List of Electives

Department of Biotechnology
Ministry of Science & Technology,
Government of India

List of Electives

सत्यमेव जयते

Department of Biotechnology

Ministry of Science & Technology,
Government of India

CONTENTS

LIST OF ELECTIVES

1. Animal Biotechnology - 3 Credits

Unit I

Animal cell culture

Structure of animal cell; History of animal cell culture; Basic requirements for animal cell culture; Cell culture media and reagents; Animal cell, tissue and organ cultures; Primary culture, secondary culture; Continuous cell lines; Suspension cultures; Somatic cell cloning and hybridization; Transfection and transformation of cells; Commercial scale production of animal cells; Stem cells and their application; Application of animal cell culture for *in vitro* testing of drugs; Testing of toxicity of environmental pollutants in cell culture; Application of cell culture technology in production of human and animal vaccines and pharmaceutical proteins.

Unit II

Animal health Biotechnology

Introduction to immune system; Cellular and humoral immune response; History of development of vaccines; Introduction to the concept of vaccines; Conventional methods of vaccine production; Recombinant approaches to vaccine production; Hybridoma technology; Phage display technology for production of antibodies; Antigen-antibody based diagnostic assays including radioimmunoassays and enzyme immunoassays; Immunoblotting; Nucleic acid based diagnostic methods including nucleic acid probe hybridization; Restriction endonuclease analysis; PCR, Real time PCR; Nucleic acid sequencing; Commercial scale production of diagnostic antigens and antisera; Animal disease diagnostic kits; Probiotics.

Unit III

Animal Reproductive Biotechnology

Structure of sperms and ovum; Cryopreservation of sperms and ova of livestock; Artificial insemination; Super ovulation; *in vitro* fertilization; Culture of embryos; Cryopreservation of embryos; Embryo transfer; Embryo-splitting; Embryo sexing; Micromanipulation of animal embryos; Transgenic animal technology and its different applications; Animal viral vectors; Animal cloning- basic concepts; Cloning from embryonic cells and adult cells; Cloning of farm animals; Cloning for conservation of endangered species; Ethical, social and moral issues related to cloning; *in situ* and *ex situ* preservation of germplasm; *in utero* testing of foetus for genetic defects; Pregnancy diagnostic kits; Anti-fertility animal vaccines.

Unit IV

Animal genomics

Introduction to different breeds of cattle, buffalo, sheep, goats, pigs, camels, horses, canines and poultry; Genetic characterization of livestock breeds; Marker assisted breeding of livestock and poultry; Introduction to animal genomics; Different methods for characterization of animal genomes, SNP, STR, QTLS, RFLP, RAPD, proteomics, metobolomics; Genetic basis for disease resistance; Gene knock out technology and animal models for human genetic disorders.

Unit V

DNA Forensics

Immunological and nucleic acid based methods for identification of animal species; Detection of adulteration in meat using DNA based methods; Detection of food/feed adulteration with animal protein; Identification of wild animal species using DNA based methods using different parts including bones, hair, blood, skin and other parts confiscated by anti-poaching agencies; Human forensics; Microbial forensics; Bioterror agents; Biocrimes and Bioterrorism.

Texts/References

1. Ed. John R.W. Masters, Animal Cell Culture - Practical Approach, 3rd Edition, Oxford University Press, 2000.
2. Ed. Martin, Clynes Animal Cell Culture Techniques, Springer, 1998.
3. Animal Cell Biotechnology. Portner, 2nd Edition, Humana Press, 2007.
4. A. Puller (ed), Genetic engineering in Animals, VCH Publishers.
5. Gordon, Reproductive Technologies in Farm Animals, CAB Intl., 2005.
6. Pinkert, Transgenic animal technology, Academic Press, 2006.

2. Animal Cytogenetics & Immunogenetics - 3 Credits

Unit I

Development in animal cytogenetics and immunogenetics of farm animals; Immunoglobulins and their types; Antigen-antibody interactions.

Unit II

Major histocompatibility complex; Genetics of biochemical variants and their application; Ir-genes and concepts of disease resistance including major genes; Hybridoma and its significance; Concept of immuno-fertility.

Unit III

Chromatin structure of eukaryotes; Chromosome number and morphology in farm animals banding and karyotyping; Chromosomal and genetic syndromes.

Unit IV

Mutation and assays of mutagenesis; Sister chromatid exchanges; Recombinant DNA technique and its application in animal improvement programme.

Practicals

Polymorphism of haemoglobulins, transferrins, enzymes/proteins; Preparation of monovalent blood reagent-isoimmunization, Titre testing and absorption of polyvalent serum; Identification of bar bodies; In vitro and in vivo preparation of somatic metaphase chromosomes; Screening of chromosomal abnormalities; Microphotography and karyotyping; Banding procedures for comparing the chromosomal complement.

Texts/References

1. Chakrabarty AM. Genetic Engineering. CRC Press, 1979.
2. Hare WCD & Elizabeth L Singh, Cytogenetics in Animal Reproduction. CABI. 1999.
3. Roitt I., Essential Immunology, 11th Edition, Blackwell, 2008.
4. Stine GJ., The New Human Genetics, Wm C Brown Publ. 1989.

5. Summer AT & Chandley AC., Chromosome Today, Chapman & Hall, 1993.
6. Yunis J.J., Human Chromosome Methodology, Academic Press. 1965.

3. Animal Population Genetics - 3 Credits

Unit I

Population vs individual; Dynamics of population; Gene and genotypic frequencies; Hardy-Weinberg equilibrium; Homeostasis- genetic and developmental; Co-adapted and integrated gene pool.

Unit II

Approach to equilibrium under random mating-single autosomal locus with two alleles; Single sex-linked locus; Two pairs of autosomal linked and unlinked loci; Linkage as a cause of correlation; Population mean and variance under different situations; Estimation of number of loci governing a metric trait; Average effect, average effect of gene substitution.

Unit III

Partitioning of phenotypic variance into different components; Genotype x environment interaction and correlation; Resemblance between relatives; Phenotypic covariances among relatives and their genetic expectations

Unit IV

Heritability- uses, estimation and its precision; Repeatability estimation and its precision; Correlation-phenotypic, genetic and environmental.

Unit V

Threshold traits- estimation of genetic parameters; Discrepancy between actual and expected genetic estimators; Genetic slippage.

Texts/References

1. Bulmer MG., The Mathematical Theory of Quantitative Genetics, Clarendon Press, 1980.
2. Crow JF & Kimura M., An Introduction to Population Genetics Theory, Harper & Row. 1970.
3. Falconer DS & Mackay TFC, An Introduction to Quantitative Genetics, Longman, 2004.
4. Jain JP., Statistical Techniques in Quantitative genetics, Tata McGraw-Hill. 1982.
5. Pirchner F. 1981. Population Genetics in Animal Breeding. S Chand.

4. Bacteriology - 3 Credits

Unit I

Introduction to historical development of cellular organization; Genetic and chemical characteristics of eukaryotic and prokaryotic cells

Unit II

Classification, nomenclature and identification; Genetic characterization and numerical taxonomy; Bacterial cell structure, physiology and antigenic structure.

Unit III
Determinants of pathogenicity and its molecular basis; Bacteriophages: temperate and virulent phages; lysogeny and lysogenic conversion

Unit IV
Bacterial genetics: bacterial variation, genetic transfer mechanisms (transformation, transduction and conjugation); Plasmids, transposons and drug resistance; Recombinant DNA technology.

Unit V
Systemic study of following bacteria: Gram negative- aerobic rods and cocci, family Pseudomonadaceae, Legionellaceae, Neisseriaceae, and genus Brucella; Facultative anaerobic Gram negative rods, family-Vibrionaceae, Pasteurellaceae, Enterobacteriaceae and other genera.

Practicals
Morphological characterization, Cell fractionation, Enrichment and isolation technology, Various methods used in growth measurement and bacterial preservation, Gene transfer experiment. Detailed characterization(isolation, biochemical, serological, pathogenicity etc.) of bacteria.

Texts/References
1. Glen Sonder J & Karen W Post., Veterinary Microbiology: Bacterial and Fungal Agents of Animal Diseases, 1st Edition, Saunders; 2004.
2. Prescot LM, Harley JP & Klen DA., Microbiology, Wm. C. Brown Publ. 2005
3. Tortora GJ, Funke BR & Case CL., Microbiology: An Introduction, 8th Edition, Benjamin/ Cummins Publ. 2004.

5. Bioentrepreneurship - 3 Credits

Accounting and Finance
Taking decision on starting a venture; Assessment of feasibility of a given venture/new venture; Approach a bank for a loan; Sources of financial assistance; Making a business proposal/Plan for seeking loans from financial institution and Banks; Funds from bank for capital expenditure and for working; Statutory and legal requirements for starting a company/venture; Budget planning and cash flow management; Basics in accounting practices: concepts of balance sheet, P&L account, and double entry bookkeeping; Estimation of income, expenditure, profit, income tax etc.

Marketing
Assessment of market demand for potential product(s) of interest; Market conditions, segments; Prediction of market changes; Identifying needs of customers including gaps in the market, packaging the product; Market linkages, branding issues; Developing distribution channels; Pricing/Policies/Competition; Promotion/ Advertising; Services Marketing

Negotiations/Strategy
With financiers, bankers etc.; With government/law enforcement authorities; With companies/Institutions for technology transfer; Dispute resolution skills; External environment/changes; Crisis/ Avoiding/Managing; Broader vision–Global thinking

Information Technology
How to use IT for business administration; Use of IT in improving business performance; Available software for better financial management; E-business setup, management.

Human Resource Development (HRD)
Leadership skills; Managerial skills; Organization structure, pros & cons of different structures; Team building, teamwork; Appraisal; Rewards in small scale set up.

Fundamentals of Entrepreneurship
Support mechanism for entrepreneurship in India

Role of knowledge centre and R&D
Knowledge centres like universities and research institutions; Role of technology and upgradation; Assessment of scale of development of Technology; Managing Technology Transfer; Regulations for transfer of foreign technologies; Technology transfer agencies.

Case Study
1. Candidates should be made to start a 'mock paper company', systematically following all the procedures.
    - The market analysis developed by them will be used to choose the product or services.
    - A product or service is created in paper and positioned in the market. As a product or services available only in paper to be sold in the market through the existing links. At this juncture, the pricing of the product or the service needs to be finalized, linking the distribution system until the product or services reaches the end consumer.
    - Candidates who have developed such product or service could present the same as a project work to the Panel of Experts, including representatives from industry sector. If the presented product or service is found to have real potential, the candidates would be exposed to the next level of actual implementation of the project.
2. Go to any venture capital website (like sequoiacap.com) and prepare a proposal for funding from venture capital.

6. Biogenerics & Biopharmaceuticals - 3 Credits

Unit I
Definition: Generics and its advantages; Biogenerics and Biosimilars; Why biosimilars are not (bio) generics; The advent of Biosimilars; The role of patents in the drug industry; Protein-based biopharmaceuticals; Manufacturing processes; Global market; International Non-proprietary Names (INN) nomenclature system biosimilars regulation (EU position, US pathways, Government initiatives)

Unit II
Approved follow-on proteins/Biosimilars; Characteristics of high-selling peptides and proteins,; Products with expired patents; Challenging originator's patents; Target products for FOB (follow-on biologicals)/ Biosimilars development peptides; Recombinant non-glycosylated proteins; Recombinant glycosylated proteins; Industries dealing with biogenerics and its market value; World scenario; Indian scenario.

Unit III

Approaches to the characterization of biosimilars; Problems in characterizing biologics (Types of biologic, Peptides, Non-glycosylated proteins, Glycosylated proteins, Monoclonal antibodies); Equivalence issues; Post-translational modifications; Effect of microheterogeneity; Pharmacokinetics; Pharmacodynamics; and Clinical efficacy; Analytical methods for the characterization of biosimilars (Chromatography, Protein sequencing, Mass spectrometry, UV absorption, Circular dichroism, X-ray techniques, Nuclear magnetic resonance, Electrophoresis, Western blotting, Bioassays, ELISA, Immunoprecipitation and other procedures)

Unit IV

Immunogenicity of biopharmaceuticals: Immunogenicity; Factors contributing to immunogenicity (product-related factors, host- related factors), Consequence of immunogenicity to biopharmaceuticals; Measurement of immunogenicity

Unit V

Case studies: Erythropoietin, Insulin, Somatotropin, Interleukin-2, Interferon Granulocyte- macrophage-CSF, DNase, Factor VIIa, Factor IX, Factor VIII, Activated protein C, Tissue plasminogen activator, Monoclonal antibodies etc.

