

# **M.Sc. Biotechnology**

**NEP Syllabus- 2022-23**

**(CBCS system)**



**Raja Mahendra Pratap Singh State University,**

**Aligarh (UP) 202001.**

**M.Sc. Biotechnology**  
**NEP-2022-23.**

<b>First Semester</b>						
<b>Course Type</b>	<b>Paper Code</b>	<b>SUBJECTS</b>	<b>Credits</b>	<b>Internal Marks</b>	<b>External Marks</b>	<b>Total</b>
<b>Compulsory Course</b>	RB100701T	Cell Biology	4	25	75	100
	RB100702T	Biochemistry	4	25	75	100
	RB100703T	Microbial Physiology & Genetics.	4	25	75	100
	RB100704T	Biostatistics & Computer App.	4	25	75	100
<b>Compulsory Course Practical</b>	RB100705P	<b>Practical (Based on Papers 701-704)</b>	4	25	75	100
	RB100706R	<b>Research Project(Tour/Training/Project)</b>				
<b>MINOR</b>	RB100707*	<b>(Any One) from other Faculty</b>	4	25	75	100
		<b>Total</b>	<b>24</b>	<b>150</b>	<b>450</b>	<b>700</b>

<b>Second Semester</b>						
<b>Compulsory Course</b>	RB100801T	Bioanalytical Techniques	4	25	75	100
	RB100802T	Molecular Biology	4	25	75	100
	RB100803T	Immunology	4	25	75	100
<b>Elective Course-I</b>	RB100804T	Food Biotechnology	4	25	75	100
	RB100805T	Genomics and Proteomics				
<b>Compulsory Course Practical</b>	RB100806P	<b>Practical (Based on Papers 801-805)</b>	4	25	75	100
	RB100807R	<b>Research Project(Tour/Training/Project)</b>	8	50	150	200
		<b>Total</b>	<b>28</b>	<b>150</b>	<b>450</b>	<b>700</b>

<b>Third Semester</b>						
<b>Compulsory Course</b>	RB100901T	Recombinant DNA Technology	4	25	75	100
	RB100902T	Animal Biotechnology	4	25	75	100
	RB100903T	Plant Biotechnology	4	25	75	100
<b>Elective Course-II</b>	RB100904T	Nano Biotechnology	4	25	75	100
	RB100905T	Pharmaceutical Biotechnology				
<b>Compulsory Course Practical</b>	RB100906P	<b>Practical (Based on Papers 901-905)</b>	4	25	75	100
	RB100907R	<b>Review Literature/Assignment/Tour</b>	4	25	75	100
		<b>Total</b>	<b>24</b>	<b>230</b>	<b>470</b>	<b>700</b>

<b>Fourth Semester</b>						
<b>Compulsory Course</b>	RB101001T	Environmental Biotechnology	4	25	75	100
	RB101002T	Bioprocess Engineering Technology	4	25	75	100
<b>Elective Course-III</b>	RB101003T	Fundamentals of Nutritional Science	4	25	75	100
	RB101004T	Medical Biotechnology				
<b>Elective-IV Course</b>	RB101005T	Clinical Biotechnology & IPR	4	25	75	100
	RB101006T	Bioentrepreneurship				
<b>Compulsory Course Practical</b>	RB101007T	<b>Practical (Based on Papers 1001-1004)</b>	4	25	75	100
	RB101008R	<b>Project Work</b>	4	25	75	100
		<b>Total</b>	<b>24</b>	<b>150</b>	<b>450</b>	<b>700</b>

**\*Elective Course to select any one out of two given.**

**\*Minor course will be from other Faculty**

## **RB10701-CELL BIOLOGY**

### **Unit I: Introduction**

Cell types (prokaryotes/ eukaryotes), cell organelles, cell wall, cell membrane, cytoplasmic organelles, structure of nuclear envelope, nuclear pore, complex, transport across envelope, regulation of nuclear import.

### **Unit II: Protein trafficking**

Targeting proteins to endoplasmic reticulum, signal recognition particle, signal recognition particle receptor, protein folding and processing in ER, protein export from ER, Protein sorting and export from golgi apparatus; SNARE hypothesis; Protein import into Mitochondria, Import and sorting of chloroplast protein.

