RKDF University
SYLLABUS FOR ENTRANCE TEST FOR PH.D. SUBJECT : GENETICS

1. General Genetics

Cellular reproduction (cell division): The cell cycle, mitosis, amitosis and meiosis. Nondisjunction and its consequences. Genetic significance of mitosis and meiosis.

Principles of mendelian inheritance: a). Terminology: Gene, allele, locus, genome, genotype, phenotype, homozygote, heterozygote, hemizygote. b). Segregation: Mendel's experiments; monohybrid cross, test cross, back cross, reciprocal cross. c). Independent assortment: Mendel's experiments; dihybrid crosses, genotypes of dihybrid crosses. Correspondence between mendelian factors and chromosomes, chromosome theory of inheritance. Segregation and assortment in haploid organisms. Incomplete dominance, over dominance, codominance, multiple alleles and polygenic inheritance.

Gene interaction: Epistasis, additivity, interaction between more than two gene pairs. Modifiers, complementary gene action, pleiotropism, lethality, segregation distortion. Crossing over and linkage, chromosome mapping, use of genetic maps, cross over suppression, tetrad analysis in *Neurospora*.

Sex-determination and sex- linked inheritance, sex- influenced, sex-limited traits, and sex-reversal. Extra chromosomal inheritance.

Properties and evolution of genetic material flow of genetic information. Organisation of viral and bacterial genomes. Eukaryotic genomes: c-value paradox; repetitive DNA; modern concept of gene; gene families; non- coding genes.

2. Principles of Biochemistry

pH, acids, bases and buffers, The Henderson-Hasselbalch equation, titration and buffers, physiological buffers (bicarbonate buffer, protein/ amino acids and buffer system). Principles

of energetics: enthalpy (*H*), entropy (*S*) and free energy (*G*), high and low energy phosphate compounds, oxidation- reduction reaction, activation energy. Types of bonds.

Structure and properties of carbohydrates: triose, tetrose, pentose and hexose sugars; disaccharides, polysaccharides, glycoprotein. Structure and properties of lipids and biomembranes: fatty acids, acylglycerole, phospho-glycerides, sphingolipids, terpenes, steroids, lipid digestion, lipoprotein, biological membranes.

Structure of amino acids. Structure and properties of polypeptides and proteins: A). Peptide bonds, proteolysis, amino acids composition of polypeptides. B). Structure of polypeptide/proteins: Primary structure: determination of primary structure (Edman reaction, alternative method by sequencing the DNA coding for the polypeptide). Secondary structure: α-helix, β-pleated sheet, the random coil and triple helix. Tertiary structure: fibrous and globular proteins. Quaternary structure C). Oxygen carrying proteins: role of haemoglobin and myogloin in oxygen transport, oxygen dissociation curves of haemoglobin.

Enzymes: Classification and mode of action-nomenclature and types; enzyme kinetics: reaction order (zero-order, first-order and second –order reactions); Michaelis-Menten equation; enzyme inhibitors; regulation of enzyme activity (common mechanisms: photolytic activation, control proteins to inhibit or stimulate enzymes, reversible covalent modification. allosteric control). Vitamins and coenzymes: Water-soluble vitamins and coenzymes (vitamins B and vitamin C) Fat soluble vitamins-vitamins not acting as coenzymes: vitamin A, D, E and K. Hormones viz. peptide hormones, steroid hormones. Plant growth regulators viz. auxins, cytokinins, gibberellins, abscessic acid, ethylene.

Nucleic acids: structure of purines and pyrimidines, nucleotides, nucleosides, Watson and Crick model, forms of DNA, RNA, types of RNA. Biological importance of DNA, RNA.

3. Analytical Techniques

Chromatography: principles and applications. Adsorption, partition and ion exchange chromatography. Gel filtration, affinity and HPLC, GLC, GC and FPLC.

Moving boundary, zonal and isoelectric focusing techniques of electrophoresis Paper, agarose gel, 2D Gel and SDS- PAGE.

Sedimentation and velocity, preparative and analytical ultracentrifugation techniques. Differential and density centrifugation, subcellular fractionation.

