

CODE	COURSE TITLE	CREDITS
ABT 601*	BASIC & APPLIED BIOTECHNOLOGY	3+0
ABT 602**	FUNDAMENTALS OF CELL & MOLECULAR BIOLOGY	3+0
ABT 603*	APPLIED MOLECULAR BIOLOGY	2+1
ABT 604**	ANIMAL CELL CULTURE: PRINCIPLES & APPLICATIONS	1+2
ABT 605**	MOLECULAR DIAGNOSTICS	1+2
ABT 606	VACCINE BIOTECHNOLOGY	2+1
ABT 607	IMMUNOLOGY APPLIED TO BIOTECHNOLOGY	1+1
ABT 608	INTRODUCTION TO BIOINFORMATICS	2+1
ABT 609**	ANIMAL GENOMICS	2+1
ABT 610**	REPRODUCTIVE BIOTECHNOLOGY	2+1
ABT 611**	TECHNIQUES IN MOLECULAR BIOLOGY & GENETIC ENGINEERING	0+3
ABT 612	BIODIVERSITY, BIOSAFETY & BIOETHICS	2+0
ABT 613	MOLECULAR FORENSICS	2+1
ABT 614	INDUSTRIAL BIOTECHNOLOGY	2+1
ABT 615*	PROBIOTICS & FEED BIOTECHNOLOGY	3+0
ABT 616	ANIMAL BIOTECHNOLOGY	3+0
ABT 691	MASTER'S SEMINAR	1+0
ABT 699	MASTER'S RESEARCH	20
ABT 701	GENE CLONING AND EXPRESSION	1+1
ABT 702*	FUNCTIONAL GENOMICS & PROTEOMICS	2+1
ABT 703	ADVANCES IN REPRODUCTIVE BIOTECHNOLOGY	2+1
ABT 704	TRENDS IN VACCINOLOGY	3+0
ABT 705	ADVANCES IN ANIMAL CELL CULTURE	2+1
ABT 706	TRANSGENIC ANIMAL TECHNOLOGY	2+0
ABT 791	DOCTORAL SEMINAR I	1+0
ABT 792	DOCTORAL SEMINAR II	1+0
ABT 799	DOCTORAL RESEARCH	45

* Courses may also be taken as Minor/Supporting ** Compulsory for Master's Programme

ORGANIZATION OF COURSE CONTENTS & CREDIT REQUIREMENTS

Code Numbers

- All courses are divided into two series: 500-series courses pertain to Master's level, and 600-series to Doctoral level (corresponding Code nos. for Animal Biotechnology are 600- and 700-series).
- A Ph. D. student must take a minimum of two 600 series courses, but may also take 500-series courses if not studied during Master's programme. Credit seminar for Master's level is designated by code no. 591, and the two seminars for Doctoral level are coded as 691 and 692, respectively.
- Similarly, 599 and 699 codes have been given for Master's research and Doctoral research, respectively.

Course Contents

The contents of each course have been organized into:

- Objective - to elucidate the basic purpose.
- Theory units - to facilitate uniform coverage of syllabus for paper setting.
- Suggested Readings - to recommend some standard books as reference material. This does not unequivocally exclude other such reference material that may be recommended according to the advancements and local requirements.
- A list of journals pertaining to the discipline is provided at the end, which may be useful as study material for 600-series courses as well as research topics.
- E-Resources - for quick update on specific topics/events pertaining to the subject.
- Broad research topics provided at the end would facilitate the advisors for appropriate research directions to the PG students.

Minimum Credit Requirements

Subject	Master's programme	Doctoral programme
Major	20	15
Minor	09	08
Supporting	05	05
Seminar	01	02
Research	20	45
Total Credits	55	75
Compulsory Non Credit Courses	See relevant section	

Major subject: The subject (department) in which the students takes admission **Minor subject:** The subject closely related to students major subject (e.g., if the major subject is Entomology, the appropriate minor subjects should be Plant Pathology or Nematology).

Supporting subject: The subject not related to the major subject. It could be any subject considered relevant for student's research work.

Non-Credit Compulsory Courses: Please see the relevant section for details. Six courses (PGS 501- PGS 506) are of general nature and are compulsory for Master's programme. Ph. D. students may be exempted from these courses if already studied during Master's degree.

*May be taken as minor/supporting courses; **Compulsory for M.Sc. Programme

ABT 601
Objective

BASIC AND APPLIED BIOTECHNOLOGY

3+0

Understanding the fundamental principles of biotechnology and its application in agriculture, veterinary sciences, medical sciences, industry and environment.

Theory

UNIT I

History of biotechnology, scope of biotechnology, introduction of genetic engineering, plant and animal tissue culture.

UNIT II

Fermentation technology, immobilized enzymes, vaccines, antibodies and hybridoma technology, diagnostics, embryo transfer technology, sexing of embryo, transgenics.

UNIT III

Genome, genome mapping, physical maps, genetic maps, different types of DNA markers and their applications.

UNIT IV

Application of biotechnology in agriculture, veterinary sciences, pharmaceutical industry, food industry, chemical industry and environment.

Suggested Readings

Becker JM, Cold Well GA & Zachgo EA. 2007. *Biotechnology a Laboratory Course*. Academic Press.

Brown CM, Campbell I & Priest FG. 2005. *Introduction to Biotechnology*. Panima.

Singh BD. 2006. *Biotechnology ExpandingHoriozon*. Kalyani.

ABT 602 FUNDAMENTALS OF CELL & MOLECULAR BIOLOGY 3+0

Objective

Molecular structure and functions of cells and molecules such as DNA, RNA and proteins.

Theory

UNIT I

Evolution of cells, Introduction to molecular interactions, thermodynamics, and equilibrium in molecular recognition and biological functions. Energy production: Structure of mitochondria, and chloroplasts, respiratory chain, ATP synthesis, photosynthesis, genomes of mitochondria and chloroplasts, cellular compartments and intercellular sorting of proteins: endoplasmic reticulum, lysosome, peroxisomes, synthesis and shorting of proteins (lysosomal proteins, membrane proteins, secretary proteins, lipoproteins, glycolipids. Lipid synthesis and transport.

