MAULANA ABUL KALAM AZAD UNIVERSITY OF TECHNOLOGY, WEST BENGAL
(Formerly West Bengal University of Technology)
Syllabus for M. Sc. In Genetics
(Effective for academic session 2019-20)

Semester-I

MSGN101: Biochemistry credits 3

Unit 1: Basic chemistry for biologists

Formation of chemical bonds, molecular orbital (MO) theory and linear combination of atomic orbitals (LCAO),basics of mass spectrometry, molecules, Avogadro number, molarity, chemical reactions, reaction stoichiometry, rates of reaction, rate constants, order of reactions,kinetic versus thermodynamic controls of a reaction, reaction equilibrium (equilibrium constant); light and matter interactions (optical spectroscopy, fluorescence, bioluminescence, paramagnetism and diamagnetism, photoelectron spectroscopy; chemical bonds (ionic, covalent, Van der Walls forces); electronegativity, polarity; VSEPR theory and molecular geometry, dipole moment, orbital hybridizations; acids, bases and pH - Arrhenious theory, pH, ionic product of water, weak acids and bases, conjugate acid-base pairs, buffers and buffering action etc; chemical thermodynamics - internal energy, heat and temperature, enthalpy (bond enthalpy and reaction enthalpy), entropy, Gibbs free energy of ATP driven reactions, spontaneity versus driven reactions in biology;bond rotations and molecular conformations - Newman projections, conformational analysis of alkanes, alkenes and alkynes; functional groups, optically asymmetric carbon centers, amino acids, proteins, rotational freedoms in polypeptide backbone (Ramachandran plot).

Unit 2 :Protein Structure

Water – properties of water, essential role of water for life on earth pH, buffer, maintenance of blood pH and pH of gastric juice, pH optima of different enzymes (pepsin, trypsin and alkaline phosphatase), ionization and hydrophobicity, emergent properties of biomolecules in water, biomolecular hierarchy, macromolecules, molecular assemblies; Structure-function relationships: amino acids – structure and functional group properties, peptides and covalent structure of proteins, elucidation of primary and higher order structures, Ramachandran plot, evolution of protein structure, protein degradation and introduction to molecular pathways controlling protein degradation, structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin *etc.*; basic principles of protein purification; tools to characterize expressed proteins; Protein folding: Anfinsen's Dogma, Levinthal paradox, cooperativity in protein folding, free energy landscape of protein folding and pathways of protein folding.

Unit 3: Enzyme

Enzyme catalysis – general principles of catalysis; quantitation of enzyme activity and efficiency; enzyme characterization and Michaelis-Menten kinetics; relevance of enzymes in metabolic regulation, activation, inhibition and covalent modification; single substrate enzymes;restriction enzymes and nucleoside monophosphate kinase; regulatory strategies with specific example of haemoglobin; isozymes; role of covalent modification in enzymatic activity; zymogens.

Unit 4 :Glycobiology

Sugars-mono, di, and polysaccharides with specific reference to glycogen, amylose. lipids- structure and properties of important members of storage and membrane.

Unit 5 :Nucleic acid

nucleosides, nucleotides, nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical structure.

Unit 6: Bioenergetics

Bioenergetics-basic principles; equilibria and concept of free energy; coupled interconnecting reactions in metabolism; oxidation of carbon fuels;Ca++ signaling pathways; glycolysis and gluconeogenesis;Citric acid cycle, entry to citric acid cycle, citric acid cycle as a source of biosynthetic precursors; Oxidative phosphorylation, Photosynthesis – chloroplasts and two photosystems; proton gradient across thylakoid membrane.

Unit 7: Role of vitamins & cofactors in metabolism

Calvin cycle and pentose phosphate pathway; glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, elucidation of metabolic pathways; logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; principles of metabolic regulation; steps for regulation.

Texts/References:

1. M.T. Madigan and J.M. Martinko, Brock Biology of Microorganisms, 11th Edition, Pearson Prentice-Hall, 2006.
2. L. Stryer, Biochemistry, 4th Edition, Freeman, 2002.
3. G. Gottschalk, Bacterial Metabolism, 2nd Edition, Springer-Verlag, New-York, Berlin. 1986.

MSGN102: Laboratory Techniques credits 3

Unit1 :Chromatography Techniques - Paper Chromatography, Thin-layer chromatography, Displacement chromatography, Gas chromatography, High performance / pressure liquid chromatography, Ion exchange chromatography, Size-exclusion chromatography, Affinity chromatography.

Unit 2: Electrophoretic techniques and blotting techniques - Theory and application of Polyacrylamide and Agarose gel electrophoresis; Capillaryelectrophoresis; 2D Electrophoresis; Immunoelectrophoresis, Isoelectric focussing, Disc gel electrophoresis; Gradient electrophoresis; Pulsed field gel electrophoresis, Western blot, Eastern blot, Southern blot, Northern blot.

Unit 3 :Radioactivity - Radioactive & stable isotopes; Pattern and rate of radioactive decay; Units of radioactivity;Measurement of radioactivity; Geiger-Muller counter; Solid & Liquid scintillation counters (Basic principle, instrumentation & technique); Applications of isotopes in biochemistry; Autoradiography.

