-complexes, cancer markers, Complement deficiencies, hemolytic assays for complement, hereditary angioneurotic edema, flow cytometry.
7. **Diagnostic application of monoclonal antibodies:** Progression of treatment, side effects of antibody therapy.
8. **Immunoematology:** Full blood count, clinical utility of ESR determination, hemoglobinopathy, glycosylated hemoglobin (HbA1c), blood transfusion, transfusion reactions, acute kidney shutdown, haemostasis, cross-matching, tissue typing.

**BMB-PG 08: Advanced Nutrition and Nutritional Biochemistry**

**4 Credits**

**1. Malnutrition and Immunity**

- (a) Role of nutrition in immune response to infection
- (b) Malnutrition and immunity
- (c) Nutrition and immunodeficiency disorders
- (d) Dietary modification in infection

## 2. Nutrition and Genomics

- (a) Genetic and environmental variations and nutrient composition of foods.
- (b) Role of nutrients in gene expression and regulation

## 3. Nutrition – Drug Interaction

- (a) Effect of Food on drug pharmacokinetics
- (b) Effects of drugs on nutrition: drugs which affect food intake, absorption, metabolism and excretion.

## 4. Nutrition and IT

- (a) Nutrition Information, Education and communication – IT offers a new approach
- (b) IT & Nutritional support for patients with chronic illnesses

## 5. Malnutrition and Psychosocial Development

- (a) Introduction : Definition and Terms
- (b) Impact of PEM on brain development and psychosocial development
- (c) Nutritional rehabilitation and mental development
- (d) Malnutrition and cognitive development: A multifaceted problem

## 6. Current Topics in Nutrition

- (a) Eating disorders ; Anorexia nervosa and Bulimia nervosa
- (b) Total parenteral nutrition (TPN)
- (c) Sports nutrition
- (d) Poverty and nutrition
- (e) Nutrition in emergencies : famine, war, flood and natural disasters.
- (f) International nutrition : Nutrition in developing economics
- (g) Globalization and Nutrition
- (h) Nutritional enhancement of plant foods

## 7. Applied Nutrition

- (a) Diet, Nutrition – and lifestyle – related chronic non-communicable diseases (NCDS)
- (b) Low birth weight: increased risk of morbidity, mortality and retarded cognitive development
- (c) Nutrition and HIV/AIDS
- (d) Street food as meal of millions
- (e) Nutrition Interventions Programmes in Bangladesh.

## BMB-PG-09: Biochemistry of Natural Product

2 Credits

### 1. NMR spectroscopy:

- (a) Chemical shifts. Factors affecting the chemical shift, coupling constants - vicinal coupling, geminal coupling, long range coupling, use of coupling constant values in the determination of stereochemistry of some important natural and biochemical substances. AB and ABX system, two dimensional NMR: NOE, COSY.

- (b) Use of NMR in biochemistry and molecular biology: Use of  $^{13}\text{C}$  NMR in the elucidation of biochemical pathways including the biosynthesis of cephalosporin, bikaverin, penicillin, chlorophyll and vitamin B<sub>12</sub>; use of NMR in the determination of 3 dimensional structure of proteins, enzymes, DNA, RNA and protein signaling.
- (c) Use of NMR in Designing lead compounds (drugs): Use of NMR in drug screening. Clinical use of  $^{31}\text{P}$  NMR – Detection of abnormalities in different organs by the use of  $^{31}\text{P}$  NMR. Magnetic resonance tomography (MR) – use of MR to locates tumors, Vascular dilations and many other pathological abnormalities.
- 2. Mass spectroscopy:** Mass fragmentation of some important natural products.
  - 3. Structure determination of some medicinally important alkaloids:** Quinine, atrophine, morphine by synthetic and digradative methods. Biosynthesis of some complex alkaloids.
  - 4. Molecular Mechanism of actions of some selective, antibiotics. prodrugs:** Advantages of prodrugs, semesynthetic antibiotics, synthesis of antibiotics, mechanism of antibiotic action, Allergetic reactions, Chemical synthesis of some medicinal steroids: Progesterone, cortisol, vitamin D.
  - 5. Structure of selected vitamins:** Vitamin B<sub>12</sub>, biological reactions with participation of Vitamin B<sub>12</sub> and coenzymes B<sub>12</sub>. Chemical synthesis of vitamin E  $\alpha$ -tocopherol and  $\beta$ -tocopherol

**BMB-PG 10: Viva-voce**

**4 Credits**