UNIT II

Cytoskeleton: Mechanism of muscle contraction, actin filaments and cell cortex, cilliary movements and cytoplasmic microtubules and intermediate filaments. Cell signaling: Endocrine, exocrine and synaptic signaling molecules, surface and intracellular receptors, G proteins and generation of secondary messengers, mode of action of cAMP and Ca⁺⁺ calmodulin, target cell adaptation. Cell growth and divisions: Cell cycle, cell division controls and transformation, growth factors, genes for social control of cell division, mechanism of cell division, cell adhesion, cell junctions and the extra cellular matrix, growth, development and differentiation.

UNIT III

History of molecular biology, nucleic acid as hereditary material, structure of DNA, chromatin, rRNA, tRNA and mRNA, proteins. DNA replication, transcription, translation, genetic code, operon, positive and negative control of gene expression, important enzymes such as RNA replicase, reverse transcriptase, ligase, polymerase, ribozyme, etc.

UNIT IV

Molecular mechanism of mutation. Molecular organization of cell, structure of genomes, synthetic chromosomes. RNA processing and alternative splicing, molecular biology of photosynthesis, nitrogen fixation and stress tolerance, development and differentiation and molecular evolution, RNAi and application.

Suggested Readings

Lewin B. 2008. *Gene IX*. Jones & Bartlett.

Primrose SB. 2001. *Molecular Biotechnology*. Panima.

Twyman RM. 2003. *Advanced Molecular Biology*. Bios Scientific.

ABT 603

APPLIED MOLECULAR BIOLOGY

2+1

Objective

Understanding the principle and application of recombinant DNA in biotechnology.

Theory

UNIT I

Enzymes used in molecular biology and recombinant DNA research, cloning and expression vectors, gene identification, construction of gene libraries, gene mapping and DNA structure analysis.

UNIT II

Methods of DNA sequencing, synthesis of double stranded DNA and complementary DNA, cDNA library identification and enrichment of recombinant clones.

UNIT III

Methods for transfer of cloned DNA, analysis and expression of recombinant DNA, site directed DNA alterations and gene manipulations, cloning in bacteria, yeast, plant and animal cells.

UNIT IV

Genetics of tumourogenic region of agrobacteria and its applications in agriculture, veterinary and medical sciences, biotechnology applications for production of high value and industrial products, safety aspects of genetic manipulations.

Practical

- i. Extraction of DNA and RNA.
- ii. Polyacrylamide gel electrophoresis (PAGE)
- iii. Agarose gel electrophoresis.
- iv. Restriction endonuclease analysis of DNA.
- v. Isolation and purification of plasmid.
- vi. Polymerase chain reaction.
- vii. Cloning of gene.
- viii. Expression of cloned gene.
- ix. Purification of recombinant protein.
- x. Blotting
- xi. RFLP

xii. RAPD.

Suggested Readings

Kun LY. 2006. *Microbial Biotechnology*. World Scientific.

Sambrook J and Russel DW. 2001. *Molecular Cloning: a Laboratory Manual*. Cold Spring Harbour Lab. Press.

Twyman RM. 2003. *Advanced Molecular Biology*. Bios Scientific.

ABT 604 ANIMAL CELL CULTURE: PRINCIPLES AND APPLICATIONS 1+2

Objective :Understanding the principles of animal cell culture and its application.

Theory

UNIT I

Introduction, importance, history of cell culture development, different tissue culture techniques including primary and secondary culture, continuous cell lines, suspension culture, organ culture etc.

UNIT II

Different type of cell culture media, growth supplements, serum free media, balanced salt solution, other cell culture reagents, culture of different tissues and its application.

UNIT III

Behavior of cells in culture conditions, division, their growth pattern, metabolism of estimation of cell number.

UNIT IV

Development of cell lines, characterization and maintenance of cell lines, stem cells, cryopreservation, common cell culture contaminants.

Practical:

- i. Packing and sterilization of glass and plastic wares for cell
- ii. Preparation of reagents and media for cell culture.
- iii. Primer culture technique chicken embryo fibroblast.
- iv. Secondary culture of chicken embryo fibroblast.
- v. Cultivation of continuous cell lines.
- vi. Quantification of cells by trypan blue exclusion dye.
- vii. Isolation of lymphocytes and cultivation of lymphocytes
- viii. Study of effect of toxic chemicals on cultured mammalian
- ix. Study of effect of virus on mammalian cells.
- x. Suspension culture technique
- xi. Cryopreservation of cell primary cultures and cell lines.
- xii. Effect of viruses on cultured mammalian cells.

Suggested Readings

Freshney RI. 2005. *Culture of Animal Cells*. Wiley Liss. Portner R. 2007. *Animal Cell Biotechnology*. Humana Press.

ABT 605

MOLECULAR DIAGNOSTICS

1+2

Objective : Understanding the molecular techniques involved in diagnosis of diseases.

Theory

UNIT I

Introduction, importance and historical perspective of development of molecular diagnostic technology, concept of development of group specific and strain specific nucleic acid based diagnostics, basis for selection of gene/nucleotide sequence of pathogenic organism to target for detection.

UNIT II

Application of restriction endonuclease analysis for identification of pathogens, principle of development of pathogen specific DNA probes, Southern and Northern hybridization.

UNIT III

Theoretical background of development of PCR and Real time PCR and its variations, application of PCR for diagnosis of infectious diseases of animals and poultry, nucleic acid sequence based diagnostics.

UNIT IV

Advancements in diagnostic technology including DNA array technology, biosensors and nanotechnology. OIE guidelines in development of diagnostics.