Radioactivity: disintegration of radionuclides, half life of radioactive compounds, measurement of radioactivity. Scintillation counting, isotopic tracer techniques, autoradiography. Use of isotopes: in vivo and in vitro labeling, radio diagnosis. Spectrophotometry and colorometry: principles, types and applications, Beer-Lambart law, extinction coefficient. Principle and applications of atomic absorption spectrophotometry.

Principles of optical rotatory dispersion and dichroism, X-ray diffraction, X-ray crystallography. Principle and applications of NMR. Microscopy principle and applications: simple, compound, florescent, electron, scanning and transmission microscope. Fixation and staining.

4. Biostatistics and Computer Applications

Fundamental of biostatistics, sample and sampling, collection of data and their representation, measures of central tendency, measures of dispersion. Normal, binomial and Poisson distributions.

Probability, laws of probability. Need of statistical testing, degree of freedom, level of significance.

Tests of significance: applications of 't'-test and *chi* square test. Correlation and regression, coefficient of correlation and its significance, relationship between correlation and regression.

Measure of biodiversity, metroglyph and index score method. Analysis of variance. Principle of field experimentation, Randomized block design, Latin square design, split plot design and stript plot design.

Introduction to computer and their applications. Concepts of operating system, software and database management system. Computer networks and internet (ftp, http, www). Introduction to neural networks.

5. Cell and Molecular Biology

The cell theory, structure and function of pro-and eukaryotic cells Structure and function of cellular organelles (viz. mitochondria, chloroplast, golgi bodies, endoplasmic reticulum, lysosome, plastids) Genetic organisation of nucleus, mitochondria and choloroplast. Structure and function of nuclear membrane and nucleolus. Cytoskeleton and cell motility.

Transcription in prokaryotes and eukaryotes. Replication in bacterial and eukaryotic chromosomes. Genetic code, central dogma, wobble hypothesis. Translation: general mechanism; role of rRNA in translation.

Regulation of gene expression: inducible and repressible system; positive and negative regulation; enhancers and promoters; transcription factors-types, DNA binding motifs. Models of gene regulation in prokaryotes and eukaryotes. Post transcriptional regulation: alternative splicing; transport and targeting of RNA; post- transcriptional gene silencing. Mechanism of steroids hormone and stress induced gene expressions.

Gene mapping in bacteria: transformation, conjugation, transduction, sexduction. Recombination, deletion and complementation mapping in T4 phage (rll locus). Homologous recombination: models and molecular mechanism. Gene conversion: molecular mechanisms Transposons and mechanism of transposition.

Endogenous and exogenous origin of DNA damage. Types of DNA damage. DNA repair pathways. Mutations; classification, mutagens, molecular mechanism of mutations. Detection of mutations, application of mutagenesis for human welfare.

6. Cytogenetics

The architecture of prokaryotic and eukaryotic chromosomes, nucleosome model. The DNA packaging in chromatin. Metaphase chromosome, classification based on centromeric position, centromeric index, arm ratio. Polytene chromosome, lampbush chromosome, B-chromosome.

Variation in chromosome number; euploidy, aneuploidy. Variation in the arrangement of chromosome segments; translocation, inversion. Variation in the number of chromosomal segments; deletion, dupication. Variation in chromosomal morphology; isochromosome, bridge-break-fusion cycle, ring chromosome, Robertsonian translocation (centric fusion). Role of chromosomal alterations in speciation and evolution.

Euchromatin and heterochromatin; distribution and fuction Fundamentals of chromosome preparations: role of colchicine and hypotonic treatment, major chromatin stains. Chromosomal banding techniques: NOR (nucleolar organising region), C-banding, G-banding, Q-banding, FISH (fluorescent *in situ* hybridisation) Introduction to chromosome painting.

Methods of chromosome manipulation in animal and plants; induction of polyploidy. Gynogenesis and androgenesis. Sex chromosomes in plants and animals: male heterogamety, female heterogamety, multiple sex chromosomes. Cytotaxonomy and karyotype concept.

Chromosome as a functioning organelle. Dosage compensation, Lyon's hypothesis. Chromosome constancy and dynamism

7. Plant Improvement and Seed Technology

Nature and objectives of plant breeding, concept of ideotype. Germplasm collection and conservation, centers of diversity. Plant introduction, pure line theory, techniques of hybridization and consequences of hybridization. Origin of cultivated plants viz. wheat, cotton, brassica, tobacco, triticale.