Texts/References

1. Sarfaraz K. Niazi, Handbook of Biogeneric Therapeutic Proteins: Regulatory, Manufacturing, Testing, and Patent Issues, CRC Press, 2006.
2. Rodney J Y Ho, MILO Gibaldi, Biotechnology & Biopharmaceuticals Transforming proteins and genes into drugs, 1st Edition, Wiley Liss, 2003.

7. Bioinformatics - 3 Credits

Unit I

Bioinformatics basics: Computers in biology and medicine; Importance of Unix and Linux systems and its basic commands; Database concepts; Protein and nucleic acid databases; Structural databases; Biological XML DTD's; Pattern matching algorithm basics; Computational tools for DNA sequence analysis: GCG: The Wisconsin package of sequence analysis programs; Web-based interfaces for the GCG sequence analysis programs.

Unit II

Databases and search tools: Biological back ground for sequence analysis; Identification of protein sequence from DNA sequence; Searching of databases similar sequence; The NCBI; Publicly available tools; Resources at EBI; Resources on the web; Database mining tools.

Unit III

DNA sequence analysis: The gene bank sequence database; Submitting DNA sequence to the databases and database searching; Sequence alignment; Pair wise alignment techniques; Multiple sequence analysis; Multiple sequence alignment; Flexible sequence similarity searching with the FASTA3 program package; Use of CLUSTAL W and CLUSTAL X for the multiple sequence alignment; Submitting DNA protein sequence to databases: Where and how to submit, SEQUIN, genome centres; Submitting aligned set of sequences, updates and internet resources.

Unit IV

Protein Modeling: Introduction; Force field methods; Energy, Buried and exposed residues; Side chains and neighbours; Fixed regions; Hydrogen bonds; Mapping properties onto surfaces; Fitting monomers; rms fit of conformers; Assigning secondary structures; Sequence alignment- methods, evaluation, scoring; Protein completion: backbone construction and side chain addition; Small peptide methodology; Software accessibility; Building peptides; Protein displays; Substructure manipulations, Annealing.

Peptidomimetics: Introduction, classification; Conformationally restricted peptides, design, pseudopeptides, peptidomimetics and transition state analogs; Biologically active template; Amino acid replacements; Peptidomimetics and rational drug design; CADD techniques in peptidomimetics; Development of non peptide peptidomimetics.

Unit V

Protein Structure Prediction: Protein folding and model generation; Secondary structure prediction; Analyzing secondary structures; Protein loop searching; Loop generating methods; Loop analysis; Homology modeling: potential applications, description, methodology, homologous sequence identification; Align structures, align model sequence; Construction of variable and conserved regions; Threading techniques; Topology fingerprint approach for prediction; Evaluation of alternate models; Structure prediction on a mystery sequence; Structure aided sequence techniques of structure prediction; Structural profiles, alignment algorithms, mutation tables, prediction, validation, sequence based methods of structure prediction, prediction using inverse folding, fold prediction; Significance analysis, scoring techniques, sequence-sequence scoring. *The virtual library:* Searching MEDLINE, Pubmed, current content, science citation index and current awareness services, electronic journals, grants, and funding information.

Texts/References

1. David W. Mount, Bioinformatics: Sequence and Genome Analysis 2nd Edition, CSHL Press, 2004.
2. A. Baxevanis and F. B. F. Ouellette, Bioinformatics: a practical guide to the analysis of genes and proteins, 2nd Edition, John Wiley, 2001.
3. Jonathan Pevsner, Bioinformatics and Functional Genomics,1st Edition, Wiley-Liss, 2003.
4. P. E. Bourne and H. Weissig, Structural Bioinformatics,2nd Edition, Wiley, 2008.
5. C. Branden and J. Tooze, Introduction to Protein Structure, 2nd Revised Edition Garland Publishing, 1998.

8. Biometrical Techniques in Animal Breeding - 3 Credits

Unit I

Genetic models for estimation of crossbreeding parameters and their comparison.

Unit II

Methods for estimation of genetic divergence among breeds/strains; Genotype-environment interaction estimation.

Unit III

Basic concept of linear models; Generalized LS; Weighted LS; Additive genetic relationship matrix and its significance; Development of mixed model equations.

Unit IV

Genetic evaluation by animal model, sire model, maternal grandsire model; Methods of joint evaluation of sire and cow; Methods of variance components.

Practical

Building of models for various types of data; Constructions of generalized, weighted and mixed model equations; Estimation of genetic divergence; Computation of crossbred parameters; Estimation of breeding values and variance components using different models.

Texts/References

1. Henderson CR., Application of Linear Models in Animal Breeding, Univ. of Guelph, 1984.
2. Mather K & Jinks JL., Biometrical Genetics, 3rd Edition, Chapman & Hall. 1982.
3. Searle SR., Linear Models. John Wiley & Sons. 1971.
4. Singh RK & Choudhary BD., Biometrical Methods in Quantitative Genetic Analysis, Kalyani Publication, 2007.

9. Bioprocess Engineering and Technology - 3 Credits

Unit I

Basic principle of Biochemical engineering

Isolation, screening and maintenance of industrially important microbes; Microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); Strain improvement for increased yield and other desirable characteristics.

Unit II

Concepts of basic mode of fermentation processes

Bioreactor designs; Types of fermentation and fermenters; Concepts of basic modes of fermentation - Batch, fed batch and continuous; Conventional fermentation v/s biotransformation; Solid substrate, surface and submerged fermentation; Fermentation economics; Fermentation media; Fermenter design- mechanically agitated; Pneumatic and hydrodynamic fermenters; Large scale animal and plant cell cultivation and air sterilization; Upstream processing: Media formulation; Sterilization; Aeration and agitation in bioprocess; Measurement and control of bioprocess parameters; Scale up and scale down process.

Unit III

Downstream processing

Bioseparation - filtration, centrifugation, sedimentation, flocculation; Cell disruption; Liquid-liquid extraction; Purification by chromatographic techniques; Reverse osmosis and ultra filtration; Drying; Crystallization; Storage and packaging; Treatment of effluent and its disposal.

Unit IV

Applications of enzymes in food processing

Mechanism of enzyme function and reactions in process techniques; Enzymic bioconversions e.g. starch and sugar conversion processes; High-Fructose Corn Syrup; Interesterified fat; Hydrolyzed protein etc. and their downstream processing; baking by amylases, deoxygenation and desugaring by glucoses oxidase, beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing.

Applications of Microbes in food process operations and production
Fermented foods and beverages; Food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; Microbes and their use in pickling, producing colours and flavours, alcoholic beverages and other products; Process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; Bacteriocins from lactic acid bacteria – Production and applications in food preservation.

Unit V
Enzyme kinetics; Two-substrate kinetics and pre-steady state kinetics; Allosteric enzymes; Enzyme mechanism; Enzyme inhibitors and active site determination

Production, recovery and scaling up of enzymes and their role in food and other industries; Immobilization of enzymes and their industrial applications.

Texts/ References
1. Jackson AT., Bioprocess Engineering in Biotechnology, Prentice Hall, Engelwood Cliffs, 1991.
2. Shuler ML and Kargi F., Bioprocess Engineering: Basic concepts, 2nd Edition, Prentice Hall, Engelwood Cliffs, 2002.
3. Stanbury RF and Whitaker A., Principles of Fermentation Technology, Pergamon press, Oxford, 1997.
4. Baily JE and Ollis DF., Biochemical Engineering fundamentals, 2nd Edition, McGraw-Hill Book Co., New York, 1986.
5. Aiba S, Humphrey AE and Millis NF, Biochemical Engineering, 2nd Edition, University of Tokyo press, Tokyo, 1973.
6. Comprehensive Biotechnology: The Principles, Applications and Regulations of Biotechnology in Industry, Agriculture and Medicine, Vol 1, 2, 3 and 4. Young M.M., Reed Elsevier India Private Ltd, India, 2004.
7. Mansi EMTEL, Bryle CFA. Fermentation Microbiology and Biotechnology, 2nd Edition, Taylor & Francis Ltd, UK, 2007.

10. Bioreaction Engineering - 3 Credits

Unit I
Structured growth models; Compartmental models; Cybernetic models

Unit II
Immobilized biocatalysts: external mass transfer; Internal diffusion; Reaction within catalysts.

Unit III
Reactor design (batch, continuous, fed-batch, plug flow, packed bed, airlift, immobilized enzyme/cell etc.); Optimal bioreactor operation using simple reaction kinetics.

Unit IV
Dynamic simulation of bioreactor processes (batch, fed-batch, continuous etc.); Reactors in series.

Unit V
Pathway analysis: Stoichiometric analysis; Thermodynamics-derived constraints; Flux balancing techniques; Metabolic control analysis.

Texts/References

1. J. Nielsen and J. Villadsen and G. Liden, Bioreaction Engineering Principles, 2nd Edition, Kluwer Academic. 2003.
2. Irving J. Dunn, Elmar Heinzle, John Ingham, Jiri E. Prenosil, Biological Reaction Engineering: Dynamic Modelling Fundamentals with Simulation Examples, 2nd Edition, Wiley-VCH. 2003.

11. Biostatistics - 3 Credits

Unit I

Applications of statistics in biological sciences and genetics; Descriptive statistics; Mean; Variance; Standard deviation and coefficient of variation(CV); Comparison of two CVs; Skewness; Kurtosis

Unit II

Probability – axiomatic definition; Addition theorem; Conditional probability; Bayes theorem; Random variable; Mathematical expectation; Theoretical distributions – Binomial, Poisson, Normal, Standard normal and Exponential distributions; Sampling- parameter, statistic and standard error; Census - sampling methods; Probability and non-probability sampling; Purposive sampling; Simple random sampling; Stratified sampling.

Unit III

Testing of hypothesis; Null and alternative hypothesis; Type I and type II errors; Level of significance; Large sample tests; Test of significance of single and two sample means; Testing of single and two proportions - Small sample tests: F-test – testing of single mean; Testing of two sample means using independent t test, paired t test; Chi square test: Test for goodness of fit - association of attributes – testing linkage – segregation ratio.

Unit IV

Correlation – Pearson's correlation coefficient and Spearman's rank correlation; Partial and multiple correlation – regression analysis; Sample linear and non linear regression; Multiple regression.

Unit V

Analysis of variance – definition – assumptions – model; One way analysis of variance with equal and unequal replications; Two way analysis of variance; Non parametric tests – sign test – Mann Whitney 'U' test – Kruskal Wallis test.

Texts/References

1. P.S.S. Sundar Rao, P.H.Richard, J.Richard, An introduction to Bio-statistics, Prentice Hall of India(P) Ltd., New Delhi, 2003.
2. Rangaswamy, R, A text book of Agricultural Statistics, New Age International (P) Ltd., New Delhi. 2000.
3. Gupta S.P, Statistical Methods, Sultan Chand & Sons, New Delhi. 2005.
4. Panse V.G.Panse, Sukhatme P.V, Statistical methods for Agricultural Workers, ICAR Publications, New Delhi, 2000
5. Jerrold H. Zar, Bio Statistical Analysis, Tan Prints(I) Pvt. Ltd., New Delhi, 2003.
6. Chandel, S.R.S, A Hand Book of Agricultural Statistics, Achal Prakashan Mandir, Kanpur, 1999.

12. Cancer Genetics - 3 Credits

Unit I

Introduction: Types and general characteristics of tumours; Chromosomal aberrations in neoplasia; Cell cycle check point and cancer

Unit II

Cell transformation and tumorigenesis: Oncogenes; Tumour suppressor genes; DNA repair genes and genetic instability; Epigenetic modifications, telomerase activity, centrosome malfunction; Genetic heterogeneity and clonal evolution

Unit III

Familial cancers: Retinoblastoma, Wilms' tumour, Li-Fraumeni syndrome, colorectal cancer, breast cancer; Genetic predisposition to sporadic cancer

Unit IV

Tumour progression: angiogenesis and metastasis; Tumour specific markers

Unit V

Cancer and environment: physical, chemical and biological carcinogens; Cancer risk assessment, gene therapy and counseling

Texts/References

1. Alberts et al., The Science of Genetics, Saunders, 1999.
2. Alberts et al., Molecular Biology of the Cell, Garland 2008.
3. Benjamin, Genetics: A Conceptual Approach, 3rd Edition, Freeman, 2007.
4. Berg and Singer, Genes and Genome, 1998.
5. Black, Microbiology: Principles and Explorations, 6th Edition Wiley, 2004.
6. Cowell, Molecular Genetics of Cancer, 2nd Revised Edition, Bios, 2001.