Practical

- (i) Preparations of buffers and reagents.
- (ii) Collection of clinical and environmental samples from animal and poultry farms for molecular detection of pathogens.
- (iii) Isolation of bacterial pathogens from the samples.
- (iv) Extraction of nucleic acids from bacteria and clinical specimens.
- (v) Restriction endonuclease digestion and analysis in agarose electrophoresis.
- (vi) Development of animal pathogen specific nucleic acid probes.
- (vii) Southern blotting for detection of pathogens.
- (viii) Polymerase chain reaction for detection of pathogens in blood and other animal tissues.
- (ix) RT-PCR for detection of RNA viruses.
- (x) Real time PCR for detection of pathogens in semen and other animal tissues.
- (xi) DNA fingerprinting for identification of animal species.
- (xii) PCR based detection of meat adulteration in processed and unprocessed meats.
- (xiii) Detection of food borne pathogenic organisms in vegetables and fruits using PCR technology.
- (xiv) PCR based detection of potential pathogens in milk, eggs and meat.

Suggested Reading

Rao JR, Fleming CC & Moore JE. 2006. *Molecular Diagnostics*. Horizon Bioscience.
Elles R & Mountford R. 2004. *Molecular Diagnosis of Genetic Disease*. Humana Press

ABT 606

VACCINE BIOTECHNOLOGY

2+1

Objective

Understanding different approaches of vaccine development and production.

Theory

UNIT I

History of vaccinology, conventional approaches to vaccine development, live attenuated and killed vaccines, adjuvants, quality control, preservation and monitoring of microorganisms in seed lot systems.

UNIT II

Instruments related to monitoring of temperature, sterilization, environment, quality assurance and related areas. Production techniques, growing the microorganisms in maximum titre, preservation techniques to maintain good antigen quality, freeze drying.

UNIT III

Introduction to newer vaccine approaches namely sub-unit vaccines, synthetic vaccines, DNA vaccines, virus like particles, recombinant vaccines, edible vaccines, Nano particles in vaccine delivery systems, etc.

UNIT IV

Introduction to pharmacopeal requirement, disease security and biosecurity principles and OIE guidelines such as seed management, method of manufacture, in-Process control, batch control, tests on final product.

Practical

- (i) Inoculation of embryonated chicken eggs for cultivation of
- (ii) Harvesting of virus from inoculated embryos.
- (iii) Inactivation of harvested viruses.
- (iv) Safety and sterility testing of inactivated vaccine.
- (v) Inoculation of tissue culture for propagation of virus.
- (vi) Harvesting and production of inactivated virus vaccine.
- (vii) Isolation and cloning of genes encoding immunogenic
- (viii) Expression of cloned gene.
- (ix) Purification of recombinant immunogenic protein.
- (x) Immunogenicity studies of recombinant protein
- (xi) Immunization of laboratory animals.
- (xii) Titration of antibodies against the recombinant protein.

Suggested Readings

Barry R Bloom, Paul-Henri Lambert 2002. *The Vaccine Book*. Academic Press.

Levine MM, Kaper JB, Rappuoli R, Liu MA, Good MF. 2004. *New Generation Vaccines*. 3rd Ed. Informa Healthcare.

Lowrie DB & Whalen R. 2000. *DNA Vaccines*. Humana Press.

Robinson A & Cranage MP. 2003. *Vaccine Protocols*. 2nd Ed. Humana Press.

ABT 607

IMMUNOLOGY APPLIED TO BIOTECHNOLOGY

1+1

Objective

Understanding the application of immunological techniques in biotechnology.

UNIT I

Introduction, principles of immunology, immune system, immune response, major histocompatibility complex, various techniques used in biotechnology.

UNIT II

Application of antibodies in purification, immunoblotting, expression of recombinant proteins and detection in different expression systems, industrial production of cytokines and interferon, expression of immunoglobulin genes in plants and production of antibodies.

UNIT III

Application of antibodies in chemiluminescence and fluorescence assay used for actions for recombinant

genes, antibody based nucleic acid probes and their applications, immunoinformatics.

UNIT IV

Somatic cell hybridization, hybridoma technology, commercial production of antibodies using monoclonal antibodies.

Practical

- i. Immunodiffusion.
- ii. Immunoelectrophoresis.
- iii. Fluorescent antibody test.
- iv. Enzyme immunoassays including ELISA.
- v. Immunoblotting.
- vi. Affinity chromatography,
- vii. Bioinformatics tools for immunological research.
- viii. Cultivation of normal lymphocytes and myeloma cell line.
- ix. Somatic cell hybridization and production of hybridoma.
- x. Screening of hybrids for production of monoclonal antibodies

Suggested Readings

Kindt TJ, Goldsby RA & Osbrne BA. 2007. *Kuby Immunology*. WH Freeman.

Male D, Brostoff J, Roth DB & Roitt I. 2006. *Immunology*. Elsevier. Spinger TA. 1985. *Hybridoma Technology in Biosciences and Medicine*. Plenum Press.

ABT 608

INTRODUCTIONS TO BIOINFORMATICS

2+1

Objective

To impart an introductory knowledge about the subject of Bioinformatics to the students studying any discipline of science.

Theory

UNIT I

Introduction, biological databases - primary, secondary and structural, Protein and Gene Information Resources - PIR, SWISSPROT, PDB, genbank, DDBJ. Specialized genomic resources.

UNIT II

DNA sequence analysis, cDNA libraries and EST, EST analysis, pairwise alignment techniques, database searching, multiple sequence alignment.

UNIT III

Secondary database searching, building search protocol, computer aided drug design - basic principles, docking, QSAR.

UNIT IV

Analysis packages - commercial databases and packages, GPL software for Bioinformatics, web-based analysis tools.

Practical

- i. Usage of NCBI resources
- ii. Retrieval of sequence/structure from databases
- iii. Visualization of structures
- iv. Docking of ligand receptors
- v. BLAST exercises.

Suggested Readings

Attwood TK & Parry-Smith DJ. 2003. *Introduction to Bioinformatics*. Pearson Education.

Rastogi SC, Mendiratta N & Rastogi P. 2004. *Bioinformatics: Concepts, Skills and Applications*. CBS.