Breeding methods for self pollinated crops: pure line selection, mass selection, pedigree method, bulk population breeding, back crocs method, concept of multiline variety. Breeding methods for cross pollinated plants: mass selection, recurrent selection, synthetic and hybrid varieties. Incompatibility and male sterility. General features of heterosis and inbreeding depression, theories of heterosis. Use of molecular markes in plant breeding.

Cell and tissue culture, differentiation and morphogenesis. Protoplast fusion and somatic hybridization. Induction of mutations in cell cultures, somaclonal variation. *In-vitro* propogation, application of tissue culture in crop improvement, use of anther culture and haploids in plant breeding.

Mutation breeding: induction and selection of mutations in autogamans, allogamons and vegetatively propagated plants. Breeding for disease resistance, genetics of resistance including gene for gene hypothesis. Germplasm conservation by plant tissue culture techniques. Production of secondary metabolites in cell cultures.

Seed industry in India, general principles of seed production, nucleus and breeder's seed. Seed certification and seed legislation. Seed processing and seed testing. Intellectual property rights and related issues with reference to plant breeding.

8. Population and Evolutionary Genetics

Concept of evolution and theories of organic evolution with an emphasis on Darwinism. Hardy-Weinberg's law of genetic equilibrium, destabilizing factor viz. natural selection, mutation, genetic drift, migration, meiotic drive.

Quantifying genetic variability: genetic structure of natural populations, phenotypic variation, factors affecting genetic human disease frequency. Inbreeding coefficient, its estimation. Estimation of gene frequencies, distribution of rare genes.

Analysis of quantitative traits, quantitative traits and natural selection. Estimation of heritability, genotype-environment interactions, Molecular analysis of quantitative traits, phenotypic plasticity.

Genetics of speciation: phylogenetic and biological concept of species, patterns and mechanisms of reproductive isolation, models of speciation (allopatric, sympatric, parapatric). Molecular evolution, gene evolution, evolution of gene families, assessment of molecular variation.

Population genetics and ecology: metapopulation, extinction of small populations, loss of genetic variabilities, conservation of genetic resources. Origin and evolution of economically important microbes and animals.

9. Human and Clinical Genetics

Methods of studying human genetics: pedigree construction, population and twin studies. Distribution patterns of traits in human families in accordance with mendelian principle; autosomal dominant traits, autosomal recessive traits, sex-linked and sex-influenced (or sex-limited) traits. Significance of Mendel's law of segregation and independent assortment in studying human genetics (inheritance of allelic and non- allelic genes); inheritance of blood groups. Demonstration of linkage and association of traits in human. Genomic imprinting syndromes, Mitochondrial syndromes.

The concept of penetrance and expressivity. Genetic cotrol of haemoglobin synthesis; genetic basis of hereditary persistance of foetal haemoglobin; haemoglobin disorders with special reference to sickle cell anaemia. Garrodian inborn errors of metabolism; PKU, albinism, alkaptonuria, analysis of mutations in biochemical pathways. Polymorphism and genetic markers; clinical importance of polymorphism. Ethnic factors in genetic diseases; ethnic distribution of important genetic diseases.

The human chromosomes; normal chromosome constitution, sex-chromosomes, origin of barr body, mosaicism Abnormalities of chromosome numbers; Turner syndrome, Klinefelter syndrome, XYY male, Down's syndrome. Abnormalities of chromosome structures; *Cri du chat* syndrome Genetic predisposition to sporadic cancer, tumor progression: angiogenesis and metastasis. Chromosomal aberrations in neoplasm, tumor specific markers.

Biology of twining; types and biology of twins: dizygotic, monozygotic, determination of zygosity of twins (brief description): foetal membrane method; DNA finger printing; genetic markers; similarity method; mailed questionnaire method of psychologists. Variation in twining frequencies; Weinberg's differential rule for statistical estimation of monozygotic and dizygotic twin pairs. Application of twin research; co-twin control method. The genetic and environment components of congenital defects; cleft palate, harelip, clubfoot, anencephaly, polydactyly, congenital heart malformations. Principle and strategies in identifying disease genes.

