Maulana Abul Kalam Azad University of Technology, West Bengal

Department of Biotechnology

M. Sc. in Genetics Syllabus 2019-20

Semester I

Code	Course Title	Contact Hrs./Wk	Credit
A	**Theory**	**L-T-P**	
MSUGN-101	Biochemistry	3-0-0	3
MSUGN-102	Laboratory Technique & Safety	3-0-0	3
MSUGN-103	Cell & Molecular Biology	3-0-0	3
MSUGN-104	Biostatistics	3-0-0	3
MSUGN-105	Basic Genetics	3-0-0	3
B	**Practical**		
MSUGN-191	Biochemistry& AnalyticalTechniques	0-0-6	3
MSUGN-192	Lab on Cytogenetics	0-0-6	3
MSUGN-193	Data analysis using software	0-0-4	2
C			
MSUGN-181	Seminar		1
Semester Total			**24**

Semester II

Code	Course Title	Contact Hrs./wk	Credit
A	**Theory**	**L-T-P**	
MSUGN-201	Evolutionary Biology and Population Genetics	3-0-0	3
MSUGN-202	Clinical Genetics	3-0-0	3
MSUGN-203	Immunology	3-0-0	3
MSUGN-204	Genetic Engineering	3-0-0	3
MSUGN-205	Applied Bioinformatics	3-0-0	3
MSUGN-206	Choice based courses (from MOOCS basket)		2
B	**Practical**		
MSUGN-291	Genetic Engineering Lab	0-0-6	3
MSUGN-292	Immunology Lab	0-0-6	3
C			
MSUGN-281	Seminar		1
Semester Total			**24**

Semester III

Code	Course Title	Contact Hrs./wk	Credit
A	**Theory**	**L-T-P**	
MSUGN-301	Human Genetics and Genetic Counselling	3-0-0	3
MSUGN-302	Developmental Biology	3-0-0	3
MSUGN-303	Genomics & Proteomics	3-0-0	3
MSUGN-304	IPR, Biosafety & Bioethics	3-0-0	3
MSUGN-305	Choice Based course (From Elective Basket) *	2-0-0	2
MSUGN-306	Choice Based course (from MOOCS basket)		2
B	**Practical**		
MSUGN-391	Lab on Applied Bioinformaticslab	0-0-6	3
MSUGN-392	Lab on Molecular Genetics and Developmental Genetics	0-0-6	3
C			
MSUGN-381	Project Proposal Presentation		2
Semester Total			**24**

*** Elective subjects Basket**

Code	Subject
MSMC-305A	Principles of Ecology
MSMC- 305B	Research methodology and Writing
MSMC-305C	Molecular diagnostics
MSMC-305D	Enzyme technology
MSMC-305E	Plant Molecular Biology

Semester – IV

Code	Course Title	Contact Hrs./wk	Credit
		L-T-P	
MSUGN-481	Project Work		22
MSUGN-482	Industry/ lab visit		1
MSUGN-483	Journal Club Presentation		1
Semester Total			**24**
Total Course Credit			**96**

Semester –I

MSUGN-101: Biochemistry credits 3

Unit 1: Basic chemistry

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 Classification, 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: Vitamins & cofactors

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. David L. Nelson; Michael M. Cox. Lehninger Principles of Biochemistry
2. L Stryer, Biochemsitry, Freeman publishing.

MSUGN-102: Laboratory Techniques & Safety

credits 3

Unit 1 : Laboratory safety

Basic goal of Chemical hygiene and lab safety, Occupational Safety and health administration (OSHA), Safety precaution, Health hazard, Chemical and biological hazard, Personal protective equipment.

Unit 2: Chromatography

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

Unit 3: Electrophoresis and blotting

Theory and application of Polyacrylamide and Agarose gel electrophoresis; Capillary electrophoresis; 2D Electrophoresis; Immunoelectrophoresis, Isoelectric focussing, Disc gel electrophoresis; Gradient electrophoresis; Pulsed field gel electrophoresis, Western blot, Eastern blot, Southern blot, Northern blot.

Unit 4 :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.

Unit5:Centrifugation

Basic principles; Mathematics & theory (RCF, Sedimentation coefficient etc); Types of centrifuge, Micro centrifuge, 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 6: Microscopy

Optical microscopy, Electron microscopy, Confocal microscopy, AFM, Flow cytometry, Instrumentation, Applications.

Unit 7: Advanced molecular biology techniques

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

Text/References :

1. Cantor & Schimmel : Biophysical Chemistry (Part I, II & III)
2. A. Lehninger : Principles of Biochemistry
3. Freifelder D., Physical Biochemistry, Application to Biochemistry and Molecular Biology, 2nd Edition, W.H. Freeman & Company, San Fransisco, 1982.
5. D. Holme & H. Peck, Analytical Biochemistry, 3rd Edition, Longman, 1998.

MSUGN-103: Cell and Molecular Biology

credits 3

Unit 1: Organization of cell

Universal features of eukaryotic 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: Plant breeding and genetics
Seed technology, Types of seed, Suicide seeds, terminator gene technology, Seed/Gene bank, Hybrid and self seed, crop improvement, seed certification, Plant promoter and transcription factors, Crop finger printing, plant breeding and GM crop,

Text/References
1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2002). Molecular Biology of the Cell. New York: Garland Science.
2. Lodish, H. F. (2000). Molecular Cell Biology. New York: W.H. Freeman.
3. Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014). Lewin's Genes XI. Burlington, MA: Jones & Bartlett Learning.
4. Cooper, G. M., & Hausman, R. E. (2009). The Cell: a Molecular Approach. Washington: ASM; Sunderland.
5. Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2012). Becker's World of the Cell. Boston: Benjamin Cummings.
6. Watson, J. D. (1987). Molecular Biology of the Gene (7th ed.). Menlo Park, CA: Benjamin/Cummings.
7. Tropp et al, Principles of Molecular Biology

MSUGN-104: Biostatistics **credits 3**

Unit 1: Introduction to Biostatistics
Basic definitions and applications. Sampling: Representative sample, sample size, sampling bias and sampling techniques. Sample distribution. 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 and Measure of dispersion
Mean, Medium and 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 hypothesis
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 Deviation. Randomized block design, complete block design.