### **Unit III: Cytoskeleton**

Structure and organization of cell skeleton; Microfilaments and Microtubule-structure and assembly, actins, myosin muscle contraction, cilia, flagella-structure and function.

### **Unit IV: Cell signaling**

Cell-cell interaction, modes of cell signaling, steroid hormone receptors, peptide hormones and growth factor, plant hormones, G-protein coupled receptors; receptor –protein tyrosine kinase, c- AMP pathway of signal transduction; c GMP, phospholipids and calcium ions, MAP kinase pathway, JAK – STAT pathway, Integrin signaling , Hedgehog and Wnt pathways.

### **Unit V: Cell division and cancer biology**

Cell Cycle: Interphase and M phase (mitosis and meiosis), Cell cycle regulation, checkpoints in cell cycle; regulators of cell cycle, Apoptosis: intrinsic and extrinsic pathways.

Cancer biology: types of cancer; development of cancer, cells; Oncogenes, protooncogenes , function of oncogene products , tumor suppressor genes , function of tumor suppression gene products, role of oncogene and tumor suppressor gene in development, molecular diagnosis of cancer.

### **TEXT AND REFERENCES**

- Molecular Cell Biology by Bruce Albert
- Molecular Biology by Lodish, Darnell and Baltimore
- Molecular Biology of the gene by Watson et al 4th ed.
- Cell and molecular biology by Gerald Karp
- Cell biology by Pollard and Earnshaw

## **RB10702-BIOCHEMISTRY:**

### **Unit - I: Introduction and protein structure**

Chemical basis of life; Composition of living matter; Water – properties, pH, ionization and hydrophobicity; Emergent properties of biomolecules in water; structure of proteins: protein folding and mis-folding, primary and higher order structures; structure-function relationships in model proteins : ribonuclease A, myoglobin, hemoglobin, chymotrypsin.

### **Unit - II: Carbohydrates and lipids**

Carbohydrates; mono, di, and polysaccharides; suitability in the context of their different functions- cellular structure, energy storage, glycosylation of other biomolecules - glycoproteins and glycolipids; Lipids structure and properties of important members of storage and membrane lipids; lipoproteins.

### **Unit – III: Membranes and Nucleic acids**

Biomembrane organization - sidedness and function; Membrane bound proteins - structure, properties and function; membrane transport, nucleic acids - structure, diversity and function.

### **Unit – IV: Bioenergetics**

Bioenergetics-basic principles; Equilibria and concept of free energy; Coupled processes; Glycolytic pathway; Krebs' cycle; Oxidative phosphorylation; Photosynthesis; Elucidation of metabolic pathways; Logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; Principles of metabolic regulation.

### **Unit – V: Secondary metabolism**

Terpenes (sesquiterpenes, carotenoids), alkaloids, flavonoids, targeting mevalonic acid pathway/MEP pathway in bacteria, phenolic compounds, shikimic acid pathway, importance of secondary metabolites.

## **Unit 4**

Enzymes (13 Hours) 4.1 Enzyme Nomenclature, Classification, Cofactor, Active Site, Specificity and Factors Affecting Enzyme Action 4.2 Enzyme Regulation- Enzyme Inhibition (Competitive Inhibition, Uncompetitive Inhibition), Control of Enzyme Quantity, Altering the Catalytic Efficiency of the Enzyme 4.3 Enzymes in Clinical Diagnosis and Pharmaceutical Industries

### **TEXT AND REFERENCES:**

- Principles of Biochemistry, A.L. Lehninger, D.L. Nelson, M.M. Cox. , Worth Publishing.
- Harper's Biochemistry K. Robert, M.D. Murray, D.K. Granner, P.A. Mayes and V.I.Rodwell, McGraw Hill/ Appleton and Lange.
- Biochemistry (Fifth Edition), Lubert Stryer.
- V.Voet and J.G.Voet, Biochemistry, 3rd edition, John Wiley, New York, 2004.

## **RB10703-MICROBIOLOGY PHYSIOLOGY AND GENETICS**

### **Unit I: Introduction to microbiology**

Microbes and their types, Viruses, Bacteria, fungi and protozoans – Morphology and classification. Abnormal forms of bacteria, archaeobacteria, mycoplasma and PPLO, cultivation of bacteria – nutritional requirements of bacteria, physical requirements, different types of media & their preparations. Koch's postulates, Axenic culture, Isolation of pure cultures, maintenance and preservation of the pure cultures. Culture characteristics, bacterial growth kinetics, enumeration of cells by direct and indirect methods.

