Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

Syllabus for M. Sc. In Genetics

(Effective from academic session 2019-20)

Semester – I

Code **A**	Course Title **Theory**	Contact Hrs./Wk **L-T-P**	Credit
MSGN-101	Biochemistry	3-0-0	3
MSGN-102	Laboratory Techniques	3-0-0	3
MSGN-103	Cell and Molecular Biology	3-0-0	3
MSGN-104	Biostatistics	3-0-0	3
MSGN-105	Basic genetics	3-0-0	3
B	**Practical**		
MSGN-191	Biochemistry & Analytical Techniques Lab	0-0-6	3
MSGN-192	Cytogenetics Lab	0-0-6	3
MSGN-193	Data analysis using statistical software	0-0-6	2
C			
MSGN-181	Seminar		1
Semester Total			**24**

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: Cytogenetics Lab credits 3

1. Basic principles of Cyto-Genetics procedures
2. Setting up Laboratory
3. Peripheral Blood Cyto-Genetics Methods
4. Chromosome staining
5. Microscopy & Imaging
6. Whole Blood Culture
7. Lymphocyte Culture
8. Blood Cell Determination
9. Chromosome preparation: staining and observation
10. 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.

Semester II

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

MSGN201 :Evolutionary biology and population Genetics

credits
3

Unit I- Genetic constitution of a population Genetic constitution of a population: (a) Gene frequencies and genotypes; (b) Hardy-Weinberg equilibrium; (c) Changes in gene frequency andcontinuous 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 II- Basic definitions- Gene pool, Gene drift, Migration & gene flow, Founder effects,extinction, Speciation, Reduction in gene flow and bottle-necks, Reproductive isolation.

Unit III. Quantitative trait loci- Quantitative trait loci: (a) Major genes; (b) Methods ofmapping 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 IV Population genetics- In-breeding depression & mating systems; population bottlenecks, migrations, Bayesian statistics; adaptive landscape, spatial variation & genetic fitness.

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

Unit VI- Modes of speciation- Modes of speciation: (a) allopatric speciation (b) parapatricspeciation (c) sympatric speciation; Evolutionary processes causing speciation: (a) naturalselection (b) sexual selection (c) random genetic drift (d) Muller incompatibility.

Unit VII-Phylogenetic analysis- Importance of mitochondrial DNA and Y-chromosomesequence derived population studies: Founder effects, human-origins and subsequent humanmigration 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

MSGN202: 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- Types of mutations, factors causing mutations andeffects; Common singe gene disorders:Disorders of haematological system-thalassemia,hemophilia, sickle cell disease;
Common disorders of neurological system- Huntington disease,Fragile X syndrome, Hereditary ataxias, Neuromuscular disorders like Duchenne musculardystrophy, Spinal muscular atrophy; Diseases associated with dynamic mutations –Myotonic dystrophy (MD); fragile X chromosome syndrome (Martin–Bell syndrome); Huntington's chorea, Spinocerebellar ataxia 1 (SCA1); Machado-Joseph Disease (MJD)/SCA3 Friedreich's Ataxia;
Biochemical basis of Genetic diseases; Inborn errors of metabolism;
Disorders of immune system;
Genomic Imprinting defects,
Microdeletion syndromes nature, molecular characterization, mechanisms of phenotypic expression of the Prader-Willi Syndrome(PWS), Angelman Syndrome(AS) and other diseases associated with chromosome imprinting;
Congenital anomalies of development– dysmorphology and teratogenesis; Congenital malformations, deformations and disruptions, dysplasia, large and small malformations, Types of combined anomalies, disorders in sexual differentiation, intersexual conditions; Mitochondrial Diseases–Leber Hereditary optic neuropathy(LHON); Myoclonic Epilepsy with Ragged Red Fibres (MERRF); Mitochondrial encephalomyopathy, lactic acidosis, and stroke-likeepisodes(MELAS); Kearns–Sayre syndrome, etc.

Or

Unit 2: Molecular basis of genetic diseases- An overview of the genetic basis of syndromes and disorders

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 **4**

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 IV 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 4: 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 5: 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

MSGN 203: Immunology credits 3

Unit 1 : Fundamental concepts and anatomy of the 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 generated by B and T lymphocytes

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 ofImmunofluorescence 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 V 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,

MSGN-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 mp vectors; PUC19 and Bluescript 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; DNaseIfootprinting; 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-CAS with specific emphasis on Chinese and American clinical trials.