13. Cell and Developmental Biology - 3 Credits

Unit I

Cell Theory & Methods of Study

Microscope and its modifications – Light, phase contrast and interference, Fluorescence, Confocal, Electron (TEM and SEM), Electron tunneling and Atomic Force Microscopy, etc.

Membrane Structure and Function

Structural models; Composition and dynamics; Transport of ions and macromolecules; Pumps, carriers and channels; Endo- and Exocytosis; Membrane carbohydrates and their significance in cellular recognition; Cellular junctions and adhesions; Structure and functional significance of plasmodesmata.

Unit II

Organelles

Nucleus – Structure and function of nuclear envelope, lamina and nucleolus; Macromolecular trafficking; Chromatin organization and packaging; Cell cycle and control mechanisms; Mitochondria – structure, organization of respiratory chain complexes, ATP synthase, Structure-function relationship; Mitochondrial DNA and male sterility; Origin and evolution; Chloroplast– Structure-function relationship; Chloroplast DNA and its significance; Chloroplast biogenesis; Origin and evolution.

Unit III

Endo-membrane System and Cellular Motility

Structure and function of microbodies, Golgi apparatus, Lysosomes and Endoplasmic Reticulum; Organization and role of microtubules and microfilaments; Cell shape and motility; Actin-binding proteins and their significance; Muscle organization and function; Molecular motors; Intermediate filaments; Extracellular matrix in plants and animals.

Unit IV

Cellular Movements and Pattern Formation

Laying of body axis planes; Differentiation of germ layers; Cellular polarity; Model plants like Fucus and Volvox; Maternal gene effects; Zygotic gene effects; Homeotic gene effects in Drosophila; Embryogenesis and early pattern formation in plants; Cell lineages and developmental control genes in Caenorhabditis.

Unit V

Differentiation of Specialized Cells

Stem cell differentiation; Blood cell formation; Fibroblasts and their differentiation; Cellular basis of immunity; Differentiation of cancerous cells and role of proto-oncogenes; Phase changes in Salmonella; Mating cell types in yeast; Surface antigen changes in Trypanosomes; Heterocyst differentiation in Anabaena; Sex determination in Drosophila.

Plant Meristem Organization and Differentiation

Organization of Shoot Apical Meristem(SAM); Organization of Root Apical Meristem(RAM); Pollen germination and pollen tube guidance; Phloem differentiation; Self-incompatibility and its genetic control; Embryo and endosperm development; Heterosis and apomixis.

Texts/References

1. Lodish *et al*., Molecular cell Biology, 4th Edition, W.H. Freeman & Company, 2000.
2. Smith & Wood, Cell Biology, 2nd Edition, Chapman & Hall, London, 1996.
3. Watson *et al*., Molecular Biology of the gene, 5th Edition, Pearson Prentice Hall. USA, 2003.
4. B. M. Turner, Chromatin & Gene regulation, 1st Edition, Wiley-Blackwell, 2002.
5. Benjamin Lewin, Gene IX, 9th Edition, Jones and Barlett Publishers, 2007.

14. Clinical Genetics & Genetic Counseling - 3 Credits

Unit I

Genetics in Medical Practice: Genetic Principles and their application in medical practice; Case studies (Interacting with patients, learning family history and drawing pedigree chart); Syndromes and disorders:

Definition and their genetic basis; Molecular pathology of monogenic diseases: Cystic fibrosis, Tay Sach's Syndrome & Marfan Syndrome; Genetics of diseases due to Inborn errors of metabolism: Phenylketonuria, Galactosemia & Mucopolysaccharidosis.

Unit II

Genetics of Neurogenetic disorders: Charcot-Marie tooth syndrome, Spino-muscular atrophy, Alzheimer's disease & Syndromes due to triplet nucleotide expansion; Genetic basis of muscle disorders: Dystrophies (Duchenne Muscular dystrophy and Becker Muscular Dystrophy), Myotonias & Myopathies; Genetic disorders of Haemopoitic systems: Overview of hematopoisis, Blood cell types and haemoglobin, Sickle cell anemia, Thalassemias & Hemophilias.

Unit III

Genetic basis of eye disorders: Colour Blindness, Retinitis pigmentosa, Glaucoma & Cataracts; Genetics of skeleton & skin disorders; Genetics of Syndromes & Genomic Imprinting: Neurofibromatosis I, Prader-Willi & Angelman syndromes, Beckwith-Wiedeman syndrome; Genetics of Cancers and cancer-prone syndromes: Haematological malignancies, Retinoblastoma, Wilm's tumour, Colorectal cancer, DNA-repair deficiency syndromes, Breast cancer.

Unit IV

Complex polygenic syndromes: Hyperlipidemia, Atherosclerosis, Diabetes mellitus ; Mitochondrial syndromes; Management of genetic disorders; Genetic counseling: Historical overview (philosophy & ethos) and Components of genetic counseling: Indications for and purpose; Information gathering and construction of pedigrees; Medical Genetic evaluation (Basic components of Medical History, Past medical history, social & family history).

Unit V

Components of genetic counseling: Physical examination (General and dysmorphology examination, Documentation), Legal and ethical considerations; Patterns of inheritance, risk assessment and counseling in common Mendelian and multifactor syndromes; Genetic testing: biochemical & molecular tests: in children, Presymptomatic testing for late onset diseases (predictive medicine); Prenatal and Preimplantation screening and diagnosis: Indications for prenatal diagnosis, Indications for chromosomal testing, Noninvasive methods (Ultrasound, Embryoscopy, MRI, etc.); Invasive methods; Prenatal screening for Down's syndrome (maternal serum) & Neural tube defect; Pre-implantation genetic diagnosis; Ethical issues in pre-natal screening & diagnosis.

Texts/References

1. Baker et al, A Guide to Genetic Counseling, Wiley-Liss, 1998.
2. Pastemak, An Introduction to Molecular Human Genetics: Mechanisms of Inherited Diseases, 2nd Edition, Fritzgarald, Wiley Liss, 2005.
3. Iankowski and Polak, Clinical Gene Analysis and Manipulation: Tools, Techniques and Troubleshooting, Cambridge University Press, 1996.
4. Wilson, Clinical Genetics, Wiley-Liss, 2000.
5. Robinson and Linden, Clinical Genetics Handbook, 2nd Edition Blackwell Science, 1994.
6. Rasko and Downes, Genes in Medicine, Chapman & Hall, 1996.
7. Young, Introduction to Risk Calculation in Genetic Counseling, 3rd Edition Oxford University Press, 2006.

15. Clinical Trials & Bioethics - 3 Credits

Unit I

Fundamentals of clinical trials; Basic statistics for clinical trials; Clinical trials in practice; Reporting and reviewing clinical trials; Legislation and good clinical practice - overview of the European directives and legislation governing clinical trials in the 21st century; International perspectives; Principles of the International Committee on Harmonisation (ICH)-GCP.

Unit II

Drug development and trial planning - pre-study requirements for clinical trials; Regulatory approvals for clinical trials; Consort statement; Trial responsibilities and protocols - roles and responsibilities of investigators, sponsors and others; Requirements of clinical trials protocols; Legislative requirements for investigational medicinal products.

Unit III

Project management in clinical trials - principles of project management; Application in clinical trial management; Risk assessment; Research ethics and Bioethics - Principles of research ethics; Ethical issues in clinical trials; Use of humans in Scientific Experiments; Ethical committee system including a historical overview; the informed consent; Introduction to ethical codes and conduct; Introduction to animal ethics; Animal rights and use of animals in the advancement of medical technology; Introduction to laws and regulation regarding use of animals in research.

Unit IV

Consent and data protection- the principles of informed consent; Consent processes; Data protection; Legislation and its application; Data management – Introduction to trial master files and essential documents; Data management.

Unit V

Quality assurance and governance - quality control in clinical trials; Monitoring and audit; Inspections; Pharmacovigilance; Research governance; Trial closure and pitfalls-trial closure; Reporting and legal requirements; Common pitfalls in clinical trial management.

16. Computational Biology - 3 Credits

Unit I

Databases

Primary and Secondary Databases; GenBank, EMBL, DDBJ, Swissprot, MIPS, PIR, TIGR, Hovergen, TAIR, PlasmoDB, ECDC, Protein and Nucleic Acid Sequences,

Unit II

Search Algorithm

Scoring Matrices and their use; Computational complexities; Analysis of Merits and demerits; Sequence pattern; Pattern databases; PROSITE, PRINTS, Markov chains and Markov models; Viterbi algorithm; Baum-Welch algorithm; FASTA and BLAST Algorithm; Needleman-Wusch & Smith-Waterman algorithms

Unit III

Structure and Analysis

Representation of molecular structures; External and internal co-ordinates; Concept of free energy of molecules; Introduction to various force fields; Molecular energy minimization techniques; Monte Carlo and Molecular Dynamics simulation

Unit IV

Experimental Methods

Molecular structure Determination; Principle of X-ray crystallography and NMR spectroscopy; 2D Protein Data bank and Nucleic Acid Data bank; Storage and Dissemination of molecular structures

Unit V

Modeling

Homology modeling; Threading; Structure prediction; Structure-structure comparison of macromolecules; Simulated docking; Drug design; 2D and 3D QSAR; Ligand databases

Texts/References

1. David W. Mount. Bioinformatics: Sequence and Genome Analysis 2nd Edition, CSHL Press, 2004.
2. A. Baxevanis and F. B. F. Ouellette, Bioinformatics: a practical guide to the analysis of genes and proteins, 2nd Edition, John Wiley, 2001.
3. Jonathan Pevsner, Bioinformatics and Functional Genomics, 1st Edition, Wiley-Liss, 2003.
4. C. Branden and J. Tooze, Introduction to Protein Structure, 2nd Edition, Garland Publishing, 1999.

17. Diagnostics - 3 Credits

Unit I

Historical Perspective of clinical diagnosis and molecular diagnostics; Nucleic acid based diagnosis: Extraction of Nucleic acids: sample collection, methods of extraction from various diagnostic materials, assessment of quality and quantity, storage; Nucleic acid hybridization: Blotting Techniques and their interpretations: Southern and Northern Blotting methods and applications in clinical diagnosis; Polymerase Chain Reaction: Principle, components, optimization and analysis of PCR products; PCR based methods for mutation detection and gene expression: Real Time PCR, ARMS, QF- PCR, OLA and Primer Extension; Electrophoresis: PAGE and Capillary Electrophoresis; Application of electrophoresis in DNA Diagnosis- SSCP, heteroduplex analysis, denaturing gradient gel, detection of mismatched nucleotides/ RNA-DNA duplexes; RFLP and DNA sequencing in the clinical diagnostics.

Unit II

Testing DNA variation for Disease association: SNPs; Methods of typing: Traditional approaches (PCR-Sequencing), Microchips (Affymetrix) and Taqman; Microarray in the analysis of gene expression; DNA microarray platforms: cDNA analysis, oligonucleotide arrays; Introduction to SAGE, CGH, array CGH and SNP arrays; Analysis of DNA methylation; Methylation in health and disease; Principle and inheritance; DNA methylation in pathology and cancer; PCR based methods in detection of methylation; Bisulfite modification and methylation specific PCR and Restriction analysis; Real Time PCR methgodologies (MethyLight), Profiling and arrays: Primer Designing for MSPs; Application of DNA methylation in disease diagnosis: cancer (malignancies) and imprinting disorders.

Unit III

Flow Cytometry and LCM: Principle; Clinical applications: enumeration of peripheral blood cells in HIV infection and Immunophenotype Characterization in various blood disorders; Laser Capture Microdissection and separation of normal and aberrant cells: application and perspectives in molecular diagnostics; Molecular Cytogenetics: Chromosomal abnormalities and indications of chromosomal evaluation; Fluorescence *in situ* Hybridization; General Procedures of FISH, M-FISH, SKY and CGH; Clinical applications of FISH: Correlation with the pathobiology of the disease, disease prognosis and monitoring, correlation with molecular data; Protein based molecular diagnostics: Immunoproteomics and detection methods based on Antigen- Antibody interactions; ELISA; Western Blotting and Far Western Blotting applications and perspectives; Immunohistochemistry and Immunocytochemistry: Methods and interpretations: applications in tumor diagnosis and infectious diseases; Correlation with molecular data.