### **Unit II: Control of micro-organisms**

Concept of sterilization and disinfection. Physical and chemical methods of microbial control. Chemotherapeutics, susceptibility test (broth procedures and diffusion methods), mode of action of antibiotics, narrow and broad spectrum (Penicillin, ampicillin, sulfonamide, vancomycin, tetracycline, chloramphenicol), antifungals (clotrimazole, fluconazole), antiretroviral (tenofovir, AZT).

### **Unit III: Microbial genetics**

Molecular classification of microbes, The Basics of microbial genetics, prokaryotic gene organization, The basic principles of microbial DNA, replication, transcription and translation. Microbial regulation of gene expression: the *trp* and *lac* operon.

### **Unit IV: Microbial genetic change and viral genetics**

Basics of microbial gene transfer: transformation, transduction, conjugation, plasmids, transposons. Viral Genetics Reproductive cycles of bacteriophage, M13 and lambda.

### **Unit V: Soil and Agricultural Microbiology**

Normal microflora of soil, host parasite interactions, allelochemistry and mechanisms of pathogenesis, agriculturally-important pathogenic microorganisms (bacteria, fungi and viruses), applications of the basic principles of microbiology in effective diagnosis, treatment and prevention of infectious disease.

### **TEXT AND REFERENCES:**

- Microbiology VI Edition, M.J. Pelczar, E.C.S. Chan and N.R. Kreig, Tata McGraw Hill.
- General Microbiology, R.Y. Stanier, J.L. Ingraham, M. L. Wheelis and P.R. Painter, Macmillan.
- The microbes – An Introduction to their Nature and Importance, P.V. Vandemark and B.L. Batzing Benjamin Cummings.
- The Microbial World, Roger Y. Stanier, Prentice Hall.
- Microbiology, Tortora, Funke and Chase, Benjamin & Cummings.

# **RB10704-BIOINFORMATICS AND BIOSTATISTICS**

## **A.BIOINFORMATICS**

### **UNIT I Introduction to computers and Bioinformatics**

**Software and Hardware, storage and memory devices, input and output devices, f internet and e-mail.Bioinformatics- History, scope and applications.**

### **UNIT II Biologicazl databases**

**EMBL,GENBANK, DDBJ,PIR,PDB,SWISSPROT and TrEMBL. Understanding the structure of each source and using it on the web.**

### **UNIT III Sequence alignments**

**Pairwise sequence Alignments, FASTA and BLAST, using it on the web, Interpreting results, MultipleSequence Alignment Phylogenetic Analysis. Open reading frame.**

**Protein Secondary structure prediction methods, and homology modeling**

## **B.BIOSTATISTICS**

### **UNIT I: Descriptive Statistics**

**Introduction of Statistics, Applications and drawback of Statistics, Concept of variables in biological systems, Collection, classification, tabulation, graphical and diagrammatic representation of numerical data Measures of central tendency: Arithmetic Mean, Median, Mode, Geometric Mean, Harmonic Mean and Quartiles.**

**Measures of Dispersion:** Range, Quartile deviation, Mean deviation, Standard deviation and Coefficient of variation.

**Correlation and Regression:** Correlation Coefficient, Rank correlation, Regression coefficients, Regression lines (Y on X and X on Y).

### **UNIT II: Probability theory and Tests of Significance**

**Probability: Introduction, Random experiment, Sample space, Events, Definition of Probability, Addition and Multiplication Law of Probability, Conditional Probability, Bayes theorem, Applications of probability.Probability Distributions: Random variables, Binomial distribution, Poisson distribution and Normal distribution, Applications of distributions.**

**Tests of Significance:** Based on t, F, Z and Chi-square distributions.

### **UNIT III: Analysis of Variance and Design of ExperimentANOVA:**

One-way and Two way classifications.