Texts/References

1. Gene XII, Lewin's
2. Molecular cell Biology, David Baltimore and Harvey Lodish

MSGN205: 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: distancebased 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; RNAstructure prediction; Mfold; Protein structure prediction by comparative modelling approaches(homology modelling, threading);Ab initio structure prediction: force fields, backbone conformergeneration by Monte Carlo approaches, side-chain packing; Energyminimization; Molecular dynamics; Rosetta; Structure comparison(DALI, VAST etc.); CASP; Protein-ligand docking; Computer-aideddrug design (pharmacophore identification); QSAR; Protein-Proteininteractions.

Unit 4: System-wide analyses

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

MSGN206:MOOCs

Subject Code	Course Topic
MSGN206A	**Bioreactor**
MSGN206B	**Human molecular genetics**
MSGN206C	**Current Regulatory Requirements For Conducting Clinical Trials In India For Investigational New Drugs/new Drug (Version 2.0)**
MSGN206D	**Introduction to research**
MSGN206E	**Health Research Fundamentals**
MSGN206F	**Cell Culture Technology**

MSGN206G	**Medical Biomaterials**
MSGN206H	**Immunology**
MSGN206I	**Environmental Remediation of Contaminated Sites**
MSGN206J	**Nanotechnology**
MSGN206K	**Wild life ecology**

MSGN291:Lab On Genetic Engineering

Credits3

1. Isolation of totalgenomic 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* (DH5α) competent cells.
5. Transformation of plasmid DNA in *E.coli* DH5α.
6. Screening of recombinant clones by blue white screening.
7. Designing of primers for directional cloning.
8. Cloning of a candidate gene by directional cloning method.
9. Plasmid isolation by Alkaline Lysis method.
10. Isolation of plant total protein from plant leaves and analysis of the isolated protein by SDS-PAGE.

MSGN292: Lab on Immunology

credits 3

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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. Flowcytometry, 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 amicroscope.
9. Cryopreservation of cultured cells and cell revival.

Semester III

Code	Course Title	Contact Hrs./wk	Credit
A	**Theory**	**L-T-P**	
MSGN-301	Human genetics and genetic counselling	3-0-0	3
MSGN-302	Developmental genetics	3-0-0	3
MSGN-303	Genomics & Proteomics	3-0-0	3
MSGN-304	IPR, Biosafety & Bioethics	3-0-0	3
MSGN-305	Choice Based course (From Elective Basket)	2-0-0	2
MSGN-306	Choice Based course (From MOOCS Basket)	2-0-0	2
B	**Practical**		
MSGN-391	Lab for Applied Bioinformatics	0-0-6	3
MSGN-392	Lab for developmental genetics	0-0-6	3
C			
MSGN-381	Project Proposal Presentation /seminar		2
Semester Total			**24**

MSGN 301: Human genetics and genetic counselling credits 3

History of human genetics- Pedigrees- gathering family history; Pedigree symbols; Construction of pedigrees;Presentation of molecular genetic data in pedigrees; Pedigree analysis of monogenic traits: Autosomal inheritance-dominant, recessive; Sex-linked inheritance- X-linked recessive, dominant; Y–linked; Sex-limited and sex-influenced traits; Mitochondrial inheritance; MIM number; Complications to the basic pedigree patterns: Nonpenetrance,variable expressivity, pleiotropy, onset, dominance problem; Anticipation; Compound heterozygosity.

Complications to basic pedigree patterns- Genomic imprinting and uniparentaldisomy; Spontaneous mutations; Mosaicism and chimerism; Male lethality; X-inactivation; Consanguinity and its effects in the pedigree pattern; Allele frequency in population; Complex traits-polygenic and multifactorial:Approaches to analysis of complex traits- 'Nature vs nurture';Role of family and shared environment; Monozygotic and dizygotic twins and adoption studies;Polygenic inheritance of continuous (quantitative) traits, normal growth charts, Dysmorphology;Polygenic inheritance of discontinuous (dichotomous) traits - threshold model, liability andrecurrence risk; Genetic susceptibility in complex traits; Alcoholism, cardiovascular disease,diabetes mellitus, obesity & epilepsy; Estimation of genetic components of multifactorial traits:empiric risk; Heritability; Coefficient of relationship; Application of Bayes' theorem.