Text/References:
1. Aitken, M., Broadhursts, B., & Haldky, S. (2009) Mathematics for Biological Scientists. Garland Science.
2. Billingsley, P. (1986). Probability and Measure. New York: Wiley.
3. Rosner, B. (2000). Fundamentals of Biostatistics. Boston, MA: Duxbury Press.
4. Daniel, W. W. (1987). Biostatistics, a Foundation for Analysis in the Health Sciences. New York: Wiley.

MSUGN-105: Basic Genetics **3 Credits**

Unit 1: 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 2: 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 3: 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

Unit 4: Drosophila Genetics
Genetic crosses. Chromosomal and Molecular basis of sex determination in Drosophila ,

Molecular basis of dosage compensation in Drosophila.

Unit 5: Pedigrees
Gathering family history; Pedigree symbols; Construction of pedigrees, Presentation of molecular genetic data in pedigrees; Pedigree analysis of monogenic traits

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

MSUGN-191: Biochemistry and Analytical Techniques
credits 3
1. To prepare an Acetic-Na Acetate 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

MSUGN-192: 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

MSMB193: Data analysis using 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
5. Nonparametric Mann-Whitney test, including confidence interval of difference of medians.
6. Wilcoxon test with confidence interval of median.
7. Usage of two and three way anova.
8. Kaplan-Meier survival analysis

Semester II

MSUGN-201: Evolutionary Biology and Population Genetics

Credits 3

Unit 1: Genetic constitution of a population
Genetic constitution of a population: (a) Gene frequencies and genotypes; (b) Hardy-Weinberg equilibrium; (c) Changes in gene frequency and continuous variation; (d) Mutation, Selection, Equilibrium. Polymorphisms; Values, means andvariance: (a) Metric characteristics, Population means; (b) Genetic components of variation; (c)Genotype and environment correlation; (d) Environmental variance.

Unit 2: Basic definitions Gene pool, Gene drift, Migration & gene flow, Founder effects, extinction, Speciation, Reduction in gene flow and bottle-necks, Reproductive isolation.

Unit 3: Quantitative trait loci
Quantitative trait loci: (a) Major genes; (b) Methods of mapping QTLs; (c) Genetical and statistical considerations; (d) QTLs in plants, fruit fly,mouse/rats, yeast; (e) Genomic methods of mapping QTLs; (f) Haplotype mapping and genome-wide association studies (GWAS) ; (g) QTL interactions: genetic and environment

Unit 4: Population genetics
In-breeding depression; mating systems; population bottlenecks, migrations, Bayesian statistics; adaptive landscape, spatial variation; genetic fitness.

Unit 5: Genetic determinants shaping population traits Genetic determinants that shape population traits: (a) overdominance (b) pleiotropy (c) epistasis(d) variable selection (e) gene flow.

Unit 6: Modes of speciation
Modes of speciation: (a) allopatric speciation (b) parapatric speciation (c) sympatric speciation; Evolutionary processes causing speciation: (a) natural selection (b) sexual selection (c) random genetic drift (d) Muller incompatibility.

Unit 7: Phylogenetic analysis
Importance of mitochondrial DNA and Y-chromosome sequence derived population studies: Founder effects, human-origins and subsequent human migration patterns.

Recommended Textbooks and References:
1. Hartl, D. L.; Jones, E. W. (1998). Genetics: Principles and Analysis. Sudbury,MA: Jones and Bartlett
2. Pierce, B. A. (2005). Genetics: a Conceptual Approach. New York: W.H. Freeman
3. Tamarin, R. H.; Leavitt, R. W. (1991). Principles of Genetics. Dubuque, IA: Wm. C. Brown
4. Smith, J. M. (1989). Evolutionary Genetics. Oxford: Oxford University Press
5. Falconer and Mackay: Introduction to Quantitative Genetics
6. Lynch and Walsh: Genetics and Analysis of Quantitative Traits

MSUGN-202: Clinical Genetics **Credits 3**

Unit 1: History and classification of genetic disorders
Origin of medical genetics, major developments and its impact on clinical practice; Single gene disorders, Patterns of inheritance, Classical and non-classical; Clinical cytogenetics: Principles and mechanisms of chromosome abnormalities; Numerical Chromosome Aberrations, Structural Chromosomal Aberrations; Common autosomal and the sex Chromosomes abnormalities; Cancer genetics: common cancers and diagnostics; Genetics of complex/polygenic disorders and diagnostics.