ABT 609

ANIMAL GENOMICS

2+1

Objective

Understanding structural, functional and comparative genomics of farm animals and its application for livestock improvement.

Theory

UNIT I

Historical perspective, genome organization in eukaryotes, satellite DNA including mini and microsatellites and their various families, long and short interspersed nucleotide elements, DNA markers-RAPD, STR, SSCP, RFLP, DNA fingerprinting, SNP, EST etc.

UNIT II

Importance of gene mapping in livestock, methods and techniques used for gene mapping, physical mapping, linkage analysis, cytogenetic techniques, FISH technique in gene mapping, somatic cell hybridization, radiation hybrid maps, *in-situ* hybridization, comparative gene mapping.

UNIT III

Genetic distance analysis, breed characterization on the basis of DNA markers, genetic markers for quantitative traits loci, marker assisted selection for incorporation of desirable traits DNA markers with economic traits, restriction fragment length polymorphism (RFLP) of different structural genes.

UNIT IV

Current status of gene maps of livestock, MHC and its relevance to disease resistance and immune response, genes influencing production traits, mitochondrial DNA of farm animals, evolutionary significance, applications of genome analysis of animals in breeding.

Practical

- i. Chromosome preparation (normal karyotyping, different types of banding) in farm animals.
- ii. Isolation and purification of animal genomic DNA from blood lymphocytes.
- iii. Analysis of DNA by agarose or polyacrylamide gel electrophoresis.
- iv. Chromosome preparation (normal karyotyping, different types of banding) in farm animals.
- v. Isolation and purification of animal genomic DNA from blood lymphocytes.
- vi. Analysis of DNA by agarose or polyacrylamide gel electrophoresis.
- vii. Checking the quality and quantity of genomic DNA.
- viii. Restriction digestion and analysis.
- ix. Southern hybridization
- x. DNA fingerprinting.
- xi. Techniques for revealing polymorphism-DNA fingerprinting,
- xii. RFLP, SSCP, AFLP, STRP etc.
- xiii. Genomic DNA cloning or cDNA cloning.
- xiv. Differentiation of tissues of different species by mitochondrial genome analysis.

Suggested Readings

Gibson G & Muse SV. 2004. *A Primer of Genome Science*. Sinauer Associates.
Primrose SB & Twyman RM. 2007. *Principles of Genome Analysis and Genomics*. Blackwell.
Sensen CW. 2005. *Handbook of Genome Research*. Vols. I, II. Wiley- CVH.

ABT 610

REPRODUCTIVE BIOTECHNOLOGY

2+1

Objective

Understanding *in-vitro* reproductive techniques for ovum and embryo manipulation.

Theory

UNIT I

History, importance of assisted reproductive biotechnology in man and animal, introduction to embryo biotechnology, endocrine therapeutics.

UNIT II

Biotechnological approaches to reproduction, methodology of super ovulation, *in vitro* fertilization, embryo culture and micromanipulation, preparation of sperm for IVF.

UNIT III

Different method of gene transfer and their limitations, embryo splitting, embryo sexing by different methods, production of transgenic livestock by nuclear transfer and its application, regulatory issues.

UNIT III

Cloning of domestic animals. Conservation of endangered species. Characterization of embryonic stem cells. Different applications of embryonic stem cells.

Practical

- i. Synchronization and superovulation protocols.
- ii. Collection of embryos using non-surgical procedures.
- iii. Transferring embryos using non- surgical procedures.
- iv. Embryo freezing protocols.
- v. Oocyte collection and evaluation from slaughterhouse ovaries.
- vi. In vitro fertilization protocols.
- vii. Micromanipulation of early embryos.

Suggested Readings

Ball PJH & Peter AR. 2004. *Reproduction in Cattle*. Blackwell.
Gordon I. 2003. *Laboratory Production of Cattle Embryos*. CABI.
Gordon I. 2005. *Reproductive Techniques in Farm Animals*. CABI.

ABT 611 TECHNIQUES INMOLECULAR BIOLOGY AND GENETIC ENGINEERING

0+3

Objective

To provide comprehensive hands-on training on techniques of molecular biology and genetic engineering.

Practical

UNIT I

Isolation of bacterial plasmids and chromosomal DNA. Isolation of DNA from mammalian cells. Isolation of mRNA/RNA. Quantitation of nucleic acids.

UNIT II

Plasmid minprep; Restriction endonuclease digestion of plasmid and chromosomal DNA. Agarose gel

electrophoresis of RE digested DNA; Isolation of DNA; cDNA synthesis UNIT

UNIT III

Polymerase Chain Reaction using random primers as well as specific primers. Different types of PCR, Real time polymerase chain reaction

UNIT IV

Cloning of bacterial and viral genes in to plasmid vectors. DNA ligation and transformation; Confirmation of insert by RE digestion and touch PCR; Transformation of yeast; Synthesis of nucleic acid probes; Nucleic acid hybridization

Suggested Readings

Kun LY. 2006. *Microbial Biotechnology*. World Scientific.

Sambrook J & Russel DW. 2001. *Molecular Cloning: a Laboratory Manual*. Cold Spring Harbour Lab. Press.

Twyman RM. 2003. *Advanced Molecular Biology*. Bios Scientific.

ABT 612

BIODIVERSITY, BIOSAFETY AND BIOETHICS

2+0

Objective

Understanding the basis of genetic diversity and its maintenance, biosafety procedures.

Theory

UNIT I

Historical and geographical causes of diversity, genetic diversity, molecular taxonomy, species and population biodiversity. Quantifying biodiversity, maintenance of ecological biodiversity, biodiversity and centres of origin of animals, biodiversity hotspots in India.

UNIT II

Collection and conservation of biodiversity, conservation of animal genetic resources, assessing, analyzing and documenting biodiversity. Morphological and molecular characterization of biodiversity, vulnerable and extinction of biodiversity, introduction to biodiversity database, global biodiversity information system, bioethics, CBD.