Genetic mapping of Mendelian and complex characters- Identifying recombinants and non-recombinants in pedigrees; Genetic and physical map distances; Genetic markers; Mappingof genetic traits: Two-point mapping- LOD score analysis; Multipoint mapping; Homozygositymapping; Genetic mapping of complex traits; Difficulties in mapping: Allele sharing methods-affected sib pair analysis; Allelic association, Linkage disequilibrium mapping, Transmissiondisequilibrium test; Human Genome Mapping: Physical mapping of the human genome: Lowresolution mapping-Cell hybrids, mini- and microcells, synteny of genes, Radiation hybridmapping; Human genome mapping: Assembly of clone contigs and identifying genes in clonedDNA; Integration of cytogenetic, genetic and physical maps; DNA testing; Direct and indirecttesting (gene tracking) in individuals; DNA tests for identity and relationships including forensicapplications; Population screening: ethics, organization and advantages

Chromosomal inheritance in human– importance, karyotype, chromosome replication, autosomal abnormalities, Meiotic non-disjunction, Mitotic non-disjunction (Mosaic), Robertsonian translocation, isochrome formation.

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

Non-Meiotic chromosomal abnormalities in human– Inversions, Ring chromosomes, non-Robertsonian translocation, uniparentaldisomy.

Population screening- ethics, organization and advantages 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;
Molecular pathology: Nomenclature of mutations and their databases; Loss of function and gainof function mutations in diseases.

Pharmacogenetics : Definition, Drug metabolism, Genetic variations revealed solely by the effect of drugs, Hereditary disorders with altered drug response, Evolutionary origins of variationin drug response, pharmaco-genetics, Eco-genetics

Genomics and complex disorders How Genetics Became Genomics / Human Genome Projects Begins and Extension of other

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

MSGN302 : Developmental genetics

Unit 1
Principles of Embryology - Genetic approaches, Genetic marking, Genetic malformations. **(2 Periods)**

Unit2
Developmental patterns – Developmental dynamics of cell specification (Autonomous, Syncytial & Conditional), Morphogenetic fields. **(2 Periods)**

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 **(2 Periods)**

Unit 4. Genetic analysis of developmental pathways in model organisms – Yeast, Arabidopsis, Drosophila, C. elegans, Xenopus, Zebrafish, Chick & Mouse. **(3periods)**

Unit 5
Approaches to the study of plant development- Important differences between plant and animal development, Pattern formation, Germ line development **(3 periods)**
Embryogenesis- early events in embryogenesis, Polarity of apical-basal axis mutants, Segment deletion mutants, Radial axis mutants. **(3 periods)**
Seedling Development- Shoot development, leaf developments, genetics of development. **(2 periods)**
Transition to Flowering- Control of flowering through the action of transgenes, Molecular genetics and the ABC Model for flower development, Cadasteral functions of Homeotic genes, Molecular function of MADSBox genes **(4 Periods)**

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. **(9 Periods)**

Unit 7 Molecular regulations of human development
Human hox genes and genetic effects due to mutations in Hox gene, somite differentiation and homeo box genes (Anterior- Posterio patterning). **(5 Periods)**

Unit 8. 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. **(5 Periods)**

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

MSGN 303: Genomics& Proteomics credits 3

Metagenomics

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

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

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

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

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

MSGN304: IPR, Biosafety &Bioethics 3 Credits

Unit 1: IPR

IPR and its different forms

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 What is a trademark. Rights of trademark. INDUSTRIAL DESIGNS Industrial design. Protection provided by industrial designs. Geographical indication, tradesecret

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.

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 vscisgenic plants or products derived from RNAi, genome editing tools.

MSGN391: Lab on Applied Bioinformatics

3 Credits

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.

MSGN392: Lab on 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. Developmental pattern in model organisms – Drosophila, Zebra fish and Mouse
2. specimens of early human development and slides of chick &/or pig or mouse embryos to correlate avian and mammalian early development with human development
3. Specimens of congenital malformations.

(Elective)
MSGN305A: Neurogenetics

Neuronal assembly
6 lectures
Major regions of human brain; Cellular components of nervous tissue; Sub cellular organization of nervous system; Membrane potential and action potential; neurotransmitters.