Mapping of human chromosome. Introduction to the human genome project; beginning, aims and controversy. Benefits of genome sequencing of human; benefits of studying non-human organism (functional genomics in model organisms). Identification of new genes; DNA microarray analysis (genomic technique). Eugenics: theoretical and practical considerations.

10. Developmental and Behavioural Genetics

Early development; fertilization, types of cleavage, gastrulation. Development of vertebrate nervous system: formation of neural tube, tissue architecture of the central nervous system (CNS). Genetics of pattern formation with reference to drosophila: maternal genes, formation of body axes, segmentation genes, homeotic gene function on imaginal disc development.

Programmed rearrangements in genes: chromatin diminution, endoreplication cycle, gene amplification. Embryonic stem cells and their applications.

Nature-nurture and behavior. Genetic experiments to investigate animal behavior: selection studies, inbred strain studies. Identifying genes for behaviour and induced mutations. Genetics of human behavior: twin and adoption study designs, interpreting heritability, linkage and association studies. Environmental influence- shared and non- shared environment.

Neurogenetics: study designs; genetic and environmental manipulations, circadian rhythms, learning and memory. Cognitive disabilities: mental retardation, learning disorders, communication disorder, dementia.

Psychopathology: schizophrenia, mood disorders, anxiety disorders, disorders of childhood. Personality and personality disorders: antisocial personality, criminal behavior.

11. Immunology

Types of immunity, innate, acquired active, passive, self vs non-self discrimination. Physiology of immune system: lymphoid tissue, differentiation of lymphocyte, lymphocytes sub-population in man and mouse. Antigen types Antibodies: structure, distribution and functions, isotypic, allotypic, idiotypic variants. Antigen antibody reactions, RIA, ELISA.

Humoral immunity and cell mediated immunity, B and T cell and their antigens. Signaling pathways and receptor molecules in B and T cell activation. Immunological specificity and memory, cell mediated cytotoxicity. APC cells, phagocytic cells, macrophages activation, dendric cells, natural killer cells, lymphokinesis.

Structure and functions of class I and II MHC molecule. Genetic rearrangement of immunoglobulin gene. MHC antigen in transplantation and HLA tissue typing Effecter mechanisms in immunity.

The complement system: definition, significance and mode of activation, classical and alternative pathway. Biological functions of C proteins. Cell mediated effecter response. Infection and Immunity, vaccine and vaccination.

Immunological tolerance, suppressor, hypersensitivity. Autoimmunity, Immunodeficiency, AIDS, HIV, hepatitis, muscular dystrophy, arthritis. Monoclonal antibodies as biomedical tool. Genetic disorder of haemopoetic systems: overview of blood cell types, sickle cell anemia, thalassemia and haemophelia. Immune response during tuberculosis and malaria.

12. Biotechnology and Bioinformatics

Microbes as the tools in Biotechnology: identification and classification of microbes. Methods for isolation and culture techniques, microbial growth and its kinetics. Fermentation

technology: primary and secondary metabolism, continuous and batch type culture techniques, types and design of fermenters. Fermentation process: brewing, production of antibiotics (penicillin) and other organic compounds, single cell protein. Role of microbes in food and dairy products, food preservation.

Techniques used in recombinant DNA technology, Cloning vectors, cloning in bacteria and eukaryotes. Construction and screening of genomic & cDNA library. Application of recombinant DNA technology in medicine and agriculture, GMO. Application of gene cloning in synthesis of drug and enzymes (insulin, interferons).

Restriction mapping, Southern blotting, northern and western blotting techniques, RFLP, RAPD, SSR, 16sRNA. DNA sequencing techniques Preparation of radiolablled and synthetic probes. Gene amplification, DNA chip technology and microarray.

Introductory bioinformatics, scope, applications and challenges of bioinformatics, useful bioinformatics websites. Introduction to genetic algorithms Retrieval of biological data (entrez, srs and dbget/linkdb) Database searches: FASTA and BLAST, sequence filters, iterative database searches and psi-BLAST).

Sequence alignment methods and applications of gene and protein families. Methods and applications of phylogenetic trees (phylip etc.) Whole genome analysis, comparative genomics, paralogs and orthologs, second generation sequence analysis. Structure prediction and 2D analysis of protein. Introduction to drug designing, primer designing.