Unit 2: Molecular basis of genetic diseases
Monogenic diseases with well known molecular pathology: Cystic fibrosis, Tay-Sachs syndrome, Marfan syndrome
Inborn errors of metabolism and their genetic bases: Phenylketonuria, Maple syrup urine syndrome, Mucopolysaccharidosis, Galactosemia; Genome imprinting Syndromes: Prader-Willi & Angelman syndromes, Beckwith-Wiedeman Syndrome;
Genomic syndromes: Neurofibromatosis I
Neurogenetic disorders: Huntington Disease, Fragile X syndrome, Hereditary ataxias, Charcot-Marie-Tooth syndrome, spinal muscular atrophy
Syndromes due to triplet nucleotide expansion:
Alzheimer's disease
Muscle genetic disorders: Dystrophies (Duchenne Muscular dytstrophy and Becker Muscular Dystrophy), Myotonias, Myopathies
Genetic disorders of Haemopoitic systems: Overview of Blood cell types and haemoglobin, Sickle cell anemia, Thalassemias, Hemophilias
Genetic disorders of eye: Colour Blindness, Retinitis pigmentosa, Retinoblastoma, Glaucoma, Cataracts
Complex polygenic syndromes: Hyperlipidemia, Atherosclerosis,Diabetes mellitus
Mitochondrial syndromes

Unit 3: Diagnostics- and management
Cytogenetic testing- Karyotype, Molecular-cytogenetic testing-FISH,MLPA, QFPCR,CMA; Testing for single gene disorders-common molecular techniques and advanced techniques for known and unknown mutations; Inherited variation and Polymorphism, RFLP, Microsatellite, Minisatellite; Genetic screening,,PGD, PND carrier testing; Predictive testing -Newborn screening; Antenatal screening, population screening;
Treatment of genetic disorders

Unit 4: Genetic counseling and methods of prenatal testing
Genetic counselling andprinciples in practice – case studies and risk assessment, pedigree analysis;:Indications for prenatal diagnosis, invasive methods, Non-invasive methods of prenatal testing; Pre-implantation and preconceptiondiagnosis-indications, assisted reproduction techniques, methods of pre-implantation and preconception genetic diagnosis, Pre-implantation genetic screening; Therapy of genetic diseases-conventional therapy of genetic diseases, gene therapy of monogenic diseases, antisense therapyof diseases associated with somatic mutations, cancer and viral infections; targeted therapy, gene editing therapy

Unit 5: Personalised medicine
Future scope- Recent advances in human molecular genetics paving ways towards potential application of personalised therapies , genomic variation , copy number variations in different diseases/medicines:pharmacogenomics/ drug metabolism in relation

to individual genetic makeup.

Unit 6: Ethical issues and genetic services

Ethical issues in medical genetics, legal and social issues; Genetics and society; Genetic services in India.

Recommended Textbooks and References:

1. Gersen S.L, M.B. Keagle (eds) (2005) The Principles of Clinical Cytogenetics,2nd edition.
Humana Press, Totowa, NJ, 596p.
2. Elles RG, Mountford R (eds) (2003) Molecular Diagnosis of Genetic Diseases,2ndEdn.
Humana Press, Totowa, NJ.
3. Botstein D1, Risch N. Discovering Genotypes Underlying Human Phenotypes: Past Successes for Mendelian Disease, Future Approaches for Complex Disease. Nat Genet. 2003 Mar;33 Suppl:228-37.
4. Peter Turnpenny.Churchill Livingstone, Emery's Elements of Medical Genetics,(14th
Eds.), Elsevier.
5. Robert L. Nussbaum,Roderick R. McInnes, Huntington F Willard, Thompson;
Thompson Genetics in Medicine, (8eds), Elsevier.
6. C.R. Scriver, A.L. Beaudet, W.S. Sly, D. Valle, The Metabolic and Molecular Bases of Inherited Disease, 7th ed. Vol. 3, McGraw Hill, New York.
7. Peter S Harper, (2010), Practical Genetic Counselling 7th Edition.
8. Janice Berliner, Ethical Dilemmas in Genetics and Genetic Counseling-Principles through
Case Scenarios.
9. Chakravarty A and Chakravarty S; 2018 Human genetics and genomic sciences, platinum press, Kolkata

MSUGN-203: Immunology **credits 3**

Unit 1 : Immune system

Components of innate and acquired immunity; Phagocytosis; Complement and Inflammatory responses; pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP); Haematopoesis; Organs and cells of the immune system-primary and secondary lymphoid organs; Lymphatic system; Lymphocyte circulation; Lymphocyte homing; Mucosal and Cutaneous associated Lymphoid tissue.(MALT&CALT); Mucosal Immunity; Antigens - immunogens, haptens; Major Histocompatibility Complex - MHC genes, MHC and immune responsiveness and disease susceptibility, HLA typing.

Unit 2: Immune responses

Immunoglobulins-basic structure, classes and subclasses of immunoglobulins, antigenic determinants; Multigene organization of immunoglobulin genes; VDJ Recombination, B-cell receptor; Immunoglobulin superfamily; Principles of cell signaling;

Immunological basis of self - non-self discrimination; Kinetics of immune response, memory; $_B$ cell maturation, activation and differentiation; Generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; Functional T Cell Subsets; Cell-mediated immune responses, ADCC; Cytokines-properties, receptors and therapeutic uses; Antigen processing and presentation-endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; Cell-cell co-operation, Hapten- carrier system.

Unit 3: Antigen-antibody interactions

Precipitation, agglutination and complement mediated immune reactions; Advanced immunological techniques - RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence, flow cytometry and immunoelectron microscopy; Surface plasma resonance, Biosenor assays for assessing ligand -receptor interaction, CMI techniques-lymphoproliferation assay, Mixed lymphocyte reaction, Cell Cytotoxicity assays, Apoptotosis, Microarrays, Transgenic mice, Gene knock outs, CD nomenclature, Identification of immune Cells; Principle of Immunofluorescence Microscopy, Flurochromes; Staining techniques for live cell imaging and fixed cells; Flow cytometry, Instrumentation, Applications.

Unit 4: Vaccinology

Active and passive immunization; Live, killed, attenuated, sub unit vaccines; Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; Peptide vaccines, conjugate vaccines; Antibody genes and antibody engineering- chimeric and hybrid monoclonal antibodies; Catalytic antibodies and generation of immunoglobulin gene libraries.