**Design of Experiment: Principles of Design of Experiment, Completely Randomized Design (CRD), Randomized Block Design, (RBD), Latin Square Design (LSD), Statistical and graphic software-their use in research for data analysis, interpretation and presentation.**

## **RB10801-BIOANALYTICAL TECHNIQUES**

### **UNIT I Chromatography**

**Principle, types and applications- partition, adsorption, paper, thin layer, ion exchange, molecular sieve, supercritical fluid, gas chromatography and HPLC.**

### **UNIT II Electrophoresis**

**Principle, instrumentation and applications of moving boundary and zonal electrophoresis, including paper and gel (SDS-PAGE and Agarose) electrophoresis, isoelectrofocusing, PFGE and Capillary electrophoresis.**

### **UNIT III Centrifugation**

**Principles of sedimentation & centrifugation, relationship between RCF and RPM, types of centrifuge, differential and density gradient centrifugation (rate zonal and isopycnic).**

### **UNIT IV Microscopy**

**Principles and applications of light microscope, fluorescence, Phase contrast, Dark field, electron (TEM and SEM), interference, polarization, inverted and stereomicroscope. Freeze fracture, fixation and staining**

### **UNIT V Spectroscopy**

**Principle, Instrumentation and applications of UV-Visible, IR, NMR, atomic absorption, Fluorescence spectroscopy, X-ray Crystallography and Mass Spectrometry.**

### **UNIT VI Radiation Biology**

**Radioisotope Techniques: Radio-tracers, interaction of radiation with matter, GM counter, Scintillation counters, autoradiography and radioimmunoassay.**

### **List of suggested reading:**

- 1. Instrumental Analysis : D. Skoog*
- 2. Biophysical Chemistry : David Sheehan*
- 3. Principles of Biophysical Chemistry : David Frifelder*
- 4. Biophysics : Upadhyay & Upadhyay*
- 5. Methods of Instrumental Analysis : Willard*
- 6. Principles and techniques of practical Biochemistry, by Wilson/Walker : Wiley Publication(2010)*



## **RB10802-MOLECULAR BIOLOGY**

### **UNIT-I**

Chromatin structure and gene expression: Chromatin structure and transcription. Regulation of chromatin structure , Transcription in prokaryotes and Eukaryotes, Structure of RNA polymerase (Channel in and Channel out). Types of RNA polymerases, Types of Promoters, initiation, elongation, termination and anti-termination. Initiation factor, role of transcription factors, Regulation of RNA polymerase. Transcription in cell organelles (Mitochondria and chloroplast).

### **UNIT-II**

Post Transcriptional and translational events

RNA processing in eukaryotes: modifications, splicing and splicing machinery, processing of RNA. Editing and amplification Translation: in Prokaryotes and Eukaryotes. Initiation, elongation, and termination ,mRNA localization and stability Modification folding and transport protein. Molecular chaperons in folding, Protein sorting and trafficking using signal proteins,

### **UNIT-III**

RNA interferences and epigenetics

DNA rearrangement, RNAi, regulation of translation, RNA interference, Gene silencing, Epigenetic inheritance and Retrotransposons

### **UNIT-IV**

Omic studies

Omes and Omics, concepts and applications, genome overview at the level of chromosomes (with model organisms as example), strategies for large scale DNA sequencing. EST and STS, Whole

Genome Analysis techniques. Next generation sequencing methods, organization, structure, and mapping of genomes (with model organisms as example)

Introduction to proteomics, transcriptomics,metabolomics.

Whole exome analysis.

References:

1. Genes XI, 11th edition (2012), Benjamin Lewin, Publisher - Jones and Barlett Inc. USA
2. Molecular Biology of the Gene, 6th Edition (2008), James D.Watson, Pearson Education, Inc. and Dorling Kindersley Publishing, Inc. USA
3. Molecular Biology, 5th Edition (2011), Weaver R., McGrawHill Science. USA
4. Fundamentals of Molecular Biology, (2009), Pal J.K. andSarojGhaskadbi, Oxford University Press. India
5. Molecular Biology: genes to proteins, 4th edition (2011), Burton E Tropp Jones & Bartlett Learning, USA
6. Discovering genomics, Proteomics and Bioinformatics (2006) A. Malcolm Campbell, Laurie J. Heyer Benjamin Cummings;2nd edition.