Unit IV

Quality assurance in molecular diagnostics: Quality assessment, preanalytic, analytic and post analytic phases; Verification of Molecular Assays; Standards and Standardization of Molecular Diagnostics; Laboratory development of molecular diagnostics: Implementation, validation, verifications (analytical and clinical), quality control and quality assurance of the testing process; Examples of molecular diagnostics of some common genetic and non-genetic diseases (Trinucleotide Repeats: Fragile X Syndrome, DMD. Endocrine disorders- Diabetes mellitus, Cystic Fibrosis, Chronic Myeloid Leukemia, Human HIV-1

Unit V

HLA Typing: HLA/ MHC genetics; Molecular methods of HLA typing

PCR-Sequence Specific Primers; Sequence Specific Oligonucleotide Probe Hybridization, Forensic Diagnosis: DNA typing : Overview; Techniques for human identification; Evidence collection and sample preparation; PCR amplification of STR loci; Electrophoresis and data analysis; Molecular Diagnosis and Genetic Counseling; Clinical genetic services; Uses of genetic testing; Components of genetic counseling process; Genetic Counseling and Genetic testing; Ethical, Social and legal issues related to molecular genetic testing; Informed consent for clinical testing and research; Confidentiality and Discrimination; Gene patenting.

Texts/References

1. WB Coleman and GJ Tsongalis, Molecular Diagnosis for the Clinical Laboratories, 2nd Edition, Human Press, 2006.
2. Iankowski and Polak, Clinical Gene Analysis and Manipulation: Tools, Techniques and Troubleshooting, 1st Edition, Cambridge University Press, 1996.
3. Francesco Falciani, Microarray Technology Through Applications, Taylor & Francis, 2007.
4. Darby & Hewiston, In Situ Hybridization Protocols, Third edition, Humana Press, 2006.
5. Sharpe & Carter, Genetic Testing, Care, Consent & Liability, Wiley-Liss, 2006.
6. Jochen decker, Molecular Diagnosis of Infectious Diseases, Humana Press

18. Environmental Biotechnology - 3 Credits

Unit I

Introduction

Environment; Basic concepts; Resources; Eco system: plants, animals, microbes; Ecosystem management; Renewable resources; Sustainability; Microbiology of degradation and decay; Role of Biotech in environmental protection; Control and management of biological processes

Unit II

Pollution

Enviromental pollution; Source of pollution; Air, water as a source of natural resource; Hydrocarbons, substituted hydro carbons; Oil pollution; Surfactants; Pesticides; Measurement of pollution; Water pollution; Biofilm; Soil pollution; Radioactive pollution; Radiation; Ozone depletion; Green house effect; Impact of pollutants; Measurement techniques; Pollution of milk and aquatic animals

Unit III

Control, remediation and management

Waste water collection; control and management; Waste water treatment; Sewage treatment through chemical, microbial and biotech techniques; Anaerobic processes; Anaerobic filters; Anaerobic sludge blanket reactors; Bioremediation of organic pollutants and odorous compounds; Use of bacteria, fungi, plants, enzymes, and GE organisms; Plasmid borne metabolic treatment; Bioaugmentation; Bioremediation of contaminated soils and waste land; Bioremediation of contaminated ground water; Macrophytes in water treatment; Phytoremediation of soil metals; Treatment for waste water from dairy, distillery, tannery, sugar and antibiotic industries

Unit IV

Alternate source of energy

Biomass as source of energy; Bioreactors; Rural biotechnology; Biocomposting; Biofertilizers; Vermiculture; Organic farming; Bio-mineralization; Biofuels; Bioethanol and biohydrogen; Solid waste management

Unit V

Environment and health in respect to genetics

Gene and environment; Effect of carbon and other nanoparticles upon health; Gene mutation; Genetic testing; Genetic sensors; Environmental pollution and children; Human biomonitoring

Texts/References

1. MetCalfe and Eddy Inc., Wastewater Engineering: Treatment, Disposal and Reuse", 4th Edition, McGraw Hill Book Co., 2003
2. Mackenzie L. Davis and David A. Cornwell, Introduction to Environmental Engineering, 4th Edition, McGraw Hill Book Co., 2006.
3. R.M.Maier, I.L.Pepper and C.P.Gerba, Elsevier, Environmental Microbiology: A Laboratory Manual, 2nd Edition, Academic Press, 2004.
4. B.C.Bhattacharyya and R.Banerjee, Environmental Biotechnology, Oxford University Press
5. I.S.Thakur, Environmental Biotechnology: Basic Concepts and Applications, I.K.International.

19. Environmental Engineering - 3 Credits

Unit I

Parameters and standards of noise, air, water and waste water

Major physico-chemical parameters; Need of standards for major pollutants; Types of pollutants; Significance of various parameters; Standards adopted by CPCB and SPCB; Drinking water quality standards; Effluent discharge standards for disposal on land, rivers and streams.

Unit II

Water Treatment Methods

Methods of water treatment; Optimized design; Plant control and operational variables; Preliminary treatment process; Clarification; Coagulation; Aerobic oxidation; Anaerobic oxidation; Disinfection of water; Water softening; Reverse osmosis; Electrodialysis and other treatment methods.

Waste water Treatments

Physical treatments – Principle; Flow measurement; Screening; Grit removal; Chemical treatments; Principles of chemical treatment: coagulation, flocculation, sedimentation; Biological treatments - Principles of biological treatment; Microbial growth and their kinetics for substrate removal; Technical considerations in biological treatment; Necessary recycle systems; Waste stabilization ponds; Aerated laggons; Oxidation ditch; Trickling filter; Rotating biological contactors; Activated sludge process.

Unit III

Reuse and recycle of water & waste water

Primary, secondary and tertiary treatments; Sludge dewatering and its disposal; Water reclamation and reuse; Removal of impurities; Removal of residual impurities; Effluent recycle and disposal.

Designs and functioning of ETP

Concept of ETP; Need of ETP in industry; Concept of CETP; Major units in ETP and their functions; Design aspects of major ETP units; MIS system related to ETP in industry.

Unit IV

Air and noise pollution control technologies

Meteorology and plume Dispersion; Laws governing behavior of air pollutants; Thermodynamics of major air pollutants; Particulate matter control equipment; Settling chamber; Cyclones; Fabric filter; Electrostatic precipitator; Wet scrubber; Control of gaseous pollutants; Control technologies for controlling oxides of sulphur and nitrogen; Principle, design and working of catalytic converters; Use of catalytic converters in vehicular pollution control; Principle and working and use of noise meter; Legislative control of noise; Noise reduction and control techniques.

Unit V

Municipal, Industrial and biomedical solid wastes and their treatment

Need of solid waste treatment characteristics of municipal, industrial and biomedical wastes; Collection, reduction of waste strength & volume; Classification and characterization of solid waste; Dry and wet waste treatments recovery and recycling of metals; Disposal methods for medical, industrial and biomedical wastes; Composting and vermin-composting.

Innovative techniques for prevention and control of Pollution

Use of solar radiation in industrial effluent treatment; Solar detoxification process; Carbon adsorption; Adsorption media filters; Micro-screening and other low cost treatment methods; Removal of chromium, phenol, mercury, nitrogen etc. from industrial effluents.

Texts/References

1. Mackenzie Davis, Susan J. Masten, Principles of Environmental Engineering and Science, 1st Edition, McGraw-Hill College, 2003.

2. MacKenzie L. Davis, David A. Cornwell, Introduction to Environmental Engineering, 4th Edition, McGraw-Hill College, 2006.
3. Joseph A. Salvato, Environmental Engineering and Sanitation, 4th Edition, Wiley, 1992.
4. Tom D. Reynolds, Paul Richards, Unit Operations and Processes in Environmental Engineering, 2nd Edition, Thomson Learning, 1995.
5. Gilbert M. Masters, Introduction to Environmental Engineering and Science, 2nd Edition, Prentice Hall publication, 1997.
6. Gerard Kiely, Environmental Engineering, McGraw-Hill College, International Edition, 1997.
7. Jerry Nathanson, Basic Environmental Technology: Water Supply, Waste Management, and Pollution Control, 5th Edition, Prentice Hall, 2003.
8. W. W. Nazaroff, William W. Nazaroff, Lisa Alvarez-Cohen, Environmental Engineering Science, John Wiley & Sons Inc, 2000.
9. Howard S. Peavy, George Tchobanoglous, Donald R. Rowe, Environmental Engineering, McGraw-Hill College, 1985.
10. Jerry A. Nathanson, Basic Environmental Technology: Water Supply, Waste Management & Pollution Control, 5th Edition, Prentice Hall, 2007.

20. Evolutionary Genetics - 1.5 Credits

Unit I

Concept and theories of evolution (Classical to Modern); Concept of species and modes of speciation: sympatry, allopatry, stasipatry & parapatry; Mechanism of speciation; Isolating mechanisms; Nonrandom and random breeding: Inbreeding and assortative mating; Path diagram construction and inbreeding coefficient, allelic identities by descent; Heterosis & heterozygous superiority

Unit II

Molecular population genetics: Molecular evolution (neutral theory, punctuated equilibrium); Molecular clock; Molecular evolution and Phylogenetic tree: Development of Phylogenetic tree; Amino acid sequence and phylogeny; DNA-based phylogenetic trees; DNA-DNA hybridization; Restriction enzyme sites; Nucleotide sequence comparison and homologies; Human phylogeny: Hominid evolution: anatomical, Geographical, Cultural; Molecular phylogenetics of *Homo sapiens*.

Unit III

Admixture: Meeting of human populations & its genetic imprint; Detection of admixture (based on allele frequencies & DNA data); Y Chromosome & mitochondrial DNA markers in genealogical studies; Peopling of continents (Europe, Africa, Asia): Geo-Genomics and Human migrations; Culture and human evolution:

Learning, society and culture; Relative rates of cultural and biological evolution; Social Darwinism; Sociobiology & economics of genetics (econogenomics)

21. Female Infertility

Unit I

Congenital and nutritional causes of female infertility; Hormonal and infectious causes of female infertility.

Unit II
Ovarian dysfunction; Anoestrus; Cystic ovarian degeneration and therapeutic management.

Unit III
Repeat breeding: its causes, diagnosis and treatment.

Unit IV
Early embryonic death (EED): its causes, diagnosis and therapeutic management.

Unit V
Abortion, causes of abortion, diagnosis and prevention; Effect of stress on fertility.

Practical
Diagnosis and treatment of infertility in female animals using uterine culture; Uterine biopsy; Exfoliated vaginal cytology and hormone assay; Use of ultrasonography in pregnancy diagnosis and in diagnosis of infertility.

Texts/References
1. Laing JA., Fertility and Infertility in Domestic Animals, 4th Edition, English Language Book Soc. & Bailliere Tindall, 1988.
2. Roberts SJ., Veterinary Obstetrics and Genital Diseases, 3rd Editon, Scientific Book Agency, 1986

22. Food Process and Biotechnology - 3 Credits

Unit I
Biotechnology for food production
History; Developments and current status of transgenic crops for: Crop improvement & enhanced agronomic performance; Food products with enhanced shelf-life; Processing and functional quality; Nutritional enhancement-macro and micro-nutrients; Plant vaccines and antibodies

Unit II
Applications of enzymes in food processing
Mechanism of enzyme function and reactions in process techniques; Enzymic bioconversions e.g. starch and sugar conversion processes; HFCS; Interesterified fat, hydrolyzed protein etc. and their downstream processing; Baking by amylases; Deoxygenation and desugaring by glucoses oxidase; Beer mashing and chill proofing; Cheese making by proteases and various other enzyme catalytic actions in food processing.

Unit III
Applications of Microbes in food process operations and production
Fermented foods and beverages; Food ingredients and additives prepared by fermentation and their purification; Fermentation as a method of preparing and preserving foods; Microbes and their use in pickling; Producing colours and flavours, alcoholic beverages and other products; Process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; Bacteriocins from lactic acid bacteria – Production and applications in food preservation.

Unit IV

Biotechnology applications in the production of additives / ingredients

Enzymes, carotenoids, amino acids, organic acids, vitamins, antibiotics, colouring, flavours and nutraceuticals; Biotechnology applications in the production of new protein foods- Single cell proteins (SCP) mushroom, food yeasts, algal proteins

Unit V

Safety assessment of genetically modified (GM) foods

International and National guidelines; Regulations & safety issues related to production, consumption, import/export and labeling of GM foods.

Texts/References

1. Guttierrez-Lopez GF and Barbosa-Canovas GV (Eds) Food Science and Food Biotechnology, CRC Press, 2003.
2. Crueger W and Crueger A Biotechnology: A Textbook of Industrial Microbiology, 2nd Edition, Panima Publishing Corporation, New Delhi, 2003.
3. Halford NG, Genetically Modified Crops, Imperial College Press, 2003.
4. Helferich W and Winter C K., Food Toxicology, 2nd Edition, CRC Press, 2001.
5. Joshi V K and Pandey A Biotechnology: Food, Fermentation, Microbiology, Biochemistry and Technology, Vol I & II, Educational Publishers and Distributors, 2004.