Unit 5: Clinical Immunology

Immunity to Infection: Bacteria, viral, fungal and parasitic infections (with examples from each group); Hypersensitivity - Type I-IV; Autoimmunity; Types of autoimmune diseases; Mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; Treatment of autoimmune diseases; Transplantation-Immunological basis of graft rejection; Clinical transplantation and immunosuppressive therapy; Tumor immunology - Tumor antigens; Immune response to tumors and tumor evasion of the immune system, Cancer immunotherapy; Immunodeficiency- Primary immunodeficiencies, Acquired or secondary immunodeficiencies. Immunoglobulin therapy, Specific and nonspecific immunotherapy for Asthma and allergic diseases.

Text/ Reference

1. Kuby, RA Goldsby, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman, 2002.
2. Brostoff J, Seaddin JK, Male D, Roitt IM., Clinical Immunology, 6th Edition, Gower Medical Publishing, 2002.

3. Janeway et al., Immunobiology, 4th Edition, Current Biology publications., 1999.
4. Paul, Fundamental of Immunology, 4th edition, Lippencott Raven

MSUGN-204: Genetic Engineering **credits 3**

Unit 1: Tools for genetic engineering

Impact of genetic engineering in modern society; general requirements for performing a genetic engineering experiment; restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing; labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes; hybridization techniques: northern, southern, south-western and far-western and colony hybridization, fluorescence in situ hybridization.

Unit 2: Vectors

Plasmids; Bacteriophages; M13 vectors; PUC19 and pBluescript vectors, phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Principles for maximizing gene expression: expression vectors, pMal, GST, pET- based vectors; Protein purification: His-tag; GST-tag; MBP-tag etc. Intein-based vectors; Inclusion bodies; methodologies to reduce formation of inclusion bodies; mammalian expression and replicating vectors; Baculovirus and Pichia vectors system, plant based vectors, Ti and Ri plasmids as vectors, yeast vectors, shuttle vectors.

Unit 3: PCR and cloning

primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, cloning of PCR products; TA cloning vectors; proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP, DGGE, RFLP, RAPD, AFLP, DNA microsatellite, DNA marker, Polymorphism, Positional cloning, functional cloning, therapeutic cloning.

Unit 4: cDNA analysis

Insertion of foreign DNA into host cells; transformation, electroporation, transfection; construction of libraries; isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; construction of microarrays – genomic arrays, cDNA arrays and oligo arrays; study of protein-DNA interactions: electrophoretic mobility shift assay; DNaseI footprinting; methyl interference assay, chromatin immunoprecipitation; protein-protein interactions using yeast two-hybrid system; phage display.

Unit 5: Gene silencing and genome editing technologies

Gene silencing techniques; Transposon and jumping gene, introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene

silencing; gene knockouts and gene therapy; creation of transgenic plants; debate over GM crops; introduction to methods of genetic manipulation in different model systems e.g. fruit flies (Drosophila), worms (C. elegans), frogs (Xenopus), fish (zebra fish) and chick; Transgenics- gene replacement; gene targeting; creation of transgenic and knock-out mice; disease model; introduction to genome editing by CRISPR-CAS9 with specific emphasis on Chinese and American clinical trials, Plant markers and polymorphism, plant tissue culture and gene transfer

Texts/References

1. Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick. Lewin's Gene XII,
2. David Baltimore and Harvey Lodish Molecular cell Biology, 6th Edition
3. James D. Watson (2017) Molecular Biology of the Gene (2017) Pearson Publisher
4. Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub
5. S. Primrose, R. Twyman, B. Old, and G. Bertola (2006), Principles of Gene Manipulation and Genomics, Blackwell Publishing Limited; 7th Edition
6. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
7. Selected Papers from Scientific Journals, particularly Nature & Science.
8. Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc.

MSUGN-205: Applied Bioinformatics **credits 3**

Unit 1: Sequence-alignment related problems

Sequence databases; Similarity matrices; Pairwise alignment; BLAST; Statistical significance of alignment; Sequence assembly, Multiple sequence alignment; Clustal; Phylogenetics: distance based approaches, maximum parsimony.

Unit 2: Pattern analysis in sequences

Motif representation: consensus, regular expressions; PSSMs; Markov models; Regulatory sequence identification using Meme; Gene finding: composition based finding, sequence motif-based finding.

Units 3: Structure-related problems

Representation of molecular structures (DNA, mRNA, protein), secondary structures, domains and motifs; Structure classification (SCOP, CATH); Visualization software (Pymol, Rasmol etc.); Experimental determination of structures (X-ray crystallography, NMR); Structure databases; Secondary structure prediction; RNA structure prediction; Mfold; Protein structure prediction by comparative modelling approaches(homology modelling, threading); Ab initio structure prediction: force fields, backbone conformer generation by Monte Carlo approaches, side-chain packing; Energy minimization; Molecular dynamics; Rosetta; Structure comparison (DALI, VAST etc.); CASP; Protein-ligand docking; Computer-aided drug design (pharmacophore identification); QSAR; Protein-Protein interactions.

Unit 4: System-wide analyses

Transcriptomics: Microarray technology, expression profiles, data analysis; SAGE; Proteomics: 2D gel electrophoresis; Mass Spectrometry; Protein arrays; Metabolomics:13C NMR based metabolic flux analysis.

Text/References:

1. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring
Harbor, NY: Cold Spring Harbor Laboratory Press.
2. Bourne, P. E., & Gu, J. (2009). Structural Bioinformatics. Hoboken,
NJ: Wiley-Liss.
3. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press.
4. Campbell, M & Heyer, L. J. (2006), Discovering Genomics, Proteomics and Bioinformatics, Pearson Education.
5. Oprea, T. (2005). Chemoinformatics in Drug Discovery, Volume 23. Wiley Online Library.
6. Gasteiger, J. & Engel,T. (2003), Chemoinformatics: a Textbook, Wiley Online Library.