UNIT III

Biosafety and Risk assessment issues; Health aspects; toxicology, allergenicity; Ecological aspects; Regulations; National biosafety policy and law. The Cartagena Protocol on biosafety. The WTO and other international agreements; Cross border movement of germplasm; Risk management issues; Monitoring strategies and methods for detecting transgenics; Risks, benefits and impacts of transgenics to human health, society and the environment.

UNIT IV

Bio-safety and bio-hazards; general principles for the laboratory and environmental bio-safety; Environment Impact Assessment; Gene flow in natural and artificial ecologies; Sources of gene escape; Ecological risks of genetically modified plants. Implications of intellectual property rights on the commercialization of biotechnology products.

Suggested Readings

Arya R. 2005. *Biodiversity*. Deep & Deep.

Gaston KJ. 2004. *Biodiversity: an Introduction*. Blackwell.

Kannaiyan S & Gopalam A. 2007. *Biodiversity in India: Issues and Concerns*. APC.

Objective

Understanding the application of DNA based techniques in animal forensics.

TheoryUNIT I

General history of forensic science, introduction to DNA forensics, scope and application of DNA forensics in animal and human criminal investigations in variety of situations.

UNIT II

Isolation methods and techniques such as DNA finger-printings, PCR, nucleic acid hybridization, restriction endo-nuclease analysis and sequencing, Individual Animal Identification using DNA fingerprinting

UNIT III

Animal species identification in religious disputes, adulteration of meat, theft of farm animals and pets etc., advantages, disadvantages and limitations of DNA forensics.

UNIT IV

Mass spectroscopy, protein detections methods, immunological techniques including ELISA, immunoelectrophoresis and immunofluorence.

Practical

- i. Collection of material for forensic analysis.
- ii. Dispatch of material for forensic investigations.
- iii. Storage and processing of forensics material.
- iv. Preparation of different bio-reagents.
- v. Isolation and extraction of nucleic acid from samples.
- vi. Isolation and extraction of nucleic acid from wild animal scat.
- vii. Isolation of nucleic acid from blood, skin, meat, milk, hair and cooked and putrefied meat.
- viii. Designing of primers.
- ix. Polymerase chain reaction (PCR).
- x. Randomly amplified polymorphic DNA (RAPD)
- xi. Restriction fragment length polymorphism (RFLP).
- xii. Multiplex PCR for species identification.
- xiii. Detection of adulteration in meat by PCR & nucleic acid hybridization assay.

Suggested Readings

Lincoln PJ & Thomson J. 1998. *Forensic DNA Profiling Protocols*. Humana Press.

Rudin N & Inman K. 2002. *An Introduction to Forensic DNA Analysis*. 2nd Ed. CRC Press.

Objective

Understanding the concept of bioprocessing of products and their production at commercial scale.

TheoryUNIT I

Introduction, scope and historical development; isolation, screening and genetic improvement of industrially important microorganisms, fermentation: introduction, historical perspective of development of bioprocessing technology.

UNIT II

Emerging new technologies for processing and production of recombinant products, isolation, preservation. Media designs, sterilization, down stream processing, important fermentation process.

UNIT III

Immobilization of enzymes and cells, and their application, growth rate analysis, estimation of biomass, batch and plug flow cultures, chemostate cultures. Production of vaccines and diagnostics.

UNIT IV

Fermented beverages, production of single cell protein, steroid transformation, silage production, waste water treatment. Industrial application of Nanobiotechnology. Computer simulations, energy requirement and product formation in microbial culture, fed-batch and mixed cultures, scale-up principles.

Practical

- i. Isolation of industrially important microorganisms.
- ii. Maintenance and improvement.
- iii. Production of industrial compounds such as alcohol, beer, citric acid, lactic acid.
- iv. Recovery of alcohol, beer, citric acid, lactic acid.
- v. Study of bio-reactors and their operations.
- vi. Production of biofertilizers.
- vii. Experiments on microbial fermentation process.
- viii. Harvesting purification and recovery of end products.
- ix. Immobilization of cells and enzymes.
- x. Studies on enzyme kinetic behavior, growth analysis, biomass estimation, determination of mass transfer co-efficients.

Suggested Readings

Alberghina L. 2000. *Protein Engineering for Industrial Biotechnology*. Routledge.
Kun LY. 2006. *Microbial Biotechnology*. World Scientific.
Singh, R & Ghosh SK. 2004. *Industrial Biotechnology*. Global Vision Publ. House.
Thomson J. 2006. *Your Guide to Industrial Biotechnology*. Abhishek Publ.

ABT 615 PROBIOTICS AND FEED BIOTECHNOLOGY

3+0

Objective

Understanding the concept of probiotics and applications of new tools of biotechnology for quality feed/food production.

Theory

UNIT I

Introduction, history of probiotics, normal microflora of GI tract, methods for analysis of intestinal microflora, microorganisms and proteins used in probiotics, genetic modification of intestinal lactobacilli and bifidobacteria, recombinant probiotics. Mechanism of action of probiotics, immune response to probiotics, anti-mutagenic and anti-tumor activities of lactic acid bacteria, probiotics and immune system, lactic acid bacteria as live vaccines.

UNIT II

Application of probiotics for humans, farm animals and poultry, probiotics and intestinal infections, lactose mal-digestion, probiotics regulatory issues. Symbiotics, traditional probiotic products, probiotics industrial perspectives, contradictions, precautions and adverse reactions.

UNIT III

Introduction, feed processing and preservation, microbial bioconversion of lignin and cellulose rich feeds, factors affecting delignification. Diversity of organisms involved, fermentation techniques, large scale bioconversion of substrates, pre-treatment of feeds, chemical vs. microbial treatment of feeds, anti-nutritional factors present in feeds, microbial detoxification of aflatoxins, mimosine and other anti-metabolites present.

UNIT IV

Genetic manipulation of organisms to enhance bioconversion ability, manipulation of rumen fermentation by selective removal of protozoa and fungi, effect of feed additives like antibiotics, methane inhibitors, genetic manipulation of rumen microflora to improve feed utilization, single cell protein as animal feed.