Unit II
Genetic aspect of learning and memory
5 lectures
Genetics of Learning and memory; Genetic approaches to Circadian rhythms.
Unit III
Modern sequencing techniques & their applications
7 lectures
Modern sequencing technique: applications in neuroscience; Transgenics and their application in neurogenetic analysis; Gene targetting technologies and their application in neuroscience; Optogenetics and Pharmacogenetics in neuroscience.
Unit IV
Nature-nurture and behaviour
8 lectures
Genetic experiments to investigate animal behaviour: Selection Studies, Inbred strain studies, studies in genetic model organisms; Identifying genes for controlling behavior: Induced mutations; Quantitative trait loci; Synteny/orthology; Investigating the genetics of human behavior; Twin and adoption study designs, interpreting heritability; Linkage and association studies; Environmental influence- shared and non-shared environment.
Unit V
Genetics of psychiatric disorder
6 lectures

Schizophrenia, Mood disorders, Disorders of childhood; Neurogenetic disorders; Spinomuscular atrophy; Syndromes due to triplet nucleotide expansion; Alzheimer's disease;Parkinson's disease.
Recommended Textbooks and References:
1. Kaplan and Sadock, (2007), *Synopsis of Psychiatry*, 10th Edition, Williams & Wilkins.
2. Plomin *et al*., (2001), *Behavioral Genetics*. Freeman.
3. Zigmond, Bloom *et al*., (2002), *Fundamentals of Neuroscience*, 2nd Edition, Academic Press.
4. Kandel, Schwartz *et al*., (2000), *Principles of Neuroscience*, Prentice Hall.
5. Pasternak, (2005), *An Introduction to Molecular Human Genetics*, Fritzgerald.
6. Griffiths *et al*., (2015), *Introduction to Genetic Analysis*, 11th Edition, Freeman.

MSGN305B: Cancer Genomics

Unit I

Cancer genomics: perspective and new technologies

Historical perspective on the development of cancer genomics; Cancer characterization using sequencing approaches; Advances in sequencing technologies; Discoveries using second-generation sequencing technologies; Cancer transcriptome sequencing and analysis; Identifying pathogen presence in cancer samples.

Unit II

Significance of transcriptome sequencing in personalized cancer medicine

Importance of RNA; Role of MicroRNAs and Ultra-conserved Non-Coding RNAs in cancer; From microarray to RNA sequencing; Workflow for RNA sequencing; RNA sequencing data analysis in cancer genome research; Incorporating transcriptome sequencing analysis to identify genomic driver mutations; Transcriptome sequencing: from bench to bedside; Tissue Microarrays in studying gynecological cancers.

Unit III

Cancer pharmacogenomics & biomarker discovery and development

Pharmacogenomics; Cancer pharmacogenomics in children; Active ADR surveillance and future directions; Uses of biomarkers in cancer research and cancer care; Biomarker discovery and qualification; Assay validation, clinical validity, clinical utility; Incorporation of biomarkers into clinical trial design.

Unit IV

Bioinformatics for cancer genomics & genomic resource projects

4 lectures

Data Types in cancer genomics, Data management & data analysis, Data Interpretation TCGA and other sources of cancer genomic data; Key large-scale cancer genomics projects; other notable genomics projects.

Unit V

Genomics of specific cancers

8 lectures

Genetic basis of hereditary cancer syndromes; Retinoblastoma, Wilms tumor, Non-syndromic tumors and susceptibility Loci, Cancer predisposition syndromes, Genomics of adult and pediatric cancers; Special focus on common solid tumors of the Lung, Prostate, Colon and Breast:- Genomics and Molecular Profiling, Epidemiology, Standard Treatment and Prognosis; Somatic gene mutations, Personalized targeted therapy, Molecular diagnostics and treatment guidance; Special focus on common liquid tumors of the hematopoietic system- Acute myeloid leukemia: epidemiology, etiology, genetic and epigenetic alterations, somatic mutations and their contribution to survival in childhood acute myeloid leukemia; Disease-associated mutations in signal transduction pathways.

Unit VI
Impact of environment on cancer genomics
2 lectures
Important components of the exposome; Mechanisms of environmental carcinogenesis.

Recommended Textbooks and References:
1. Graham Dellaire, Jason N. Berman and Robert J. Arceci, (2013), *Cancer Genomics: from Bench to Personalized Medicine*, 1st Edition; Academic Press

MSGN305C: Nano-biotechnology (Elective)

Unit I
Introduction to Nanobiotechnology
Introduction to Nanobiotechnology; Concepts, historical perspective; Different formats of nanomaterials and applications with example for specific cases; Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures,Synthesis and characterization of different nanomaterials.