MSUGN- 291: Genetic Engineering **credits 3**

1. Isolation of total genomic DNA from bacteria and plants samples.
2. PCR amplification of a candidate gene from the isolated genomic DNA and analysis of the PCR product by agarose gel electrophoresis.
3. Cloning of the PCR amplified product in pGEM-T Easy vector.
4. Preparation of E. Coli (DH5 α) competent cells.
5. Transformation of plasmid DNA in E.coli DH5α. 1. Designing of primers for directional cloning.
6. Cloning of a candidate gene by directional cloning method.
7. Plasmid isolation by Alkaline Lysis method.
8. Isolation of plant total protein from plant leaves and analysis of the isolated protein by SDS-PAGE
9. Screening of recombinant clones by blue white screening.

MSUGN- 292: Immunology **credits 3**

1. Antibody titre by ELISA method.
2. Double diffusion, Immuno-electrophoresis and Radial Immunodiffusion. Complement fixation test.
3. SDS-PAGE, Immunoblotting, Dot blot assays
4. Demonstration of Phagocytosis of latex beads
5. Separation of mononuclear cells by Ficoll-Hypaque
6. Flow cytometry, identification of T cells and their subsets
7. Culture of Macrophage cell and demonstration of Phagocytosis of latex beads
8. Determination of Blood group of an individual and differential leucocyte count

under a microscope.
9. Cryopreservation of cultured cells and cell revival

Semester III

MSUGN 301 Human Genetics and Genetic Counselling

Unit 1: Complications to basic pedigree patterns
Complications to the basic pedigree patterns: Nonpenetrance, variable expressivity, pleiotropy, dominance problem; Anticipation; Compound heterozygosity, Genomic imprinting and uniparental disomy; Spontaneous mutations; Mosaicism and chimerism; Male lethality; X-inactivation; Consanguinity and its effects in the pedigree pattern; Complex traits-polygenic and multifactorial: Approaches to analysis of complex traits, Role of family and shared environment; Monozygotic and dizygotic twins and adoption studies; Polygenic inheritance of continuous (quantitative) traits, Polygenic inheritance of discontinuous (dichotomous) traits - threshold model, liability and recurrence risk; Genetic susceptibility in complex traits; Estimation of genetic components of multifactorial traits: empiric risk; Heritability; Coefficient of relationship; Application of Bayes' theorem.

Unit 3: Genetic mapping of Mendelian and complex characters
Identifying recombinants and non-recombinants in pedigrees; Genetic and physical map distances; Mapping of genetic traits: Two-point mapping- LOD score analysis; Multi point mapping; Homozygosity mapping; Genetic mapping of complex traits; Difficulties in mapping: Allele sharing methods-affected sib pair analysis; Allelic association, Linkage disequilibrium mapping, Transmission disequilibrium test; Human Genome Mapping: Physical mapping of the human genome: Low resolution mapping-Cell hybrids, mini- and microcells, synteny of genes, Radiation hybrid mapping

Unit 4: Chromosomal inheritance in human
Importance, karyotype, autosomal abnormalities, Meiotic non-disjunction, Mitotic non-disjunction (Mosaic), Robertsonian translocation, isochrome formation.

Unit 5: Sex chromosome abnormalities in human
Lyon's hypothesis, Barr bodies, Turner syndrome, Klinefelter syndrome, XXX and XYY syndromes.

Unit 6: Non-Meiotic chromosomal abnormalities in human
Inversions, Ring chromosomes, non-Robertsonian translocation, uniparentaldisomy

Unit 7: Population screening
Identifying human disease genes: Principles and strategies; Position-independent and positional cloning; Candidate gene approaches; Confirming a candidate gene, mutation screening, testing in animal models;
Nomenclature of mutations and their databases; Loss of function and gain of function mutations in diseases.

Unit 8: Genomics and complex disorders
How Genetics Became Genomics / Human Genome Projects Begins and other related

project

Texts/References:

1. S.R. Maloy, J.E. Cronan, D. Friefelder, Microbial Genetics, 2nd Edition, Jones and Bartlett Publishers, 1994.
2. N. Trun and J. Trempy, Fundamental Bacterial Genetics, Blackwell publishing, 2004.
3. Strachan T and Read A P, Human molecular genetics, 3rd Edition Wiley Bios, 2006.
4. Mange E J and Mange A. P., Human genetics, 2nd Edition, Sinauer Associates publications, 1999.
5. Hartl L D and Jones B, Analysis of genes and genomes, 3rd Edition, Jones and Bartlett Publishers, 1994.
6. S.B. Primrose, R.M. Twyman and R.W.Old; Principles of Gene Manipulation. 6th Edition, S.B.University Press, 2001.
7. J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL, 2001.
8. Brown TA, Genomes, 3rd ed. Garland Science 2006
9. Selected papers from scientific journals.
10. Technical Literature from Stratagene, Promega, Novagen, NewEnglandBiolabet

MSUGN302 :
Developmental Biology

Unit 1: Principles of Embryology
Genetic approaches, Genetic marking, Genetic malformations.

Unit2: Developmental patterns
Developmental dynamics of cell specification (Autonomous, Syncytial & Conditional), Morphogenetic fields.

Unit 3: The Genetic core of development
The Embryological origins of Gene Theory, Early attempts at Developmental Genetics, Genomic equivalence, determining the function of genes during development

Unit 4: Genetic analysis of developmental pathways in model organisms

Unit 5: Approaches to the study of plant development- Important differences between plant and animal development, Pattern formation, Germ line development Embryogenesis**-** early events in embryogenesis, Polarity of apical-basal axis mutants, Segment deletion mutants, Radial axis mutants.