Suggested Readings

- Fuller R. 1997. *Probiotics 2: Applications and Practical Aspects*. Springer. Huffnagle GB & Wernick S. 2007. *The Probiotics Revolution: The Definitive Guide to Safe, Natural Health*. Bantam Books.
- Kalidas S, Paliyath G, Pometto A & Levin RE. 2004. *Functional Foods and Biotechnology*. CRC Press.
- Perdigon G & Fuller R. 2000. *Probiotics 3: Immunomodulation by the Gut Microflora and Probiotics*. Springer.
- Roger A. 1989. *Food Biotechnology*. Cambridge Univ. Press.
- Sambrook J & Russel DW. 2001. *Molecular Cloning: a Laboratory Manual*. Cold Spring Harbour Lab. Press.
- Trenev N. 1998. *Probiotics: Nature's Internal Healers*. Avery.

ABT 616

ANIMAL BIOTECHNOLOGY

3+0

Objective

Intended to provide an overview and current developments in different areas of animal biotechnology

UNIT I

Structure of animal cell, history of animal cell culture, cell culture media and reagents, culture of mammalian cells, tissues and organs, 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, 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 viral vaccines and pharmaceutical proteins.

UNIT II

Introduction to immune system, cellular and humoral immune response, history of development of vaccines, introduction to the concept of vaccines, conventional methods of animal 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, commercial scale production of diagnostic antigens and antisera, animal disease diagnostic kits, probiotics.

UNIT III

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, transgenic manipulation of animal embryos, different applications of transgenic animal technology, animal viral vectors, animal cloning basic concept, cloning from- embryonic cells and adult cells, cloning of different animals, cloning for conservation for conservation 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, gene

knock out technology and animal models for human genetic disorders.

UNIT IV

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, introduction to animal genomics, different methods for characterization of animal genomes, SNP, STR, QTL, RFLP, RAPD, genetic basis for disease resistance, Transgenic animal production and application in expression of therapeutic proteins. Immunological and nucleic acid based methods for identification of animal species, detection of meat adulteration using DNA based methods, detection 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.

Suggested Readings

- Gordon I. 2005. *Reproductive Techniques in Farm Animals*. CABI. Kindt TJ, Goldsby RA & Osbrne BA. 2007. Kuby Immunology. WH Freeman.
Kun LY. 2006. *Microbial Biotechnology*. World Scientific.
Levine MM, Kaper JB, Rappuoli R, Liu MA, Good MF. 2004. *New Generation Vaccines*. 3rd Ed. Informa Healthcare.
Lincoln PJ & Thomson J. 1998. *Forensic DNA Profiling Protocols*. Humana Press.
Portner R. 2007. *Animal Cell Biotechnology*. Humana Press.
Spinger TA. 1985. *Hybridoma Technology in Biosciences and Medicine*. Plenum Press.
Twyman RM. 2003. *Advanced Molecular Biology*. Bios Scientific.

ABT 701

GENE CLONING AND EXPRESSION

1+1

Objective : Understanding the concept of gene cloning and expression.

Theory

UNIT I

Cloning vectors- plasmids, phages, cosmids, BAC, YAC, expression vectors- viral, baculo and yeast vectors, shuttle vectors

UNIT II

Restriction, ligation, transformation and recombinant selection methods, construction of genomic and cDNA library, construction of full length cDNA.

UNIT III

Linkers, adapters and cassettes, screening the library.

UNIT IV

Expression of genes, prokaryotic and eukaryotic expression, identity of protein, purification of expressed protein.

Practical

- i. Preparation of vector.
- ii. Restriction enzyme digestion of vector.
- iii. Purification of DNA.
- iv. DNA ligation.
- v. Transformation.
- vi. Calculation of transformation efficiency
- vii. Preparation of electro competent cells.
- viii. Screening by PCR.

- ix. Cloning of PCR products in vectors.
- x. Induction of expressed protein
- xi. PAGE and western blotting.

Suggested Readings

Ausubel FM, Brent R, Kingston RE, Moore DD, Seidman JG, Smith JA & Struhl K. 2002. *Short Protocols in Molecular Biology*. Wiley.

ABT 702

FUNCTIONAL GENOMICS AND PROTEOMICS

2+1

Objective

Understanding gene expression at different conditions/organs.

UNIT I

Transcriptome and different methods to study gene expression, single gene analysis, northern blots, quantitative PCR, SAGE, MPSS and Microarray.

UNIT II

Introduction to basic microarray technology, Design of experiments, Types of microarray, nanoarray, Customised microarray design, Image processing and quantification, Normalization and filtering, Exploratory statistical analysis, gene expression databases.

UNIT III

SAGE and Microbeads, massive parallel signature sequencing, Microbial transcriptome. Role of functional genomics to study cancer and various clinical applications, Development, physiology, and behavior, evolutionary and ecology.

UNIT IV

Proteomics technology, identification and analysis of proteins by 2D analysis, mass spectrophotometry, NMR and X-ray crystallography, MALDI-TOF, Differential display proteomics, Protein -protein interaction, yeast two hybrid system and phage display.

Practical

- i. Northern blotting
- ii. Quantitative PCR.
- iii. Design of microarray experiments.
- iv. Microarray image processing.
- v. Basic statistical methods.
- vi. Clustering methods to study gene expression.
- vii. Analytical software related to genomics and proteomics

Suggested Readings

Gibson G & Muse SV. 2004. *A Primer of Genome Science*. Sinauer Associates.
Primrose SB & Twyman RM. 2007. *Principles of Genome Analysis and Genomics*. Blackwell.
Sensen CW. 2005. *Handbook of Genome Research*. Vols. I, II Wiley - CVH.

ABT 703 ADVANCES IN REPRODUCTIVE BIOTECHNOLOGY 2+1

Objective :Understanding the new developments in reproductive technology.

Theory

UNIT I

Reproductive cloning, somatic cell nuclear transfer and transgenic animal production, cryopreservation of gametes.