## RB10803-IMMUNOLOGY

UNIT I	11
Types of immunity: innate, acquired, active and passive, primary and secondary lymphoid organs, antigen- antibody Interactions (physical aspects), elements of immune system: T-cells, B-cells, cell mediated subset of T- cells, helper and suppressor cells, markers, third population of lymphocytes, antigen presenting cells, cell mediated and humoral immunity, antibody dependent cell mediated cytotoxicity, natural killer cells	
UNIT II	12
Cellular and molecular aspects: nature of antigens, basic structure of antibodies, their function and diversity, antibody classes and biological activity, T-cell receptors, complement system, major histo-compatibility complex (MHC), MHC molecules, exogenous and endogenous antigen presentation, lymphokines, regulation of immune response, immunological tolerance	
UNIT III	11
Agglutination, Precipitation, Single and double immuno diffusion, immunoelectrophoresis, ELISA and its various types, Western blotting, Fusion of myeloma cells with lymphocytes, concept of trioma, hybrid-hybridoma and thymoma, applications of monoclonal antibodies	
UNIT IV	11
Synthetic vaccines, autoimmunity, hyper-sensitivity, tumor immunity, concept of idiotypes and anti-idiotypes	

### Suggested books [Latest edition]

1. Immunology: Janis Kuby
2. Essentials of Immunology: Ivan Roitt
3. Cellular and Molecular Immunology: Abul K Abbas, Andrew H Lichtman and S Jordan.
4. Immunology: An Introduction: Ian R Tizard
5. A Handbook of Practical Immunology: GP Talwar

### List of practicals

1. To study the techniques of immunization and generation of antibodies.
2. To perform differential leukocyte count of human blood.
3. Isolation of IgG from human serum by affinity chromatography using protein A column.
4. To perform precipitation tests (a) ring test (b) slide test in solution given an antigen and antibody.
5. To perform precipitation reactions in gel by Ouchterlony Technique given an antigen and antibody (double immunodiffusion) .
6. To perform single radial immunodiffusion (Mancini's Technique) using an antigen and antibody.
7. To perform immunoelectrophoresis given an antigen and antibody.
8. To perform rocket immunoelectrophoresis on given antigen and antibody.
9. To perform ELISA.
10. To perform rapid Agglutination Test for detection of RA factor in serum.

## **RB10804-GENOMICS & PROTEOMICS**

### **UNIT I**

Genomics: Genome databases of plant, animal and microbial pathogens; Large scale genome sequencing strategies, genome assembly and annotations; Metagenomic analysis: Basic concepts, gene networks and computational models; Identification of disease gene by OMIM databases; Markers for genetic mapping: RFLP, SSLP- VNTRs, STRs; Gene expression profiling; SNP databases & SNP array.

### **UNIT II**

DNA sequencing methods: Chemical degradation & Sanger's methods, Shot gun sequencing, Clone contig method, Next Generation sequencing. Comparative genomics: Whole genome alignment, BLAST2, megablast algorithm, Comparative genomic database (COG & VOG). Functional genomics: Sequence based & structure based approaches to assign gene function. Gene/ Protein function prediction using neural network. DNA microarray: Databases and tools; SAGE databases; Gene expression omnibus (GEO).

### **UNIT III**

Proteomics: Protein profiling; 2D gel electrophoresis, Multidimensional chromatography, Quantitative Mass spectrometry: Peptide mapping, N & C terminal sequencing and analytical protein chips – Computational pattern, recognition of proteomes: protein network and pathways. Principle of protein microarrays, Mass spectrometry analysis for proteomic analysis, Bioinformatics based tools for analysis of proteomic data. Application of proteomics in disease diagnosis: Biomarker, drug development and their target identification.

### **UNIT IV**

Biological databases: Nucleic acid sequence databases – Genbank, NCBI, EMBL, DDBJ; Protein sequence databases; Swiss Prot, PIR; Structure data bases: PDB, CATH, SCOP and specialized databases. Tools for Bioinformatics: Pairwise alignment, Dot plots, Scoring matrices: BLOSUM matrices, PAM matrices, Gap penalty.