Unit 6: Developmental Biology in Human - Structure, chemistry, dynamics and regulation of sperm locomotion, capacitation and egg -surface targeting. Molecular biology, Cytology and Biochemistry of oogenesis: Synthesis and storage of maternal transcripts, proteins and cell organelles. Ovulation and hormonal control in mammals. Molecular and cellular biology of fertilization: acrosome reaction and signal transduction, monospermy and species -specificity. Egg activation, early cleavages and blastocyst formation in mammals and biochemical and cellular changes during the passage down the oviduct to the uterus. Gastrulation in mammals -formation of primitive streak, morphogenetic movements and neural induction.

Unit 7: Molecular reproductive genetics of human
Determination of sex in human and it's genetic control. Bipotential gonads, common pathways of sexual differentiation.Infertility and sub-fertility, assisted reproductive technologies, extra embryos, cryo- preservation of sperms, oocytes and embryos

Recommended Textbooks and References:
1. Pastemak, 2005, *An Introduction to Molecular Human Genetics*, 2nd Edition, Fritzgarald
2. Mange and Mange, 1999, *Basic Human Genetics*, 2nd Edition, Sinauer Assoc
3. Lewis, 2007, *Human Genetics*, 7th Edition, WCB & McGraw
4. Vogel and Motulsky, 1997, *Human Genetics*, 3rd Edition, Springer Verlag
5. Strachen and Read, 2004, *Human Molecular Genetics*, 3rd Edition, Garland Sci. Publishing
6. Maroni, 2001, *Molecular and Genetic Analysis of Human Traits*, 1st Edition, Wiley-Blackwell
7. Developmental Biology , NJ Berrill (Tata McGraw-Hill)
8. Developmental Biology , Scott F Gilbert

MSUGN 303: Genomics & Proteomics credits 3

Unit 1: Metagenomics
Metagenome Sequencing and Analysis , Presequencing Considerations, MPLING and Data Generation, Sequence Processing , Tools and Databases for Metagenomic Analysis, Application For Metagenomic Data Analysis

Unit 2: Human Genomics
Human Genome and its Evolution, Overview of the Human Genome ,Protein Coding Genes in the Human Genome ,RNA Coding Genes and Gene Expression Control Regions , Genomic Heterogeneity of the Human Genome , Genetic Changes That Made Us Human , Ancient Human Genomes, UCSC Human Genomr Browser

Unit 3*:* **Transcriptomics**
What is the Transcriptome and how it is evaluated? Type of RNA molecules within Transcriptome, Transcriptome Evaluation Method: Microarray Analysis , DNA Microarrays, The Diversity of the Transcriptome, Transcriptome Analysis Throughout RNA-seq, Identification of Biomarkers and Expression Signatures, Methods for Gene Co-expression Network Visualizationand Analysis, Construction and Analysis of GCNs

Unit 4: Epigenomics
DNA Methylation, Epigenetic Mechanisms of Gene Regulation, Strategies for Epigenome Analysis, ChIP, ChIP-on-Chip, ChIP-Seq, Profiling of DNA Methylation, MeDIP-seq, Sequencing the Epigenome, Integrating Epigenomic Results, Visualizing the Epigenome, Epigenetics of Aging

Unit 5: Proteomics
Protein Structure , Amino Acids, Peptide Bonds , Primary Structure , Secondary , Tertiary Structure , Quaternary ,Experimental Determination of Amino Acid Sequences andProtein

Structures Protein 2D Gels ,Protein Western Blots . ,Mass Spectrometry, Chemical Identification of Amino Acids in Peptides , Analysis of Protein 3D Structure by X Ray Diffraction
and ,Other Assays for Protein Compositions and Interactions , Computational Methods for Modeling Molecular Structures , Molecular-Force-Field ,Molecular Dynamics ,Hydrogen Bonds, Computation and Minimization of , Solutions to the Problem of Minimization of RMSDover Rotations, Solutions to the Problem of Minimization of RMSD over Rotations and Solvent-Accessible Surface of a Protein, Computational Prediction of Protein Structure and Function , Inferring Structures of Proteins, Protein , De Novo Methods , Comparative Protein Modeling , Visualization of protein modeling by Swiss PDB package, Application of Biopolymer package in protein modeling, Necessary application of modeling in proteomics, Protein–Ligand Binding Analysis , Classification Based on Proteomic Assays

Texts/References

Branden and Tooze “Introduction to Protein Structure”
R. R. Sinden, “DNA Structure & Function”
A. R. Leach “Molecular Modelling- Principles & Function”
Mount “Bioinformatics” Cold Spring Harbour
Arthur Lesk “Introduction to Bioinformatics

MSUGN-304: IPR, Biosafety & Bioethics

credits 3

Unit 1: Intellectual property rights

Intellectual property right and its importance. Types of IPR. PATENTS Macro economic impact of the patent system Patent and kind of inventions protected by a patent. Patent document and protection inventions. Granting of patent Rights of a patent. Searching a patent. Drafting of a patent. Filing of a patent. The different layers of the international patent system (national, regional and international options) COPYRIGHT General Additional Reading: Latest editions of Designs Act, Copyright RELATED RIGHTS. Distinction between related rights and copyright. Rights covered by copyright.
TRADEMARKS and its importance, Rights of trademark. INDUSTRIAL DESIGNS Industrial design. Protection provided by industrial designs.

Unit 2: Bioethics

Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. Bioethics in research – cloning and stem cell research, Human and animal experimentation, animal rights/welfare, Agricultural biotechnology - Genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations - Protection of environment and biodiversity – biopiracy. Bioweapons.