23. General Andrology - 3 Credits

Unit I

History of artificial insemination.

Unit II

Methods of semen collection from farm animals.

Unit III

Semen evaluation, macroscopic and microscopic examination and biochemical tests; Semen culture; Tests for assessment of sperm motility; Sperm survival and fertilizing capacity of spermatozoa

Unit IV

Pathology of male genetalia: its diagnosis and therapeutic management.

Unit V

Breeding soundness evaluation of male animals.

Practical

Semen evaluation; Preparation of semen extenders; Cryopreservation of semen; Biochemical and metabolic tests of semen; Tests for evaluation of sperm motility and fertilizing capacity of spermatozoa; Semen culture; Breeding soundness evaluation of male animals.

Texts/References

1. Mann T & Lutwak-Mann C., Male Reproductive Function and Semen, Springer-Verlag, 1981.
2. Salisbury GW, VanDemark NL & Lodge JR., Physiology of Reproduction and Artificial Insemination of Cattle, 2nd Edition, WH Freeman & Co. 19

24. General Gynaecology - 3 Credits

Unit I

Puberty and sexual maturity; Role of hypothalamic-pituitary-gonadal axis in attainment of puberty and sexual maturity; Endocrine regulation of estrous cycle.

Unit II

Folliculogenesis, oogenesis and ovulation and associated endocrine pattern.

Hormonal regimens for synchronization of estrus and induction of ovarian activity.

Unit III

Gamete transport; Fertilization; Implantation and maternal recognition of pregnancy.

Unit IV

Embryonic and fetal development; Placentation; Fetal circulation and gestation.

Unit V

Pregnancy diagnosis by clinical examination; Chemical and biological tests for pregnancy diagnosis and hormonal diagnosis of pregnancy; Pseudo-pregnancy and its treatment.

Practicals

Clinical examination of female genitalia; Biometry of female genital organs; Rectal and vaginal examination to diagnose cyclic phases of estrous cycle; Farm pattern of cervical mucus and exfoliated vaginal cytology; Pregnancy diagnosis in large and small animals; Biological and chemical tests of pregnancy diagnosis.

Texts/References

1. Hafez ESE., Reproduction in Farm Animals, 7th Edition, Lippincott Williams & Wilkins. 2000.
2. Roberts SJ., Veterinary Obstetrics and Genital Diseases, 3rd Editon, Scientific Book Agency, 1986.

25. General Virology - 3 Credits

Unit I

History of virology; Origin and nature of viruses; Biochemical and morphological structure of viruses; Nomenclature and classification of viruses.

Unit II

Replication of DNA and RNA viruses, Viral genetics and evolution

Unit III
Genetic and non-genetic interactions between viruses; Virus-cell interactions; Viral pathogenesis; Viral persistence; Oncogenic viruses; Epidemiology of viral infections.

Unit IV
Immune response to viruses; Viral vaccines; Viral chemotherapy.

Practicals
Orientation to a virology laboratory, Preparation of equipment for sterilization, collection, preservation, Transportation of samples and their processing, Isolation and cultivation of viruses in animals/ birds, Embryonated chicken eggs; Media and reagents for cell culture, Trypsinization and maintenance of monolayer cell cultures, Isolation of virus in cell cultures, Titration of viruses by 50% end-point cytopathogenicity and haemagglutination; Detection of viral antibodies by serum neutralisation test; Agar gel precipitation test; Haemagglutination inhibition and ELISA.

Texts/References
1. Acheson NH., Fundamentals of Molecular Virology, Wiley, 2007.
2. Carter J & Saunders V. Virology: Principles and Applications. 1st Edition, Wiley, 2007.
3. Knipe DM, Howley PM, Griffin DE. Fields Virology, 5th Edition, Vols. I, II. Lippincott, Williams & Wilkins, 2006.
4. Mahy, BWJ & Kangaroo HO., Virology Methods Manual, 1st Edition, Academic Press, 1996.
5. Murphy FA, Gibbs, EPJ, Holzmek MK & Studdert MJ., Veterinary Virology, 3rd Edition, Academic Press. 1999.

26. Genetics - 3 Credits

Unit I
Bacterial mutants and mutations
Isolation; Useful phenotypes (auxotrophic, conditional, lethal, resistant); Mutation rate; Types of mutations(base pair changes; frameshift; insertions; deletions; tandem duplication); Reversion vs. suppression; Mutagenic agents; Mechanisms of mutagenesis; Assay of mutagenic agents (Ames test)

Gene transfer in bacteria
History; Transduction – generalized and specialized; Conjugation – F, F', Hfr; F transfer; Hfr-mediated chromosome transfer; Transformation – natural and artificial transformation; Merodiploid generation; Gene mapping; Transposable genetic elements; Insertion sequences; Composite and Complex transposons; Replicative and non-replicative transposition; Genetic analysis using transposons.

Unit II
Bacteriophages and Plasmids
Bacteriophage–structure; Assay; Lambda phage – genetic map, lysogenic and lytic cycles; Gene regulation; Filamentous phages such as M13; Plasmids – natural plasmids; their properties and phenotypes; Plasmid biology - copy number and its control; Incompatibility; Plasmid survival strategies; Antibiotic resistance markers on plasmids (mechanism of action and resistance); Genetic analysis using phage and plasmid

Restriction-modification systems
History; Types of systems and their characteristics; Methylation-dependent restriction systems; applications.

Unit III

Mendelian Genetics

Introduction to human genetics; Background and history; Types of genetic diseases; Role of genetics in medicine; Human pedigrees; Patterns of single gene inheritance-autosomal recessive; Autosomal dominant; X linked inheritance; Complicating factors - incomplete penetrance; variable expression; Multiple alleles; Co dominance; Sex influenced expression; Hemoglobinopathies - Genetic disorders of hemoglobin and their diseases.

Non Mendelian inheritance patterns

Mitochondrial inheritance; Genomic imprinting; Lyon hypothesis; isodisomy; Complex inheritance-genetic and environmental variation; Heritability; Twin studies; Behavioral traits; Analysis of quantitative and qualitative traits

Unit IV

Cytogenetics

Cell division and errors in cell division; Non disjunction; Structural and numerical chromosomal abnormalities – deletion; duplication; translocation; Sex determination; Role of Y chromosome; Genetic recombination; Disorders of sex chromosomes and autosomes; Molecular cytogenetics – Fluorescence In Situ Hybridization (FISH); Comparative Genomic Hybridization (CGH).

Developmental genetics

Genes in early development; Maternal effect genes; Pattern formation genes; Homeotic genes; Signaling and adhesion molecules.

Immunogenetics

Major histocompatibility complex; Immunoglobulin genes - tissue antigen and organ transplantation; Single gene disorders of immune system.

Unit V

Genetic variation

Mutations; kinds of mutation; agents of mutation; genome polymorphism; uses of polymorphism.

Gene mapping and human genome project

Physical mapping; linkage and association

Population genetics and evolution

Phenotype; Genotype; Gene frequency; Hardy Weinberg law; Factors distinguishing Hardy Weinberg equilibrium; Mutation selection; Migration; Gene flow; Genetic drift; Human genetic diversity; Origin of major human groups.

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.

27. Genoinformatics - 3 Credits

Unit I

Overview of genomes

Diversity of Genomes: Prokaryotic and Eukaryotic Genomes: Structure, Organization, Evolution of Genome: Lateral or Horizontal Transfer among Genomes

Unit II

Genome analysis

Introduction; Gene mapping and applications- Genetic and Physical Mapping; Integrated map; Sequence assembly; Completed Genomes: Bacterium, Nematode, Plant and Human

Unit III

Genome annotation

Genome Annotation- Introduction, Structural and functional annotation; Automated and manual approaches; Structural annotation – prediction and homology based; Genes – Orthologs – Paralogs - Families - Functional annotation - GO, EC number and metabolic pathways, putative, expressed and hypothetical protein

Unit IV

Phylogenetics

Phylogenetic analysis: Evolutionary Change in Nucleotide Sequences; Rates and Patterns of Nucleotide Substitution; Models for Nucleotide Substitution and Methods for Phylogenetic analysis: Sequence Alignment, Softwares (SSearch, BLAST, FASTA, CLUSTAL); Construction of Phylogenetic Tree

Unit V

Genome Expression

Gene expression; Transcriptome and Proteome- General Account, Assigning function for a gene–mutagenesis screening, over expression, knock-out mutants

Texts/References

1. Wilkins, M.R., Williams, K.L., Appel, R.D., Hochstrasser, D.F. (Editors), Proteome Research: New Frontiers in Functional Genomics. Springer Verlag Berlin Heidelberg. 1997
2. Baxevanis, A. and Ouellette, F.B.F (Editors), Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 2nd Revised Edition, John Wiley and Sons, New York. 2001
3. Dale and Schartz, From Genes to Genomes, Humana. 2003
4. Hawley and Mori, The Human Genome, Academic, 1999
5. Primrose and Twyman, Principles of Genome Analysis & Genomics, 3rd Edition, Blackwell, 2003.
6. Liebler, D., Introduction to Proteomics: Tools for New Biology. Human Press, Totowa, 2002
7. Campbell, A.M. & Heyer, L.J., Discovering Genomics, Proteomics and Bioinformatics, 2nd Edition, Benjamin/ Cummings, 2006
8. Jerome, P.E. Mathematics for Genome Analysis, Cambridge, 2002.
9. Hall, B.G., Phylogenetic Tress Made Easy: A How to Manual for Molecular Biologists. Sinauer Ass., USA. 2001
10. Nei, M. and Kumar, S., Molecular Evolution and Phylogenetics, Oxford University Press. 2000.

28. Genomics and Proteomics - 3 Credits

Unit I

Introduction

Structural organization of genome in Prokaryotes and Eukaryotes; Organelle DNA-mitochondrial, chloroplast; DNA sequencing-principles and translation to large scale projects; Recognition of coding and non-coding sequences and gene annotation; Tools for genome analysis-RFLP, DNA fingerprinting, RAPD, PCR, Linkage and Pedigree analysis-physical and genetic mapping.

Unit II

Genome sequencing projects

Microbes, plants and animals; Accessing and retrieving genome project information from web; Comparative genomics, Identification and classification using molecular markers-16S rRNA typing/sequencing, ESTs and SNPs.

Unit III

Proteomics

Protein analysis (includes measurement of concentration, amino-acid composition, N-terminal sequencing); 2-D electrophoresis of proteins; Microscale solution isoelectricfocusing; Peptide fingerprinting; LC/MS-MS for identification of proteins and modified proteins; MALDI-TOF; SAGE and Differential display proteomics, Protein-protein interactions, Yeast two hybrid system.

Unit IV

Pharmacogenetics

High throughput screening in genome for drug discovery-identification of gene targets, Pharmacogenetics and drug development

Unit V

Functional genomics and proteomics

Analysis of microarray data; Protein and peptide microarray-based technology; PCR-directed protein *in situ* arrays; Structural proteomics

Texts/References

1. Voet D, Voet JG & Pratt CW, Fundamentals of Biochemistry, 2nd Edition. Wiley 2006
2. Brown TA, Genomes, 3rd Edition. Garland Science 2006
3. Campbell AM & Heyer LJ, Discovering Genomics, Proteomics and Bioinformatics, 2nd Edition. Benjamin Cummings 2007
4. Primrose S & Twyman R, Principles of Gene Manipulation and Genomics, 7th Edition, Blackwell, 2006.
5. Glick BR & Pasternak JJ, Molecular Biotechnology, 3rd Edition, ASM Press, 1998.

29. Industrial & Food Biotechnology - 3 Credits

Unit I

Industrial and Food Biotechnology; Introduction; History; Importance; Applications of biotechnology in food processing; Significant advances; Recent developments; Risk factors; Safety regulations etc.

Unit II
Bioprocessing – Industrial use of micro organisms; Microbes exploited commercially- *Saccharomyces, Lactobacillus, Penicillium, Acetobactor, Bifidobacterium, Lactococcus, Streptococcus* etc; Fermentation-process, media and systems; Upstream and down stream processing; Product development; Dairy fermentation and fermented products

Unit III
Microbial enzymes in food processing; Industrial production of enzymes - proteases and cellulases; Food and beverage fermentation- alcoholic and non alcoholic beverages; Food additives and supplements – probiotics, health care products, vitamins and antibiotics; Fuels and industrial chemicals- Alkanes, industrial ethanol etc.