### **UNIT V**

Alignment algorithms: Needleman – Wunsch Global Alignment algorithm; Smith- Waterman Local Alignment algorithm. Use of HMM algorithm for Multisequence alignment, CLUSTALW. Genome aligners: BLAST, MUMmer, WABA, Glass, Dialign, Avid, LAGAN and Multi LAGAN; protein gene prediction method: ORF finder, restriction analysis, secondary structure prediction; homology modelling and drug designing.

## **References**

1. Ajoy Paul. (2011). Text Book of Genetics- from Genes to Genomes, 3rd Edition, Books and Allied (P) Ltd, Kolkata
2. Keith Wilson and John Walker. (2010). Principles and techniques of practical biochemistry, 7th Edition, Cambridge University Press.
3. Sathyanarayana. U. (2008). Biotechnology, Books and Allied (P) Ltd., India
4. Hubert Rehn. (2006). Protein Biochemistry and Proteomics, Academic Press
5. Liebler Humana. (2002). Introduction to proteomics: Tools for new Biology, W.CBS Pub.,

6. Apweiler R. (2000). Protein sequence databases, *Adv. Protein Chem.* 54:31-71
7. Pearson WR. (1996). Effective protein sequence comparison, *Methods Enzymol.*, 266: 227-258
8. Spang R and Vingron M. (1998). Statistics of large scale sequence searching *Bioinformatics.* 14: 279-284.
9. Baker D and Sali A. (2001). Protein structure prediction and structural genomics, *Science*, 294: 93-96
10. Stekel D. (2003). *Microarray Bioinformatics*, Cambridge University Press, Cambridge, UK.
11. Huynen MA, Snel B, Mering C and Bork P. (2003). Function prediction and protein Networks, *Curr. Opin. Cell Biol.*, 15: 191-198.

## **RB100805-FOOD BIOTECHNOLOGY**

### Unit 1

#### Food Microbiology (15 Hours)

- 1.1. Importance and Significance of Microbes in Food Science
- 1.2. Sources of Microorganisms in Foods and Their Effective Control
- 1.3. Factors Affecting Growth and Survival of Microorganisms in Foods - Intrinsic Factors and Extrinsic
- 1.4. Shelf Life - Calculation of Shelf Life, Shelf Life Requirements and Simulation
- 1.5. Microbial Toxins - Bacterial Toxins, Fungal Toxins, Food Borne Intoxications and Infections

### Unit 2

#### Food Chemistry (10 Hours)

- 2.1. Flavour - Flavourmatics/Flavouring Compounds, Sensory Assessment of Flavour, Technology for Flavour Retention
- 2.2. Pigments - Technology for Retention of Natural Colours of Food Stuffs, Food Colorants - Popular Colors Used in Food
- 2.3. Vitamins - Requirements, Allowances and Retention of Vitamins
- 2.4. Minerals - Requirements, Allowances and Retention of Minerals

### Unit 3

#### Processing of Food (13 Hours)

- 3.1. Cereals, Pulses and Oilseed Products - Milling and Processing
- 3.2. Dairy Technology - Stages of processing and Other Products
- 3.3. Fruits and Vegetables - Processing and Preservation
- 3.4. Membrane Technology in Food Processing

### Unit 4

#### Food Preservation (12 Hours)

- 4.1. Low Temperature - Cool Storage and Freezing Definition, Types of Freezing – Slow Freezing, Quick Freezing, Thawing
- 4.2. High Temperature - Commercial Heat Preservation Methods
- 4.3. Moisture Control - Drying and Dehydration, Evaporation
- 4.4. Irradiation - Uses of Radiation Processing in Food Industry, Concept of Cold Sterilization, Preservation by chemicals and Non-thermal preservation process

### Unit 5

#### Food Packaging and Safety (15 Hours)

5.1. Introduction - Packaging Functions and Requirements - Printing, Barcodes and Other Marking - Labelling Laws

5.2. Food Packaging Materials - Paper and Paper-Based Materials, Corrugated Fibre Board (CFB), Plastics, Biodegradable Plastics, Edible Packaging, Metal Packaging, Glass

5.3. Packaging of Foods - Packaging Of Fresh Produce and Processed Foods, Aseptic Packaging, Advances in Food Packaging

5.4. Quality Assurance - Microbiological Quality Standards of Food, GMP, FSSAI, FDA, EPA, HACCP, ISI, ISO, E-number, GMO Food

#### BOOKS FOR STUDY

Adams, M. R. Moss, M. O. Food Microbiology, U.S.A.: Royal Society of Chemistry, 2000.