Unit 3: Biosafety

Biosafety and Biosecurity - introduction; historical background; Introduction to biological safety cabinets; primary containment for biohazards; biosafety levels, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs; principles of safety assessment of transgenic

plants – sequential steps in risk assessment; concepts of familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation – protection goals, compilation of relevant information, risk characterization and development of analysis plan; risk assessment of transgenic crops vs cisgenic plants or products derived from RNAi, genome editing tools.

Text/References:

1. Ganguli, P. (2001). Intellectual Property Rights: Unleashing the Knowledge Economy. New Delhi: Tata McGraw-Hill Pub.
2. National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI
3. Complete Reference to Intellectual Property Rights Laws. (2007). Snow White Publication Oct.
4. Kuhse, H. (2010). Bioethics: an Anthology. Malden, MA: Blackwell.

MSUGN-391: Applied Bioinformatics Lab **credits 3**

1 Downloading macromolecular sequences from the NCBI database in different file formats.
2 Creating a non-redundant database of sequences using CD-HIT.
3Identification of relatives from the database using BLAST search. Creation of a data-set on the basis of the E-value.
3 Using EMBOSS for local and global alignment of proteins.
4 Determination of domains present in proteins and comparison of domain architecture (DA) across different proteins.
5 Identification of repeats in proteins using Pfam.
6 Further identification of repeats left undetected by Pfam using multiple sequence analysis.
7 Construction of phylogenetic tree using PHYLIP.

Lab on Molecular Genetics and Developmental Genetics 3 Credits
(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Extraction of gDNA from blood.
2. Designing of Primers to amplify target gene sequence
3. Screening of gene to identify causal mutation
4. Sequencing
5. Analysis of chromatogram
6. Developmental pattern in model organisms – Drosophila, Zebra fish and Mouse
7. specimens of early human development and slides of chick &/or pig or mouse embryos to correlate avian and mammalian early development with human development
8. Specimens of congenital malformations.

Elective subjects:

1. MSUGN-305A Principles of Ecology Credit: 2

Unit 1: The Environment
Physical environment; biotic environment; biotic and abiotic interactions. Habitat and Niche: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.

Unit 2: Population Ecology
Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations. Species Interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.

Unit 3: Community Ecology
Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones. Ecological Succession: Types; mechanisms; changes involved in succession; concept of climax. Ecosystem Ecology: Ecosystem structure; ecosystem function; energy flow and mineral cycling (C,N,P); primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine). Biogeography: Major terrestrial biomes; theory of island biogeography; biogeographical zones of India.

Unit I4: Applied Ecology
Environmental pollution; global environmental change; biodiversity: status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches. Conservation Biology: Principles of conservation, major approaches to management, Indian case studies on conservation/management strategy (Project Tiger, Biosphere reserves).

Text/References:
1. Chapman and Reiss. Ecology: Principles And Applications, 2nd Edition
2. Pd Sharma. Ecology and Environment. 13th edition
3. Eugene Odum. Fundamentals of Ecology.

2. MSUGN-305B Research methodology and Writing Credit:2

Unit 1: History of science and science methodologies
Empirical science; scientific method; manipulative experiments and controls; deductive and inductive reasoning; descriptive science; reductionist vs holistic biology.

Unit 2: Preparation for research
Choosing a mentor, lab and research question; maintaining a lab notebook. Computing skills for scientific research - web browsing for information search; search engines and their mechanism of searching; hidden Web and its importance in scientific research; internet as a medium of interaction between scientists; effective email strategy using the right tone and conciseness. Presentation skills - formal presentation skills; preparing and

presenting using over-head projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions;

Unit 3: Scientific communication
Technical writing skills - types of reports; layout of a formal report; scientific writing skills - importance of communicating science; problems while writing a scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers - peer review process and problems, recent developments such as open access and non-blind review; plagiarism; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.

Text/References:

1. Valiela, I. (2001). Doing Science: Design, Analysis, and Communication of Scientific Research. Oxford: Oxford University Press.
2. On Being a Scientist: a Guide to Responsible Conduct in Research. (2009). Washington, D.C.: National Academies Press.
3. Gopen, G. D., & Smith, J. A. The Science of Scientific Writing. American Scientist, 78(Nov-Dec 1990), 550-558.
4. Mohan, K., & Singh, N. P. (2010). Speaking English Effectively. Delhi: Macmillan India.
5. Movie: Naturally Obsessed, The Making of a Scientist.

3. MSUGN-305C Molecular diagnostics Credit:2

Unit 1: Genome: resolution, detection and analysis
PCR: Real-time; ARMS; Multiplex; ISH; FISH; ISA; RFLP; DHPLC; DGGE; CSCE; SSCP; Nucleic acid sequencing: new generations of automated sequencers; Microarray chips; EST; SAGE; microarray data normalization & analysis; molecular markers: 16S rRNA typing; Diagnostic proteomics: SELDI-TOF MS; Bioinformatics data acquisition & analysis.

Unit 2: Detection and identity of microbial diseases
Direct detection & identification of pathogenic-organisms that are slow growing or currently lacking a system of in vitro cultivation as well as genotypic markers of microbial resistance to specific antibiotics.

Unit 3: Detection of inherited diseases
Exemplified by two inherited diseases for which molecular diagnosis has provided a dramatic improvement of quality of medical care: - Fragile X Syndrome: Paradigm of the new mutational mechanism of the unstable triplet repeats, von-Hippel Lindau disease: recent acquisition in the growing number of familial cancer syndromes.

Unit 4: Molecular oncology
Detection of recognized genetic aberrations in clinical samples from cancer patients; types of cancer-causing alterations revealed by next-generation sequencing of clinical isolates; predictive biomarkers for personalized onco-therapy of human diseases such as chronic myeloid leukemia, colon, breast, lung cancer and melanoma as well as matching targeted therapies with patients and preventing toxicity of standard systemic therapies.