Unit 4 :Centrifugation - Basic principles; Mathematics & theory (RCF, Sedimentation coefficient etc); Types of centrifuge, Microcentrifuge, High speed & Ultracentrifuges; Preparative centrifugation; Differential & density gradient centrifugation; Applications (Isolation of cell components); Analytical centrifugation; Determination of molecular weight by sedimentation velocity & sedimentation equilibrium methods.

Unit 5: Microscopy

Optical microscopy, Electron microscopy, Confocal microscopy

Unit 6: Advanced techniques

DNA and Amino acid Sequencing, DNA CHIP, Microarray, Substractive Hybridization, RNase protection assay, ELISA, Mass spectroscopy, Infra red spectroscopy, NMR, Circular Dichroism

MSGN103: Cell and Molecular Biology credits 3

Unit 1: organization of cell : Universal features of cells; cell chemistry and biosynthesis: chemical organization of cells; internal organization of the cell - cell membranes: structure of cell membranes and concepts related to compartmentalization in eukaryotic cells; intracellular organelles: endoplasmic reticulum and Golgi apparatus, lysosomes and peroxisomes, ribosomes, cellular cytoskeleton, mitochondria, chloroplasts and cell energetics; nuclear compartment: nucleus, nucleolus and chromosomes.

Unit 2:Chromatin structure : Chromatin organization - histone and DNA interactome: structure and assembly of eukaryotic and prokaryotic DNA polymerases, DNA-replication, repair and recombination; chromatin control: gene transcription and silencing by chromatin-Writers,-Readers and –Erasers; Transcriptional control: Structure and assembly of eukaryotic and prokaryotic RNA Polymerases, promoters and enhancers, transcription factors as activators and repressors, transcriptional initiation, elongation and termination; post-transcriptional control: splicing and addition of cap and tail, mRNA flow through nuclear envelope into cytoplasm, breakdown of selective and specific mRNAs through interference by small non-coding RNAs (miRNAs and siRNAs), protein translation machinery, ribosomes-composition and assembly; universal genetic codes, degeneracy of codons, Wobble hypothesis; Iso-accepting tRNA; mechanism of initiation, elongation and termination; co- and post-translational modifications, mitochondrial genetic code.

Unit 3:Cellular signalling, transport and trafficking: Molecular mechanisms of membrane transport, nuclear transport, transport across mitochondria and chloroplasts; intracellular vesicular trafficking from endoplasmic reticulum through Golgi apparatus to lysosomes/cell exterior.

Unit 4:Cell cycle and its regulation; cell division: mitosis, meiosis and cytokinesis; cell differentiation: stem cells, their differentiation into different cell types and organization into specialized tissues; cell-ECM and cell-cell interactions; cell receptors and trans-membrane signalling; cell motility and migration; cell death: different modes of cell death and their regulation.

Unit 5: Manipulating and studying cells: Isolation of cells and basics of cell culture; observing cells under a microscope, different types of microscopy; analyzing and manipulating DNA, RNA and proteins.

Unit 6:Genome instability and cell transformation: Mutations, proto-oncogenes, oncogenes and tumour suppressor genes, physical, chemical and biological mutagens; types of mutations; intra-genic and inter-genic suppression; transpositions- transposable genetic elements in prokaryotes and eukaryotes, role of transposons in genome; viral and cellular oncogenes; tumor suppressor genes; structure, function and mechanism of action; activation and suppression of tumor suppressor genes; oncogenes as transcriptional activators.

Unit 7:Mammalian genetics: Mendel's experiments, monohybrid and dihybrid cross, sexual reproduction applications of chi square test, deviation from Mendelian segregation, linkage, genetic

map, Mendelism in human genetics: pedigree analysis, dosage compensation and sex determination, inheritance characteristics of sex-linked and autosomal traits,chromosome discovery, chromosomes as physical basis of inheritance, Polytene and lampbrush chromosomes, chromosomal aberrations and genetic load, sex-linked deleterious genes, extrachromosomal/non-Mendelian inheritance(episomes, mitochondria and chloroplasts), parental imprinting, Population Genetics-Variation and its modulation, effect of sexual reproduction on variation (Hardy-Weinberg Equilibrium), sources of variation, selection balanced polymorphism, random events.

Text/ Reference

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008).Molecular Biology of the Cell (5th Ed.). New York: Garland Science.
2. Lodish, H. F. (2016). Molecular Cell Biology (8th Ed.). New York: W.H. Freeman.
3. Cooper, G. M., & Hausman, R. E. (2013). The Cell: a Molecular Approach (6th Ed.).Washington: ASM; Sunderland.

MSGN104: Biostatistics credits 3

Unit 1: Introduction to Biostatistics

Basic definitions and applications. Sampling: Representative sample, sample size, sampling bias
and sampling techniques. Data collection and presentation: Types of data, methods of collection
of primary and secondary data, methods of data presentation, graphical representation by histogram, polygon, ogive curves and pie diagram.