UNIT II

Preimplantation genetic diagnosis (PGD), genomic imprinting and assisted reproduction, receptors of different hormones and their estimation.

UNIT III

Introduction to stem cells, types, identification, characterization and development of stem cells, transfection of gene in embryonic blastomeres.

UNIT IV

Stem cell therapeutics, social, ethical religious and regulatory issues.

Practical

- i. Embryo micromanipulation.
- ii. Microinjection.
- iii. Intra-cytoplasmic sperm injection.
- iv. ICSI Embryo biopsy for PGD and sexing
- v. Culture of embryonic stem cell.
- vi. Characterization of embryonic stem cells.

Suggested Readings

Selected articles from journals.

ABT 704

TRENDS IN VACCINOLOGY

3+0

Objective

Understanding the latest developments in vaccine production technologies.

Theory

UNIT I

Molecular approaches to development of vaccines including: recombinant peptide vaccines, vectored vaccines, DNA vaccines, genetically manipulated live vaccines.

UNIT II

Plant expression system based vaccines, idiotypic and synthetic peptide based vaccines, reverse genetic approach and computational vaccinology.

UNIT III

Immunomodulators including cytokines and new adjuvants, Immunomodulation, innovative methods of delivery of immunogens through liposomes, microspheres, ISCOMS, etc.

UNIT IV

Large scale production technology and quality control, regulatory issues, environmental concerns with the use of recombinant vaccines.

Practical

- i. Preparation of gene construct for recombinant and nucleic acid vaccine.
- ii. Expression of gene encoding immunogenic protein in prokaryotic/ yeast/ animal cell culture system.
- iii. Study of immune response against recombinant vaccine.
- iv. Protection and evaluation studies.
- v. Use of modern adjuvants in vaccines.
- vi. Vaccine delivery systems including use of nanoparticles

Suggested Readings Selected articles from journals.

Objective

Understanding the latest developments in cell culture techniques.

TheoryUNIT I

Development of cell lines, characterization of cell lines by morphology, chromosome analysis, DNA content, enzyme activity and antigenic markers, differentiation.

UNIT II

Cultivation requirements of different types of cells, flow cytometry, DNA transfer by calcium phosphate co-precipitation, lipofection, electroporation. UNIT III

Expression of recombinant proteins in mammalian and avian cell lines. UNIT IV

Up-scaling of cells for production of vaccines, diagnostic antigens and other pharmaceutical agents, up-stream and downstream processing, cell culture fermentors.

Practical

- i. Primary and secondary mammalian cell culture
- ii. Development of transformed cell lines.
- iii. Characterization of cell lines.
- iv. Transfection of cells with recombinant DNA.
- v. Expression of recombinant proteins.
- vi. Scaling-up of cultures.

Suggested Readings: Selected articles from journals.

Objective

Understanding the latest developments in transgenic technology.

TheoryUNIT I

Concept of transgenics, techniques of gene transfer, microinjection of recombinant DNA into fertilized eggs/stem cells, transfection of DNA totipotent keratocarcinoma cells, electroporation, gene transfer into cultured cells.

UNIT II

Suitable promoters for expression of transgenes, eukaryotic expression vectors, detection of transgenes in the new born.

UNIT III

Principles of animal cloning, application of transgenic and cloning technologies for improvement of livestock. Transgenic animals as bioreactors.

UNIT IV

Social, ethical, religious, environmental and other regulatory issues related to transgenic animal technology.

Suggested Readings: Selected articles from journals.

- ◆◆◆ Animal Biotechnology ◆◆◆
- Animal Genetics
- ◆◆◆ Animal Reproduction
 - ❖ Cellular and Molecular Probe
 - ❖ Current Science
 - ❖ ◆◆◆ Genome Research
- ◆◆◆ Indian journal of Microbiology ◆◆◆ Journal of Clinical Microbiology
 - ❖ Journal of Dairy Science
 - ❖ Journal of Reproduction and Fertility
 - ❖ Methods in Virus Research
 - ❖ Nature
 - ❖ Nature Biotechnology
 - ❖ Nature Genetics
 - ❖ Nucleic Acid Research
 - ❖ PNAS
- ◆◆◆ Reproduction in Domestic Animals Science
 - ❖ Theriogenology
- ◆◆◆ Trends in Biotechnology
 - ❖ Trends in Genetics
 - ❖ Viral Research

e-Resources

www.cls.casa.colostate.edu/TransgenicCrops/teacherlinks

www.hpc.unm.edu/~aroberts/main/top5%25.htm

www.isaaa.org

www.ciat.cgiar.org/biotechnology/cbn/gines_mera_fund.htm

www.scidev.net/en/agriculture-and-environment/agri-biotech/links/publications-and-information-services

www.biotechninstitute.org/programs/t_leader_program.html | www.sci-ed-ga.org/modules/dna/analogies.html

www.accessexcellence.org/AE/AEPC/WWC/1993

www.atschool.eduweb.co.uk/trinity/bio2.html

www.pub.ac.za/resources/teach.html ◆> www.bioblink.org/biomaterial.htm

www.biotechnology.gov.au/index.cfm?event=object.showContent&objectID=B35A91 C-DE3D-1A59-79F89FAA26F54E44