Bhatia. S.C. Food Biotechnology, WPI Publishing India, 2017.

Doyle, M. P., Buchanan, R. L. Food Microbiology: Fundamentals and Frontiers. U.S.A. ASM, 2012.

Sinosh Skariyachan and Abhilash M. Introduction to Food Biotechnology, CBS, India 2012

#### SUGGESTED BOOKS

Garbutt, J. Essentials of Food Microbiology, U.S.A.: Hodder, 1997.

George, B. J. Basic Food Microbiology. U.S.A.: Springer, 1989.

Foster W M Food Microbiology, CBS, 2005.

Joshi, V. K., Pandey. A Biotechnology: Food Fermentation Microbiology, Biochemistry and Technology. India: Educational, 1999.

Ravishankar Rai V. Advances in Food Biotechnology. Wiley-Blackwell, U.S.A. 2015.

## RB100901-RECOMBINANT DNA TECHNOLOGY

### Unit 1

Introduction and Enzymes in Recombinant DNA Technology (13 hrs.)

1.1 Introduction to Genetic Engineering and Recombinant DNA Technology

1.2 Restriction Modification Systems - Types and Nomenclature and Restriction Enzymes TYPE I, II, III

1.3 DNA Ligase- Properties and Specificity

1.4 Other Enzymes Used in Recombinant DNA Technology - S1 Nuclease, BAL 31 Nuclease

1.5 DNA Polymerase, Polynucleotide Kinase, Phosphatase, Reverse Transcriptase - Activity and Mode of Action

### Unit 2

Plasmids and Vectors (14 hrs.)

2.1 Plasmids- Properties, Incompatibility, Isolation and Purification Techniques

2.2 Plasmid Vectors and their Properties, Copy Number, pBR 322, pUC, pGEM3Z – its Construction and Derivatives, Single Stranded Plasmids

2.3 Bacteriophage lambda ( $\lambda$ ) as a Vector- Essential Features, Organization of Genome, General Structure, Rationale for Vector Construction Cosmids, Phasmids, Fosmids, Phagemids

2.4 Filamentous Phage Vectors, L Zap, L Blue Print Vectors, Shuttle Vectors

2.5 Expression Vectors, Promoter Probe Vectors, Vectors for Library Construction, Linkers, Adaptors, Homopolymer Tailing

### Unit 3

Expression Vectors (12 hrs.)

3.1 Expression Vectors - Expression of Foreign DNA in Bacteria- Fusion Protein and in *Pichia* sp. Expression System

3.2 YACs, BACs, PACs, MACs and HACs

3.3 Shotgun Cloning - Genomic Library and cDNA Library Construction- Marker Genes Recombinant Selection and Screening

### Unit 4

Sequencing and Molecular Mapping (13 hrs.)

4.1 DNA Sequencing and Polymerase Chain Reaction- its Principle, Types and Applications, Site Directed Mutagenesis

4.2 Molecular Markers and its Applications - RFLP, RAPD, AFLP, VNTR, STS, SSCP, SSR, CAPS, SCAR

4.3 Molecular Mapping of Genome - Genetic and Physical Maps, Chromosome Walking

### Unit 5

Applications in Industrial and Healthcare (13 hrs.)

5.1 Modern Biotechnology – Products Using Gene Cloning – Monoclonal Antibodies, Insulin, Growth Hormones, Vaccines

5.2 Gene Therapy for Inherited Disorders and Neoplastic Disorders

5.3 Genetically Modified Organisms in Industry – *Pseudomonas* sp., *Bacillus thuringensis*.

## **RB100902-ANIMAL BIOTECHNOLOGY**

### UNIT I

12

Introduction, brief history and terminology, source of some important mammalian cell lines. Balanced salt solutions and simple growth media, serum and its quality, medium sterilization.

Basic techniques of scale up of animal cell culture: roller bottles modification of roller bottles, multiunit system and concept of bioreactors including hollow fiber system & their application.

