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

Semester-II

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 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 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

MSMB205: 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

MSMB291: 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.

MSMB292: 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.