www.monsanto.com/products/techandsafety/technicalpubs/eduwebsites.asp

www.ejbiotechnology.info/content/vol5/issue3/teaching/01/index.html

www.ncbiotech.org/resource_center/for_educators/online_teaching_resources.html

www.ias.ac.in/currsci/dec252006/1594

www.cccoe.k12.ca.us/stsvcs/newteacher/rop/curr_rop_links2.html

www.scielo.cl/scielo.php?pid=S0717-34582003000100004&script=sci_arttext

www.sunysb.edu/ligase/Forstudents/BiotechTeachingCenter/biotechcenter.html

www.ca.uky.edu/agc/pubs/brei/brei3tg/brei3tg.htm
www.aggie-horticulture.tamu.edu/tisscult/biotech/biotechteach.html
www.ejbiotechnology.info/content/vol6/issue2/issues/2/index.html
<http://science.nhmccd.edu/biol/biolint.htm#dna>
<http://nhscience.lonestar.edu/biol/biolint.htm>
www.ingentaconnect.com/content/tandf/tsed/2000/00000022/00000009/art00007
www.buildingbiotechnology.com/free.php
www.biotechnologist2020.com/2008/04/teaching-jobs-in-bioinformatics.html
www.eric.ed.gov/ERICWebPortal/recordDetail?accno=EJ613711
www.uq.edu.au/teaching-learning/index.html?page=61920
www.nature.com/nbt/journal/v18/n9/full/nbt0900_913b.html
www.fotodyne.com/literature/datasheets/E10700
www.biotethics.org/conferences/maastricht/partecipants.html
www.brookes.ac.uk/studying/courses/postgraduate/2008/biotech
www.bioweb.usc.edu/courses/2003-spring/documents/bisc406-notes_011603
www.gen.ufl.edu/~chyn/age2062/lect/lect_09/lect_09.htm
www.bioinformaticscourses.com/BIOL358/lectures.html
www.isis.vt.edu/~nstone/LifeSci/lect5.html
www.nwo.nl/nwohome.nsf/pages/NWOA_6Y2LGH_Eng
www.soi.wide.ad.jp/class/20040016
www.sciencetech.technomuses.ca/english/schoolzone/biotech.cfm
www.freevidelectures.com/biotech.html www.gen.ufl.edu/~chyn/age4660/lect/lect_07/lect_07.htm
www.web.mit.edu/cheme/news/frontiers_2005.html

COMPULSORY NON-CREDIT COURSES

(Compulsory for Master's programme in all disciplines; Optional for Ph.D. scholars)

CODE	COURSE TITLE	CREDITS
PGS 501	LIBRARY AND INFORMATION SERVICES	0+1
PGS 502	TECHNICAL WRITING AND COMMUNICATIONS SKILLS	0+1
PGS 503	INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE	1+0
(e-Course) PGS 504	BASIC CONCEPTS IN LABORATORY TECHNIQUES AGRICULTURAL RESEARCH,	0+1
PGS 505	RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES	1+0
(e-Course) PGS 506	DISASTER MANAGEMENT	1+0
(e-Course)		

Course Contents

PGS 501 LIBRARY AND INFORMATION SERVICES 0+1

Objective

To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines etc.) of information search.

Practical

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; e- resources access methods.

PGS 502 TECHNICAL WRITING AND COMMUNICATIONS SKILLS 0+1

Objective

To equip the students/scholars with skills to write dissertations, research papers, etc.

To equip the students/scholars with skills to communicate and articulate in English (verbal as well as writing).

Practical

Technical Writing - Various forms of scientific writings- theses, technical papers, reviews, manuals, etc; Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion); Writing of abstracts, summaries, precis, citations etc.; commonly used abbreviations in the theses and research communications; illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; Writing of numbers and dates in scientific write-ups; Editing and proof-reading; Writing of a review article. *Communication Skills* - Grammar (Tenses, parts of speech, clauses, punctuation marks); Error analysis (Common errors); Concord; Collocation; Phonetic symbols and transcription; Accentual pattern: Weak forms in connected speech: Participation in group discussion: Facing an interview; presentation of scientific papers.

Suggested Readings

Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.

Collins' Cobuild English Dictionary. 1995. Harper Collins.

cylinders, flasks, separatory funnel, condensers, micropipettes and vaccumets; washing, drying and sterilization of glassware; Drying of solvents/chemicals. Weighing and preparation of solutions of different strengths and their dilution; Handling techniques of solutions; Preparation of different agro-chemical doses in field and pot applications; Preparation of solutions of acids; Neutralisation of acid and bases; Preparation of buffers of different strengths and pH values. Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath; Electric wiring and earthing. Preparation of media and methods of sterilization; Seed viability testing, testing of pollen viability; Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy

Suggested Readings

Furr AK. 2000. *CRC Hand Book of Laboratory Safety*. CRC Press.

Gabb MH & Latchem WE. 1968. *A Handbook of Laboratory Solutions*. Chemical Publ. Co.

PGS 505

(e-Course)

**AGRICULTURAL RESEARCH, RESEARCH ETHICS
AND RURAL DEVELOPMENT PROGRAMMES**

1+0

Objective

To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural development programmes and policies of Government.

UNIT I

History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

UNIT II

Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT III

Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group - Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Readings

Bhalla GS & Singh G. 2001. *Indian Agriculture - Four Decades of Development*. Sage Publ.

Punia MS. *Manual on International Research and Research Ethics*. CCS, Haryana Agricultural University, Hisar.

Rao BSV. 2007. *Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives*. Mittal Publ.

Singh K..1998. *Rural Development - Principles, Policies and Management*. Sage Publ.

Objectives

To introduce learners to the key concepts and practices of natural disaster management; to equip them to conduct thorough assessment of hazards, and risks vulnerability; and capacity building.

Theory

UNIT I

Natural Disasters- Meaning and nature of natural disasters, their types and effects. Floods, Drought, Cyclone, Earthquakes, Landslides, Avalanches, Volcanic eruptions, Heat and cold Waves, Climatic Change: Global warming, Sea Level rise, Ozone Depletion

UNIT II

Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire. Oil fire, air pollution, water pollution, deforestation, Industrial wastewater pollution, road accidents, rail accidents, air accidents, sea accidents.

UNIT III

Disaster Management- Efforts to mitigate natural disasters at national and global levels. International Strategy for Disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, Community-based organizations, and media. Central, State, District and local Administration; Armed forces in Disaster response; Disaster response: Police and other organization

Suggested Readings

Gupta HK. 2003. *Disaster Management*. Indian National Science Academy. Orient Blackswan.

Hodgkinson PE & Stewart M. 1991. *Coping with Catastrophe: A Handbook of Disaster Management*.
Routledge.

Sharma VK. 2001. *Disaster Management*. National Centre for Disaster Management, India.