Unit IV
Modification of microbes/enzymes – Strain improvement, enzyme/ cofactor engineering; Technologies for microbial inactivation; Applications in product development/improvement.

Unit V
Cell immobilization for product enhancement – Classic examples; Biosensors and Bioprocess monitoring; Model systems and process control

Texts/References
1. Gautam, N. C., Food Biotechnology in Comprehensive Biotechnology, Vol. 6., Shree Publishers, New Delhi, 2007
2. Gutierrez – Lopez, G. F. *et. al.*, Food Science and Food Biotechnology. CRC Publishers, Washington, 2003
3. Maheshwari, D. K. et. al., Biotechnological applications of microorganisms, IK . International, New Delhi, 2006
4. Stanbury, P. F. et. al., Principles of Fermentation Technology, 2nd Edition, Elsevier, UK, 1995.
5. Waites, M. J. et. al., Industrial Biotechnology: An Introduction, Blackwell publishing, UK, 2007.

30. Male Infertility - 3 Credits

Unit I
Hereditary; Congenital and nutritional causes of female infertility; Testicular hypoplasia, its causes and effect on semen and fertility.

Unit II
Hormonal and infectious causes of female infertility; Testicular degeneration, its causes and effect on semen and fertility

Unit III
Coital injuries and vices of male animals; Impotentia coeundi and impotentia generandi.

Unit IV
Pathological and functional disturbances of epididymis, vas deferens and accessory sex glands.

Unit V
Breeding soundness evaluation of animals.

Practical

Diagnosis and treatment of infertile male animals; Semen evaluation for motility, fertility and determination of other biochemical constituents of seminal plasma.

Texts/References

1. Mann T & Lutwak-Mann C., Male Reproductive Function and Semen, Springer-Verlag, 1981.
2. Salisbury GW, VanDemark NL & Lodge JR., Physiology of Reproduction and Artificial Insemination of Cattle, 2nd Edition, WH Freeman & Co. 1978.

31. Marine Food Technology - 3 Credits

Unit I

Preservation and processing – chilling methods, phenomena of rigor mortis, spoilage changes – causative factors. Drying – conventional methods. Salt curing, pickling and smoking. Freezing and cold storage, Canning procedures. Role of preservatives in processing.

Unit II

Packing – handling fresh fish, frozen packs, IQF, layered and shatter packs. Fishery by – products, cannery waste, feeds, silage, fish gelatin, fish glue, chitin and chitosan, pearl essence, fertilizer.

Unit III

Seafood microbiology – factors influencing microbial growth and activity. Seafood borne pathogens – bacteria, fungi, viruses. Spoilage factors in seafood. Toxins influencing food spoilage. Microbes as food – SCP, microbial neutraceuticals.

Unit IV

Quality management – concepts, planning, system, quality control, quality assurance, quality improvement. Certification standards – ISO and HACCP. Principles of quality related to food sanitation, contamination, pest control, human resource and occupational hazards.

Unit V

Novel product development, marketing and sea food export – MPEDA, marketing, government policies, export finance, economic importance. Novel products – nutrition promotion, consumer studies qualitative and quantitative research methods

32. Metabolic Regulation & Engineering - 3 Credits

Unit I

Elements of Metabolic Engineering

Historical perspective and introduction; Importance of metabolic engineering; Paradigm shift; Information resources; Scope and future of metabolic engineering; Building blocks of cellular components; Polymeric biomolecules; Protein structure and function; Biological information storage – DNA and RNA

Unit II

Review of cellular metabolism

Transport mechanisms and their models; Enzyme kinetics; Mechanisms and their dynamic representation; Regulation of enzyme activity versus regulation of enzyme concentration; Regulation of metabolic networks; Regulation of at the whole cell level; Examples of important pathways; Case studies and analytical-type problems

Unit III

Material and Energy Balances

Stoichiometric models and matrix representation; The chemical reaction vector and energetic; Material and energy balances revisited; Basis for simplification of reaction; Elemental balances; Component balances and the link with macroscopic measurements; Examples of construction of elemental and component balances

Unit IV

Metabolic Flux Analysis and control theory

The theory of flux balances; Derivation of the fundamental principle; Degree of freedom and solution methods; Moore-Penrose inverse and Tsai-lee matrix construction; Examples of applications of flux analysis introduction Metabolic Control Theory; Control coefficients; Elasticity coefficients; Summation and connectivity theorems; Case Studies and examples

Unit V

Metabolic Engineering Practice

The concept of metabolic pathway synthesis; Need for pathway synthesis, Examples for illustration; Overall perspective of MFA, MCA and MPA and their applications; Three success case studies

Texts/References

1. Gregory N. Stephanopoulos, Aristos A. Aristidou, Metabolic Engineering – Principles and Methodologies, 1st Edition, Jens Nielsen Academic Press, 1998
2. Relevant research papers
3. Gerhard Gottschalk, Bacterial Metabolism, 2nd Edition, Springer Verlag, 1986
4. S. A. Teukolsky, W. T. Vellerling, B. P. Flannery, W. H. Press, Numerical Recipes in C, Cambridge University Press, 1993

33. Microbial Technology - 3 Credits

Unit I

Isolation and screening of industrially important microbes; Large scale cultivation of industrial microbes; Strain improvement to improve yield of selected compounds e.g. antibiotics, enzymes or recombinant proteins.

Unit II

Basic principles of bioprocess as applied to selected microbes; Process optimization of selected products.

Unit III

Recombinant protein production in microbes ; Commercial issues pertaining to the production of recombinant products from microbes; Downstream processing approaches; Industrial microbes as cloning hosts (Streptomyces/Yeast)

Unit IV
Environmental application of microbes; Ore leaching; Toxic waste removal; soil remediation.

Unit V
Microbial application in food and healthcare industries; Food processing and food preservation; Antibiotics and enzymes of pharmaceutical use.

Texts/References
1. Glazer and Nikaids, Microbial Biotechnology, 2nd Edition, Cambridge University Press, 2007.
2. Comprehensive Biotechnology
3. Principles of Fermentation Technology
4. Journal : (A)Nature Biotechnology (B) Trends in Microbiology (C) Current opinion in Microbiology.

34. Model Genetic Systems - 1.5 Credits

Unit I
Life cycles and advantages of the following organisms commonly used in genetic studies: T4 and λ phages; *Neurospora; E.coli; Saccharomyces cereviseae and Schizosaccharomyces pombe; Caenorhabditis; Drosophila;* Zebra fish; Mouse

Unit II
Conventions of nomenclature of genes and gene products in different model systems; Conversion of synteny between human and model organisms; Normal and transformed cell lines as model genetic systems

Texts/References
1. Ashburner, Drosophila - A Laboratory Handbook, 2nd Edition, CSHL Press, 2004.
2. Demerec & Kaufmann, Drosophila Guide, 8th Edition, Carnegie, 1969.
3. Hood, The Nematode: C. elegans, CSHL, 1998.
4. Strachan and Read, Human Molecular Genetics, 3rd Edition, Wiley 2003.
5. Trends in Genetics: Genetic Nomenclature Guide, Elsevier, 1998.

35. Molecular Techniques in Animal Breeding - 3 Credits

Unit I
Basic concept: Genesis and importance of molecular techniques; Genomic organization– physical and genetic map; Current status of genome maps of livestock.

Unit II
DNA markers and their application; Random Amplification of Polymorphic DNA (RAPD), Single nucleotide polymorphism (SNP) detection, DNA Sequences, DNA finger printing.

Unit III
Restriction Enzymes; Restricted Fragment Length Polymorphism (RFLP); DNA sequencing; Polymerase Chain Reaction (PCR), its types and applications.

Unit IV
Transgenesis and methods of gene transfer; Super ovulation and embryo transfer techniques; Hybridoma technology; Statistical methods for analyzing the molecular genetic data.

Practicals
Extraction and purification of DNA; cDNA, RNA; Gel electrophoresis; Digestion of DNA using different restriction enzymes; PCR, Real time PCR, SSCP, Design the primers; Collection of oocytes and in vitro fertilization of oocytes; Statistical methods for analyzing molecular genetic data.

Texts/References
1. Akano IE, DNA Technology, IAP Academic Press, 1992.
2. Jare K Setlow, Genetic Engineering–Principles and Methods, 1st Edition, Springer, 2006.
3. Micklos DA, Fryer GA & Crotty DA., DNA Science, 2nd Editon, Cold Spring Harbour, 2003.

36. Molecular Therapeutics - 3 Credits

Unit I
Gene therapy; Intracellular barriers to gene delivery; Overview of inherited and acquired diseases for gene therapy; Retro and adeno virus mediated gene transfer; Liposome and nanoparticles mediated gene delivery

Unit II
Cellular therapy; Stem cells: definition, properties and potency of stem cells; Sources: embryonic and adult stem cells; Concept of tissue engineering; Role of scaffolds; Role of growth factors; Role of adult and embryonic stem cells; Clinical applications; Ethical issues

Unit III
Recombinant therapy; Clinical applications of recombinant technology; Erythropoietin; Insulin analogs and its role in diabetes; Recombinant human growth hormone; Streptokinase and urokinase in thrombosis; Recombinant coagulation factors

Unit IV
Immunotherapy; Monoclonal antibodies and their role in cancer; Role of recombinant interferons; Immunostimulants; Immunosupressors in organ transplants; Role of cytokine therapy in cancers; Vaccines: types, recombinant vaccines and clinical applications

Unit V
Gene silencing technology; Antisense therapy; siRNA; Tissue and organ transplantation; Transgenics and their uses; Cloning; Ethical issues

Texts/References
1. Bernhard Palsson and Sangeeta N Bhatia, Tissue Engineering, 2nd Edition, Prentice Hall, 2004.
2. Pamela Greenwell, Michelle McCulley, Molecular Therapeutics: 21st century medicine, 1st Edition, Sringer, 2008.

37. Molecular Virology - 3 Credits

Unit I

Economic losses due to important viruses; Types of plant viruses, DNA viruses, RNA viruses, satellite viruses, satellite RNA, satellite DNA, viroids, virusoids; Disease symptoms, local and systemic symptoms, necrosis, hypoplasia, hyperplasia; Vectors for virus transmission; Cell to cell and systemic movement of viruses, plasmodesmata and virus movement.

Unit II

Genome Organization of DNA viruses; *Caulimovirus* – eg. *Cauliflower mosaic virus*, Replication of CaMV, Badnavirus – *Rice tungro virus* (RTBV); *Geminiviridae* – *Bean golden mosaic virus*, β- DNAs of geminiviruses, rolling circle replication, *Nanovirus* – *Banana bunchy top virus*

Unit III

Genome Organization of positive-stranded RNA viruses – *Potyviridae*, Potato virusY (PVY), processing of polyprotein, *Comoviridae*, *Citrus triesteza virus*; *Bromoviridae*, *Alfalfa mosaic virus*; *Tubiviridae*, *Tobacco mosaic virus*, Replication of TMV, *Tobacco rattle virus*.

Unit IV

Genome Organization of negative–stranded RNA viruses; *Rhabdoviridae*, *Sonchus yellow net virus*; *Bunyaviridae*, *Tomato spotted wilt virus*; *Tenuivirus*, *Rice stripe virus*; Double-stranded RNA viruses, *Reoviridae*, *Rice dwarf virus*.

Unit V

Virus detection and diagnosis; Infectivity assays – Sap transmission, insect vector transmission, agroinfection (using *Agrobacterium*); Ultracentrifugation, electron microscopy, serological methods, immunelectrophoresis in gels, direct double-antibody sandwich method, Dot ELISA, Immunosorbent electron microscopy (ISEM), Decoration technique, Polymerase chain reaction; DNA and oligonucleotide microarray; Gene silencing, PTGS & TGS, viral suppressors of gene silencing.

Texts/References

1. Ed. C.L. Mandahar, Molecular Biology of Plant viruses, Kluwer Academic Publishers, Dordrect, 1999.
2. Roger Hull (Ed), Mathews Plant Virology, 4th Edition, Academic Press, San Diego, 2002.
3. D.G.A. Walkey (Ed), Applied Plant Virololgy, 2nd Edition, Chapman & Hall, London, 1991.