Text/References:

1. Campbell, A. M., & Heyer, L. J. (2006). Discovering Genomics, Proteomics, and Bioinformatics. San Francisco: Benjamin Cummings.
2. Brooker, R. J. (2009). Genetics: Analysis & Principles. New York, NY: McGraw-Hill.
3. Glick, B. R., Pasternak, J. J., & Patten, C. L. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, DC: ASM Press.
4. Coleman, W. B., & Tsongalis, G. J. (1997). Molecular Diagnostics: for the Clinical Laboratorian. Totowa, NJ: Humana Press.

4. MSUGN-305D Enzyme technology **Credit:2**

Unit 1: Enzymes, coenzymes and cofactors

Enzymes: Classification, mode of action, activation, specificity, Source of enzymes; production, isolation and purification of enzymes; Characterization in terms of pH, temperature, ionic strength, substrate and product tolerance, effects of metal ions; Coenzymes and cofactors: Coenzymes, classification of vitamins, role and mechanism of action of some important coenzyme (NAD+/NADP+, FAD, lipoic acid, tetrahydrofolate, B12-coenzyme), role of cofactors with specific examples.

Unit 2: Enzyme kinetics

Enzyme as biological catalysts; Enzyme action, active site, functional group, enzyme substrate complex, cofactors, Michaelis-Menten equation, Km and Vmax, enzyme inhibition; order of reaction, methods of plotting enzyme kinetics data; Enzyme turnover number. competitive, non-competitive, uncompetitive, irreversible; order of reaction, methods of plotting enzyme kinetics data; determination of Kcat, Km, Vmax, Ki, Half life, activation and deactivation energy etc, Cross-linked enzyme aggregates, Cross linked enzymes, enzyme crystals, their use and preparation; Solution of numerical problems; Energy yielding and energy-requiring reactions; Calculation of equilibrium constants; Activation energy etc.; Multisubstrate enzymes and kinetics mechanisms; Enzyme induction, repression, covalent modification, Isoenzymes, allosteric effects.

Unit 3: Applications of enzyme technology

Immobilized enzyme technology: Different techniques of immobilization of enzymes and whole cells; Advantages and disadvantages of immobilization; Kinetics of immobilized enzymes, design and operation of immobilized enzymes reactors; Type of reactors, classification, retention of enzymes in a reactor, kinetics of enzyme reactors; Reactor performance with inhibition, operation of enzyme reactors; case studies; starch conversion; APA production, biotransformations using soluble as well as immobilized enzymes; Calculation of diffusional resistances and Thiele's modulus, multi-step immobilized enzyme systems; Solution of numerical problems; Application and future of immobilized enzyme technology; Enzyme in organic solvents and ionic liquids: Various organic solvents and ionic liquids used in biocatalysis; Potential in organic solvents and ionic liquids; Applications of enzymes in analysis.

Text/References

1. Stryer, L. (2002). Biochemistry. Freeman. New York.
2. Lehninger, A. L. (2004). Principles of Biochemistry (4th ed.). Worth. New York, NY
3. Voet, D., & Voet, J. G. (2004). Biochemistry (4th ed.). Wiley & Sons. Hoboken, NJ: J
4. Rehm, H. & J. Reed, G., (1986). Enzyme Technology. Volume 7a. John Wiley & Sons.
5. Irwin H. Segel, (1976). Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry, 2nd revised Ed. John Wiley & Sons.

6. Biotol, (1992). Bioreactor Design & Product Yield. Butterworth-Heinemann
7. Wang, D. I. C. (1979). Fermentation and Enzyme Technology. Wiley. New York.

4. MSUGN-305E Plant Molecular Biology **Credit:2**

Unit 1: Plant tissue culture
Plasticity and Totipotency, The culture environment, Plant Cell culture media, Plant growth regulators and function, Culture types- Callus, Cell-suspension culture, Protoplast culture, Root culture, Shoot tip and Meristem culture, Embryo culture, Somaclonal variation, Somatic Embryogenesis, Polyploidy, Androgenesis, Artificial Seed, Agrobacterium mediated transformation.

Unit 2: Plant Transcription Factor
Introduction to Transcription factor structure and function, Methods to study transcription factor structure and function, Different plant specific transcription factors and their functions, Different Plant transcription factors and their functions.

Unit 3: Plant Physiology
Molecular mechanism of seed germination, significance of ABA and GA in seed germination, light control on flower development, short day plants and long day plants, ABC model of flowering, plant stress physiology, drought stress, salt stress, biotic stress, viral stress.

Unit 4: Plant Disease
How pathogen attack plants, Mechanism of plant defence against pathogen, Effect of pathogen on plant physiological functions, causative agent of plant disease like virus, fungi, bacteria, nematodes etc.

Semester IV

MSUGN- 481 Project Work **Credit 22**

Unit 1: Planning & performing Experiments

Based on the project proposal submitted in earlier semester, students should be able to plan, and engage in, an independent and sustained critical investigation and evaluate a chosen research topic relevant to biological sciences and society. They should be able to systematically identify relevant theory and concepts, relate these to appropriate methodologies and evidence, apply appropriate techniques and draw appropriate conclusions. Senior researchers should be able to train the students such that they can work independently and are able to understand the aim of each experiment performed by them. They should also be able to understand the possible outcomes of each experiment. At the end of their project, thesis has to be written giving all the details such as aim, methodology, results, discussion and future work related to their project. Students may aim to get their research findings published in a peer-reviewed journal. If the research findings have application-oriented outcomes, the students may file patent application.

Unit 2: Thesis Writing

At the end of their project, thesis has to be written giving all the details such as aim, methodology, results, discussion and future work related to their project. Students may aim to get their research findings published in a peer-reviewed journal. If the research findings have application-oriented outcomes, the students may file patent application.