Unit 2 : Measures of central tendency: Mean, Median, Mode.

Measures of variability: Standard deviation, standard error, range, mean deviation and coefficient
of variation. Correlation and regression: Positive and negative correlation and calculation of Karl-
Pearsons co-efficient of correlation. Linear regression and regression equation and multiple linear
regression, ANOVA, one and two way classification. Calculation of an unknown variable using regression equation.

Unit 3 :Tests of significance

Tests of significance: Small sample test (Chi-square t test, F test), large sample test (Z test) and
standard error. Introduction to probability theory and distributions, (concept without deviation) binomial, poison and normal (only definitions and problems) Computer oriented statistical techniques. Frequency table of single discrete variable, bubble spot, computation of mean, variance and standard Deviations, t test, correlation coefficient. Randomized block design, complete block design, Usage of Statistical software.

MSGN-105: Basic Genetics

credits 3

Unit I

Introduction to Genetics- Great milestones in Genetics; levels of Genetic analysis (Classical, Molecular & Population Genetics.

Basic principles of Heredity – Segregation of a single gene, the principle & verification of segregation, segregation of two or more genes, test cross with unlinked genes.

Patterns of Inheritance – Autosomal inheritance, Sex-linked inheritance and extrachromosomal inheritance-.Endosymbiont Theory, Genetic codes of Organelles, Respiration-defective Mitochondrial mutants, Cytoplasmic Male sterility in Plants, Cytoplasmic transmission of Symbionts.

Mendelian principles of Inheritance – The Big experiment of Mendel, principle of independent assortment. Extensions & Modifications of Mendelian principles – Complete & Incomplete dominance, Epistasis, Pleiotropic effects.

Unit II

Linkage, Recombination & Crossing Over – Recombination is the basis of Gene mapping, Linkage mapping, Tetrad analysis, Gene mapping in absence of Meiosis, Fine mapping.

Genetic Variation – Genes & gene products, interaction between the alleles of one gene, interacting genes & proteins, applications of chi-square test to gene interaction ratios.

Variations in Allele, Multiple alleles, Gene, Modifier genes, Partial penetrance & variable expressivity, Lethal alleles, Phenotypes produced by Conditional alleles.

Unit III

Chromosomal variation- Polyploidy [Classification (autopolyploids, allopolyploids), methods of production, cytological and genetic methods for identification, polyploid genetics (chromosome and chromatid segregation),), utility in crop improvement.

UnitIV

Drosophila Genetics: Genetic crosses. Chromosomal and Molecular basis of sex determination in Drosophila , Molecular basis of dosage compensation in Drosophila.

Unit V

Pedigrees- gathering family history; Pedigree symbols; Construction of pedigrees. Complications to the basic pedigree patterns: Nonpenetrance, variable expressivity, pleiotropy, onset, dominance problem; Anticipation; Compound heterozygosity.

References :

(1) Daniel L. Hartl& Elizabeth W. Jones : Genetics – analysis of Genes & Genomes
(2) Alan G. Atherly, Jack R. Girton& John F. McDonald : The Science of Genetics
(3) Benjamin A. Pierce : genetics – a conceptual appro
(4) D. Peter Snustad& Michael J. Simmons : Principles of Genetics
(5) Griffiths, Wessler, Lewontin, Gelbart, Suzuki &Miller : Introduction to Genetic analysis

MSGN191: Lab on Biochemistry and Analytical Techniques

credits 3

1. To prepare an Acetic-NaAcetate Buffer system and validate the Henderson-Hasselbach equation.
2. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law.
3. Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by TLC.
4. An enzyme purification theme (such as *E.coli* Alkaline phosphatase or any enzyme of the institutions choice).
   a) Preparation of cell-free lysates
   b) Ammonium Sulfate precipitation
   c) Ion-exchange Chromatagraphy
   d) Gel Filtration
   e) Affinity Chromatography
   f) Generating a Purification Table
   g) Assessing purity by SDS-PAGE Gel Electrophoresis
   h) Assessing purity by 2-D gel Electrophoresis
   i) Enzyme Kinetic Parameters: Km, Vmax and Kcat.
5. Biophysical methods (Circular dichroism spectroscopy, fluorescence spectroscopy).
6. Determination of mass of small molecules and fragmentation patterns by Mass Spectrometry

MSGN192: Lab on Cytogenetics

credits 3

1. Whole Blood Culture
2. Lymphocyte Culture
3. Blood Cell Determination
4. Chromosome preparation: staining and observation
5. Chromosome counting and determination of chromosome characteristic

MSGN193: Data Analysis using Statistical Software

credits 2

1. Introduction to different statistical software.
2. Determination of mean, median, mode of given data set.
3. Determination of standard deviation and standard error of a given data set.
4. Preparation of different types of graph from a given data set.
5. Determination of statistical significance of the experimental data: Paired and unpaired t test and p value determination
6. Nonparametric Mann-Whitney test, including confidence interval of difference of medians.
7. Wilcoxon test with confidence interval of median.
8. Usage of two and three way anova.
9. Kaplan-Meier survival analysis.