38. Nanobiotechnology

Unit I

Introduction to Nano-Biotechnology; Nanotechnology definition and concepts; Cellular Nanostructures; Nanopores; Biomolecular motors; Criteria for suitability of nanostructures for biological applications

Unit II

Basic characterization techniques; Electron microscopy; Atomic force microscopy; Photon correlation spectroscopy

Unit III
Thin films; Colloidal nanostructures; Nanovesicles; Nanospheres; Nanocapsules

Unit IV
Nanostructures for drug delivery, concepts, targeting, routes of delivery and advantages

Unit V
Nanostructures for diagnostics and biosensors; Nanoparticles for diagnostics and imaging; Nanodevices for sensor development

Texts/References
1. Multilayer Thin Films, Editor(s): Gero Decher, Joseph B. Schlenoff Publisher: Wiley-VCH Verlag GmbH & Co. KGaA ISBN: 3527304401
2. Bionanotechnology: Lessons from Nature Author: David S. Goodsell Publisher: Wiley-Liss ISBN: 047141719X
3. Biomedical Nanotechnology Editor: Neelina H. Malsch Publisher: CRC Press ISBN: 0-8247-2579-4

39. Nanobiotechnology *(for Neurosciences)*

Unit I
Introduction to nanotechnology; Molecular nanotechnology; Atoms by inference; Atomic force microscope; Nanopowders and nanomaterials: Sol-gels and their use, Use of natural nanoparticles, Nanobiometrics, Lipids as nano-bricks, Proteins as nanomolecules, DNA in nanotechnology, Present and future of nanotechnology applications in:

a) Molecular biology

b) Medicine

Unit-II
Neuroscience nanotechnology: Progress, opportunities and challenges; Nanotechnology tools for probing neurons and glia; Nanoengineered materials for neuroregeneration; Nanoparticles for effective drug delivery to the CNS; Ethical issues in nanotechnology

Texts/References
1. Gero Decher, Joseph B. Schlenoff, Multilayer Thin Films, Wiley-VCH Verlag, GmbH & Co. KGaA, 2003.
2. David S. Goodsell, Bionanotechnology: Lessons from Nature, 1st Edition, Wiley-Liss, 2004.
3. Neelina H. Malsch, Biomedical Nanotechnology, 1st Edition, CRC Press, 2005.

40. Neurogenetics - 3 Credits

Unit I
Major regions of human brain; Cellular components of nervous tissue; Sub cellular organization of the nervous system; Membrane potential and action potential

Unit II
Learning and memory; Circadian rhythms

Unit III
Neurogenetic disorders; Spinomuscular atrophy; Syndromes due to triplet nucleotide expansion; Alzheimers disease; Parkinsons disease

Unit IV
Nature-nurture and behaviour; Genetic experiments to investigate animal behaviour: Selection Studies; Inbred strain studies; Identifying genes for controlling behavior: Induced mutations; Quantitative trait loci; Synteny/orthology; Investigating the genetics of human behaviour; Twin and adoption study designs, interpreting heritability; Linkage and association studies; Environmental influence- shared and non-shared environment

Unit V
Psychopathology: Schizophrenia, Mood disorders, Disorders of childhood

Texts/References
1. Kaplan and Sadock, Synopsis of Psychiatry, 10th Edition, Williams & Wilkins, 2007.
2. Plomin et al., Behavioral Genetics. Freeman, 2001.
3. Zigmond, Bloom et al., Fundamentals Neuroscience, 2nd Edition, Academic Press, 2002.
4. Kandel, Schwartz et al., Principles of Neuroscience, Prentice Hall, 2000.
5. Pasternak, An Introduction to Molecular Human Genetics, Fritzgarald, 2005.
6. Cox and Sinclair, Molecular Biology in Medicine, 1st Edition, Blackwell, 1997.

41. Neuroinformatics - 1.5 Credits

Unit I
Linear Response Theory and Single neuron models
Properties of a linear system; Convolution and Fourier transforms; Integrate and Fire model; Multi compartment models – an overview; Network Models.

Unit II
Neural Encoding
Introduction; Spike Trains and Firing Rates; Spike Train Statistics; Neural Code; Estimating Firing Rates; Introduction to Receptive Fields; Neural Decoding and Information theory.

Unit III
Entropy, Mutual Information, Bayes Theorem
Adaptation and learning; Synaptic plasticity rules; Supervised and unsupervised learning; Classical conditioning; Reinforcement learning

Unit IV
The Human Brain Project.
Microscale and macroscale characterization; Basis of brain mapping; Functional and cognitive brain atlas; Interoperable and Federated databases.

Texts/References

1. Dayan and Abbot, Theoretical Neuroscience – Computational and Mathematical Modeling of Neural System, 1st Edition, The MIT Press, 2001.

42. Ornamental Fish Culture & Aquarium Keeping - 3 Credits

Unit I

Introduction

Fresh and marine water aquaria - Global and Indian status of aquarium keeping - Ornamental fish trade - Advantages and benefits - Criteria for choosing aquarium fishes - Common aquarium fishes - collection techniques.

Unit II

Culture and hatchery production

Breeding of fresh and marine water ornamental fishes - collection - conditioning - brood stock development - feeding - spawning - larval rearing - Live feeds - stock and mass culture.

Unit III

Designing, Aeration, filtration and lightings

In door and out door aquaria - Tank designs - fabrication - choosing of right tank - Air pumps - filters - biofilters - devices - aquarium lights - water quality maintenance - test kits.

Unit IV

Setting up of aquarium

Fresh and marine water set up - aquascaping - adding decorative materials - aquarium plants - community aquarium.

Unit V

Health management

Basic diets - pellet feeds - formulation - Diseases - diagnosis and health management - treatment methods - Colour enhancement - induced breeding

43. Pharmaceutical Biotechnology - 3 Credits

Unit I

Introduction History of pharmacy; The pharmaceutical industry & development of drugs; Economics and regulatory aspects; Quality management; GMP

Unit II

Drug kinetics and biopharmaceutics Mechanism of drug absorption, distribution, metabolism and excretion – factors affecting the ADME process; Bioequivalence; Pharmacokinetics.

Unit III

Principles of drug manufacture Liquid dosage forms – solutions, suspensions and emulsions; Topical applications – ointments, creams, suppositories; Solid dosage forms – powders, granules, capsules, tablets, coating of tablets; Aerosols; Preservation; Packing techniques

Unit IV

Advances in drug delivery Advanced drug delivery systems – controlled release; Transdermals, Liposomes and drug targeting

Unit V

Biopharmaceuticals Understanding principles of pharmacology, pharmacodynamics; Study of a few classes of therapeutics like Recombinant therapeutics, Monoclonal Antibodies, Vaccines, Gene therapy, Antibiotics and Hormones.

Texts/References

1. Lachman, L. et al., The Theory and Practice of Industrial Pharmacy, 3rd Edition, Varghese Publishing House, 1987.
2. Aulton, M.E. Pharmaceutics: The Science of Dosage form Design, 2nd Edition, Churchill Livingstons, 2002.
3. Ansel, H.C. etal., Pharmaceutical Dosage Forms and Drug Delivery Systems, 7th Edition, Lippincott Williams, Wilkins, 2002.
4. Nogardy Thomas, Medicinal Chemistry: A Molecular and Biochemical Approach, 3rd Edition, OUP, 2005.
5. Rawlins, E.A., Bentley's Textbook of Pharmaceutics, 8th Edition, Baillire, Tindall, 2005.
6. Remington: The Science and Practice of Pharmacy, Vol. I & II, 20th Edition, B.I. Publications / Lippincott Williams & Wilkins, 2000.
7. Banker, G.S. and C.T. Rhodes "Modern Pharmaceutics", 4th Edition, Marcel Dekker, 2002.
8. Tripathi, K.D. "Essentials of Medical Pharmacology", 6th Edition, Jaypee Bros. Med. Publishers, 2008.

44. Pharmacogenomics

Unit I

Pharmacogenomics; Pharmacogenetics; Benefits; Practical applications of pharmacogenomics; The Promise of Pharmacogenomics today leading to personalized medicines; Human genetic variation- examples of CYP gene variations leading to variable metabolism of drugs; Distribution of variation; Mutations & its kind; Natural selection; Variation in ethnic groups, races.

Unit II

Pharmacology; Clinical pharmacology; Drugs; Drug Legislation & safety; Types of Drugs - examples of latest drugs; Drug potency and Efficacy; ADME of Drug- Drug absorption; Drug distribution; Drug metabolism & Drug Excretion; Drug efficacy & toxicity; drug therapeutic levels; Therapeutic Index; Drug abuse; Drug response in patients by correlating gene expression; Regulation of gene expression; Polymorphism; Alleles; Single nucleotide polymorphism; Genotyping; example of TPMT and DPD gene mutation and their impact in treatment strategy

Unit III

Genetic markers-Biomarkers in early drug development; Biomarkers in Clinical development; Biomarkers for molecular Diagnostics- example of cancer biomarkers; Pharmacogenetics & drug development.

Texts/References

1. Wu R and Lin M, Statistical & Computational Pharmacogenomics, CRC Press, 2008.
2. Yan Q, Pharmacogenomics in Drug Discovery and Development, Springer-Verlag New York, LLC, 2008.
3. Meyer UA and Tyndale RF, Pharmacogenomics, 2nd Edition, CRC Press, 2005.
4. Innocenti F, Pharmacogenomics: Methods and Applications Springer-Verlag New York, LLC, 2005.
5. Rothstein MA and Collins FS, Pharmacogenomics: Social, Ethical, and Clinical Dimensions, Wiley John & Sons, Inc., 2003

45. Plant Biotechnology - 3 Credits

Unit I

Plant Tissue Culture

Historical perspective; Totipotency; Organogenesis; Somatic embryogenesis; Regulation and applications; Artificial seed production; Micropropagation; Somaclonal variation; Androgenesis and its applications in genetics and plant breeding; Germplasm conservation and cryopreservation.

Protoplast Culture and Somatic Hybridization

Protoplast isolation; Culture and usage; Somatic hybridization - methods and applications; Cybrids and somatic cell genetics.

Unit II

Agrobiology

Agrobacterium-plant interaction; Virulence; Ti and Ri plasmids; Opines and their significance; T-DNA transfer; Disarming the Ti plasmid.

Genetic Transformation

Agrobacterium-mediated gene delivery; Cointegrate and binary vectors and their utility; Direct gene transfer - PEG-mediated, electroporation, particle bombardment and alternative methods; Screenable and selectable markers; Characterization of transgenics; Chloroplast transformation; Marker-free methodologies; Gene targeting.

Unit III

Molecular Mapping & Marker Assisted Selection (MAS)

Quantitative and qualitative traits; MAS for genes of agronomic importance, e.g. insect resistance, grain quality and grain yield; Molecular polymorphism, RFLP, RAPD, STS, AFLP, SNP markers; Construction of genetic and physical map; Gene mapping and cloning; QTL mapping and cloning.

Strategies for Introducing Biotic and Abiotic Stress Resistance/Tolerance

Bacterial resistance; Viral resistance; Fungal resistance; Insects and pathogens resistance; Herbicide resistance; Drought, salinity, thermal stress, flooding and submergence tolerance.

Unit IV

Genetic Engineering for Plant Architecture and Metabolism

Seed storage proteins; Protein engineering; Vitamins and other value addition compounds; Source-sink relationships for yield increase; Post-harvest bioengineering; Plant architecture; Flowering behaviour

Plants as Biofactories
Concept of biofactories; Fermentation and production of industrial enzymes, vitamins and antibiotics and other biomolecules; Cell cultures for secondary metabolite production; Production of pharmaceutically important compounds; Bioenergy generation

Unit V

Plant Genomics
Identification of candidate genes using genetic information (positional cloning), using biochemical and expression analysis (microarray analysis, proteomics, metabolomics); Characterization and functional analysis of candidate genes: transformation, mutant populations, knockout systems; Heterologous expression systems; Protein analysis; Bioinformatics and databases; Genoinformatics.

Eco-biotechnology
Biosensors; Biofuels; Marine biofarming; Plant genetic resources; Patenting of biological material; Plant breeders rights (PBRs) and farmers rights; Biosafety and containment practices

Texts/References

1. Adrian Slater, Nigel Scott and Mark Fowler, Plant Biotechnology: The genetic manipulation of plants, 1st Edition, Oxford University Press,2003
2. Edited by BR Jordan, 2nd Edition, The Molecular Biology and Biotechnology of Flowering, CABI, 2006.
3. Neil Wille, Phytoremediation: Methods and Reviews, 1st Edition, Humana Press, 2007.
4. Denis Murphy, Plant Breeding and Biotechnology: Societal Context and the Future of Agriculture, Cambridge University Press, 2007.