Unit II
Nano – films
Thin films; Colloidal nanostructures; Self Assembly, Nanovesicles; Nanospheres; Nanocapsules and their characterisation.

Unit III
Nano particles
Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers.

Unit IV
Applications of nano – particles
Nanoparticles for diagnostics and imaging (theranostics); concepts of smart stimuli responsive nanoparticles, implications in cancer therapy, nanodevices for biosensor development.

Unit V
Nano – materials

Nanomaterials for catalysis, development and characterization of nanobiocatalysts, application of nanoscaffolds in sythesis, applications of nanobiocatalysis in the production of drugs and drug intermediates.

Unit VI

Nano – toxicity

Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment; Fate of nanomaterials in different stratas of environment;Ecotoxicity models and assays; Life Cycle Assessment, containment.

MSGN305D: Bioentrepreneurship (Elective)

Unit I

Innovation and entrepreneurship in bio-business

8 lectures

Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (*e.g.* pharmaceuticals *vs.* Industrial biotech), Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities, Alternatives faced by emerging bio-firms and the relevant tools for strategic decision, Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies.

Unit II

Bio markets -business strategy and marketing

8 lectures

Negotiating the road from lab to the market (strategies and processes of negotiation with financiers, government and regulatory authorities), Pricing strategy, Challenges in marketing in bio business (market conditions & segments; developing distribution channels, the nature, analysis and management of customer needs), Basic contract principles, different types of agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills.

Unit III

Finance and accounting 8 lectures

Business plan preparation including statutory and legal requirements, Business feasibility study, financial management issues of procurement of capital and management of costs, Collaborations & partnership, Information technology.

Unit IV

Technology management
8 lectures
Technology – assessment, development & upgradation, Managing technology transfer, Quality control & transfer of foreign technologies, Knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP).

MSGN305E: Tissue Engineering and artificial organs (Elective)

Unit I
Introduction to tissue engineering
2 L

Introduction, importance and scope of tissue engineering.

Unit II
5L
Biomaterials and scaffolds
Introduction to biomaterials and scaffolds; Requirements of biomaterials as Tissue Engineering scaffolds, Properties and types of scaffolds, Tissue specific scaffolds.

Unit III
Scaffold Preparation
5 lectures
Different methods employed in the synthesis of scaffolds and ways to process them.
Unit IV
Biology of animal cell
5 lectures
Animal cell biology, stem cells, organization of cells into tissues, tissue microenvironment, tissue injury and wound healing.

Unit V
4L
Biosensors for optimal tissue engineering
Biosensing techniques, Real time sensing in tissue engineering, in vivo implementations and challenges faced
UnitVI
Host-graft response
2 lectures
Review of basic immunology, response of body to foreign materials
Unit VII

Cell / Tissue-scaffold interaction
5 lectures
Animal cell culture on scaffolds, consequences, optimization strategies and important considerations.

Unit VIII
Tissue engineering applications
12 lectures
Skin tissue engineering, Liver tissue engineering, Bone and cartilage tissue engineering, Nerve tissue engineering, Vascular tissue engineering, Muscle tissue engineering and Kidney tissue engineering; Regulatory Affairs, Ethical issues and their impact on tissue engineering.

MSGN-306(MOOCS)

A. **Computer aided drug design (NPTEL)**
B. **Functional Genomics (NPTEL)**
C. **Introduction to proteogenomics (NPTEL)**
D. **Industrial Biotechnology (NPTEL)**
E. **Medical Nanotechnology (NPTEL)**
F. **Dairy and food process and products technology (NPTEL)**
G. **Anatomy: Musculoskeletal and Integumentary systems (EDX)**
H. **Bioistatistics and design of experiments**
I. **Waste water treatment and recycling**
J. **Plant molecular Biology**
K. **Patenting**
L. **Introduction to genetics and evolution,**
M. **Molecular Diagnostics**

Semester – IV

Code	**Course Title**	**Contact Hrs./wk**	**Credit**
		L-T-P	
MSGN-481	Project Work	0-0-0	22
MSGN-482	Lab Visit/ industry visit		1
MSGN-483	Seminar on Journal club		1
Semester Total			**24**