46. Plant Metabolite Engineering - 3 Credits

Unit I

Metabolism and Metabolic Engineering
Carbon Assimilation; Light absorption and energy conversion; Calvin Cycle; Hatch-Slack pathway; Reductive pentose phosphate pathway; Carbon dioxide uptake and assimilation; Photorespiration; Glycolate metabolism.

Biological Oxidation and Release of Energy
Enzyme Kinetics and Analysis of Sequences of Reactions; Glycolytic pathway; Kreb's cycle; High energy compounds; Oxidative phosphorylation; Chemiosmotic hypothesis; Pentose phosphate shunt pathway.

Unit II

Metabolism of Macromolecules
Biosynthesis and inter-conversion of carbohydrates; Biosynthesis, inter-conversion and degradation of lipids; Regulation of Metabolic Networks; Metabolic Flux Analysis; Metabolic Control analysis

Long-distance Transport Mechanisms
Turgor and stomatal movements; solute movement; source-sink relationship; water relations.

Unit III

Nitrogen, Sulphur and Phosphorus Metabolism
General aspects of nitrogen economy; Nitrate reduction; Pathways of ammonia assimilation; Reductive amination; Transamination; Regulation of nitrogen assimilation; Uptake, transport and assimilation of sulphate and phosphate.

Nitrogen Fixation
Symbiotic and non-symbiotic nitrogen fixation; Role of lectins; *nod* genes; *nif* genes; Structure, function and regulation of nitrogenase; Leghaemoglobin; Nodulins; Regulation and enhancement of nitrogen fixation.

Unit IV

Secondary Metabolism
Importance of Secondary Metabolites; Biosynthesis of phenolic compounds, isoprenoids, alkaloids and flavonoids; Metabolism of nucleotides, amino acids and vitamins; Bioproduction; biological treatment; and related natural and engineered systems.

Unit V

Bioinformatics for Metabolic Networks
Systems biology frameworks for metabolic engineering; Concepts of metabolic networks; Establishment of metabolic flux analysis and metabolic control analysis; Systems biology framework for integration of mathematical modeling and global measurements at metabolite, protein and transcription levels.

47. Process Control & Instrumentation - 3 Credits

Unit I
Complex analysis - Definition and properties of analytic functions; Cauchy-Riemann equations, harmonic functions; Power series and their properties; Elementary functions; Cauchy's theorem and its applications; Taylor series and Laurent expansions; Residues and the Cauchy residue formula; Evaluation of improper integrals; Conformal mappings; Inversion of Laplace transforms.

Unit II
First Principles model development; Process dynamics for first, second and higher order systems: linearization, transfer function models, effect of poles, zeros and time delays on system response

Unit III
Instrumentation: control of pH, dissolved oxygen, temperature, redox potential etc.; Introduction to feedback control: objectives, PID control

Unit IV
Analysis of closed loop systems: stability, root locus, frequency response using Bode and Nyquist plots

Unit V
Control design techniques: design criteria, time and frequency domain techniques; Model based design; Tuning

Texts/References

1. D. E. Seborg, T. F. Edgar, D. A. Mellichamp, Process Dynamics and Control, 2nd Edition, John Wiley & Sons, 2004.
2. B. W. Bequette, Process Control: Modeling, Design and Simulation, Prentice Hall, New Delhi, 2003.
3. W. L. Luyben. Process Modelling Simulation and Control for Chemical Engineers, 2nd Edition, McGraw Hill, 1990.
4. G. Stephanopoulos, Chemical Process Control: An Introduction to Theory and Practice, Prentice Hall, New Delhi, 2001.

48. Protein Engineering - 3 Credits

Unit I

Protein engineering – definition, applications; Features or characteristics of proteins that can be engineered (definition and methods of study) – affinity and specificity; Spectroscopic properties; Stability to changes in parameters as pH, temperature and amino acid sequence, aggregation propensities, etc.

Unit II

Methods of measuring the stability of a protein; Spectroscopic methods to study physicochemical properties of proteins: far-UV and near-UV CD; Fluorescence; UV absorbance; ORD; Hydrodynamic properties–viscosity, hydrogen-deuterium exchange; Brief introduction to NMR spectroscopy – emphasis on parameters that can be measured/obtained from NMR and their interpretation

Unit III

Forces stabilizing proteins – Van der waals, electrostatic, hydrogen bonding and weakly polar interactions, hydrophobic effects; Entropy – enthalpy compensation; Experimental methods of protein engineering: directed evolution like gene site saturation mutagenesis; Module shuffling; Guided protein recombination, etc., Optimization and high throughput screening methodologies like GigaMetrix, High throughput microplate screens etc., Application to devices with bacteriorhodopsin as an example; Engineering antibody affinity by yeast surface display; Applications to vaccines.

Unit IV

Computational approaches to protein engineering: sequence and 3D structure analysis, Data mining, Ramachandran map, Mechanism of stabilization of proteins from psychrophiles and thermophiles vis-à-vis those from mesophiles; Protein design.

Unit V

Case studies

Texts/References

1. Edited by T E Creighton, Protein structure: A practical approach, 2nd Edition, Oxford university press, 1997.
2. Edited by T E Creighton, Protein function. A practical approach, 2nd Edition, Oxford university press, 1997.
3. Edited by T E Creighton, Protein function. A practical approach. Oxford university press. 2004.
4. Cleland and Craik, Protein Engineering, Principles and Practice, Vol 7, Springer Netherlands 1998.
5. Mueller and Arndt., Protein engineering protocols, 1st Edition, Humana Press, 2006.
6. Ed. Robertson DE, Noel JP, Protein Engineering Methods in Enzymology, 388, Elsevier Academic Press, 2004.
7. J Kyte, Structure in protein chemistry, 2nd Edition, Garland publishers, 2006.

49. Reproductive Genetics - 1.5 Credits

Unit I

Male and female reproductive systems: Gonads and differentiation of sexual characters; Hormonal regulation of sexual differentiation

Unit II

Reproductive disorders: Disorders of gonads, genital tracts and genitalia: Pseudohermaphroditism; True hermaphroditism; Gonadal dysgenesis; Anomalies of genital ducts; Infertility; Genetic basis of male infertility; Genetic basis of female infertility; Recurrent pregnancy loss

Technologies in reproductive assistance; Legal and ethical implications in reproductive assistance

Texts/References

1. Besser & Thorner, Comprehensive clinical endocrinology, 3rd Edition, Mosby 2002.
2. Emery and Rimons, Principles & Practice of Medical Genetics, Vol I-III, Churchill Livingstone, 2002.
3. Chaudhuri, Concise Medical Physiology, New Central Book Agency, 2002.
4. Gardner, In vitro fertilization: A practical approach, Informa healthcare, 2007.

50. Stem Cell Biology - 1.5 Credits

Unit I

Introduction to Stem Cells

Definition, Classification and Sources

Unit II

Embryonic Stem Cells

Blastocyst and inner cell mass cells; Organogenesis; Mammalian Nuclear Transfer Technology; Stem cell differentiation; Stem cells cryopreservation

Unit III

Application of Stem Cells

Overview of embryonic and adult stem cells for therapy Neurodegenerative diseases; Parkinson's, Alzheimer, Spinal Code Injuries and other Brain Syndromes; Tissue systems Failures; Diabetes; Cardiomyopathy; Kidney failure; Liver failure; Cancer; Hemophilia etc.

Unit IV

Human Embryonic Stem Cells and Society

Human stem cells research: Ethical considerations; Stem cell religion consideration; Stem cell based therapies: Pre clinical regulatory consideration and Patient advocacy

Texts/References

1. Ann A. Kiessling, Human Embryonic Stem Cells: An Introduction to the Science and Therapeutic Potential, Jones and Bartett, 2003.
2. Peter J. Quesenberry, Stem Cell Biology and Gene Therapy, 1st Edition, Willy-Less, 1998.
3. Robert Lanja, Essential of Stem Cell Biology, 2nd Edition, Academic Press, 2006.
4. A.D.Ho., R.Hoffiman, Stem Cell Transplantation Biology Processes Therapy, Willy-VCH, 2006.
5. C.S.Potten, Stem Cells, Elsevier, 2006.

51. Systematic Animal Virology - 3 Credits

Unit I

Studies on animal viruses belonging to various families and prion agents given below with reference to antigens, cultivation, pathogenesis, epidemiology; Disease status in India; Diagnosis; Immunity and control.

Capripoxvirus, avipoxvirus, cowpoxvirus; Bovine herpes viruses, equine herpes viruses, Infectious lyrangeotracheitis virus; Marek's disease virus; pseudorabies virus; Malignant cattarrh fever virus; Infectious canine hepatitis virus, Egg drop syndrome virus; Inclusion body hepatitis-hydropericardium virus, papiollomatosis, canine parvoviruses, feline panleucopenia virus.

Unit II

New castle disease virus; Canine distemper virus; Rinderpest virus; PPR virus; Infectious bursal disease virus; Rotavirus; Blue tongue virus; African horse sickness virus; Rabies virus; Ephemeral fever virus; Borna virus.

Unit III

Infectious bronchitis virus; Transmissible gastroenteritis virus; Equine arteritis virus; Equine encephalomyelitis viruses; Swine fever virus; BVDV-mucosal disease virus; Foot and mouth disease virus; Duck hepatitis virus; Visna/maedi virus; Equine infectious anemia virus; Avian leucosis complex virus; Bovine leukemia virus; Chicken anemia virus; Prions: scrapie; Bovine spongiform encephalopathy.

Practicals

Isolation of viruses in embryonated eggs and cell cultures; Cytopathogenicity of representative animal viruses viz. cell death, syncytia formation, inclusion body etc.; Diagnosis of animal viruses employing various serological tests, viz., haemagglutination and haemagglutination inhibition for Newcastle disease virus; Agar gel diffusion and virus neutralization test for infectious bursal disease viruses; Diagnosis of IBD virus and rotavirus by latex agglutination test; Serotyping of FMD virus by ELISA, Electropherotyping of rotavirus; PCR for diagnosis of viral infections.

Texts/References

1. Acheson NH., Fundamentals of Molecular Virology, Wiley, 2007.
2. Carter J & Saunders V. Virology: Principles and Applications. 1st Edition, Wiley, 2007.
3. Knipe DM, Howley PM, Griffin DE. Fields Virology, 5th Edition, Vols. I, II. Lippincott, Williams & Wilkins, 2006.
4. Mahy, BWJ & Kangaroo HO., Virology Methods Manual, 1st Edition, Academic Press, 1996.
5. Murphy FA, Gibbs, EPJ, Holzmek MK & Studdert MJ., Veterinary Virology, 3rd Edition, Academic Press. 1999.

52. Vaccines - 3 Credits

Unit I

Innate Immunity; Activation of the Innate Immunity through TLR mediated signaling; Adaptive Immunity; T and B cells in adaptive immunity; Immune response in infection; Protective immune response in bacterial; Viral and parasitic infections; Correlates of protection

Unit II

Vaccination and immune response; Appropriate and inappropriate immune response during infection: CD4+ and CD8+ memory T cells; Memory B cells; Generation and Maintenance of memory T and B cells; Dendritic cells in immune response

Unit III

Adjuvants in Vaccination; Induction of Th1 and Th2 responses by using appropriate adjuvants; Microbial, Liposomal and Microparticles as adjuvant; Chemokines and cytokines; Role of soluble mediators in vaccination; Oral immunization and mucosal Immunity

Unit IV

Conventional vaccines; Bacterial vaccines; Live attenuated and inactivated vaccine; Subunit Vaccines and Toxoids; Peptide Vaccine

Unit V

New Vaccine Technologies; Rationally designed Vaccines; DNA Vaccination; Mucosal vaccination; New approaches for vaccine delivery; Engineering virus vectors for vaccination; Vaccines for specific targets; Tuberculosis Vaccine; Malaria Vaccine; HIV vaccine

Texts/References

1. Edited by Stefan H.E. Kaufmann, Novel Vaccination Strategies, Wiley-VCH Verlag GmbH & Co. KgaA, 2004 or later edition.
2. Topley & Wilson's, Microbiology and Microbial Infections Immunology Edited by Stefan H.E. Kaufmann and Michael W Steward Holder Arnold, ASM Press, 2005 or later edition.
3. Edition Charles A Janeway. Jr, Paul Travers, Mark Walport and Mark J Shlomchik, Immuno Biology, The Immune system in health and Disease, 6th Edition, Garland Science, New York, 2005 or later edition.
4. Annual Review of Immunology : Relevant issues
5. Annual Review of Microbiology : Relevant issues