### UNIT II

12

Preservation and maintenance of animal cell lines, cryo-preservation and transport of animal germplasm (i.e. semen, ova and embryos). Production of monoclonal antibodies by hybridoma technique, scale up (*in vivo* and *in vitro*), brief concept of trioma and thymoma.

### UNIT III

10

Concept of stem cells, Embryonic and adult stem cells, tissue engineering and its application. Gene cloning techniques for mammalian cells, cloning in mammalian cells. Transgenic animals, *in vitro* fertilization and embryo transfer. Molecular biological techniques for rapid diagnosis of genetic diseases and gene therapy.

### UNIT VI

11

Chemical carcinogenesis, transfection, oncogenes and antioncogenes. Cell synchronization methods and their applications, Concept of idiotype/ anti-idiotype and their applications.

**Suggested books[Latest edition]**

1. Animal Cell Biotechnology: RE Spier and JB Griffiths
2. Living Resources for Biotechnology - Animal cells: A Doyle, R Hay and BE Kirsop
3. Animal Biotechnology: Murray Moo-Young
4. Animal Cell Biotechnology-Principles and Practices: M Butler.
5. The Animal Cell Culture and Technology: M Butler.
6. Culture of Animal Cells: RT Freshney.

### **RB100903-PLANT BIOTECHNOLOGY**

<b>UNIT I</b>		<b>11</b>
	Introductory history, scope and application of plant biotechnology. Plant cell and tissue culture media, plant growth regulators in tissue culture-their use and preparation. Cellular totipotency, cyto-differentiation and organogenesis; somatic embryogenesis; transfer and establishment of whole plants in soil (acclimatization & hardening); Designing and erection of polytunnels and greenhouses.	
<b>UNIT II</b>		<b>11</b>
	Initiation of aseptic culture techniques; <i>In- vitro</i> and <i>in vivo</i> pollination and fertilization; single cell and cell suspension culture, callus culture, embryo culture and embryo rescue; protoplast culture and somatic hybridization, selection of hybrid cells; symmetric and asymmetric hybrids, cybrids.	
<b>UNIT III</b>		<b>11</b>
	<i>In vitro</i> clonal propagation and large-scale production of plants through micropropagation. Prospects and problems, meristem tip culture, shoot tip culture and shoot tip grafting. Doubled haploid production through distant hybridization, Production of haploid plants through androgenesis ( <i>anther and pollen culture</i> ) and gynogenesis ( <i>ovary and ovule culture</i> ) and their utilization.	
<b>UNIT IV</b>		<b>12</b>
	Production of useful bio-chemical substances through tissue culture system, Scale-up through bio-reactors. Bioinsecticides, biopesticides and biofertilizers. Gene transfer in nuclear genome and chloroplasts; Agrobacterium- mediated gene transfer, direct gene transfer. Transgenic plants: insect resistance, virus resistance, abiotic stress tolerance, longer shelf life (including strategies for suppression of endogenous genes), male sterility, enhanced nutrition (golden rice), edible vaccines. Preservation of plant genetic resources: Germplasm collection and conservation.	

#### Suggested books [Latest edition]

1. Plant Tissue Culture - Applications and Limitations: SS Bhojwani.
2. Genome Organization and Expression in Plants: CJ Lever.
3. Plant Cell Culture - A Practical Approach: RA Dixon & Gonzales.
4. Principles of Plant Biotechnology - An Introduction to Genetic Engineering in Plants: Mantell, Mathews & Mavkee.
5. Plant Cell Biology - A Practical Approach: N Harris & KJ Oparke.

## **RB100904-PHARMACEUTICAL BIOTECHNOLOGY**

### Unit I:

#### Introduction

Introduction and History, DNA, RNA, post-translational processing, metabolic enzymes involved in nucleic acid synthesis, G-protein coupled receptors (monomeric transmembrane proteins), small molecule receptors, ligand-gated ion channels (oligomeric transmembrane proteins), transporters (multi-transmembrane proteins).

### Unit II:

#### Drug discovery methods

Meaning of drugs, Drug Discovery Process, biological activity directed and other types of screening, natural products, combinatorial chemistry; General overview of validation techniques, Methods of Drug Discovery and development, QSAR and SAR.

Concepts of Bio availability, Process of drug absorption, Pharmacokinetic processes, Timing for optimal therapy, Drug delivery considerations for the new biotherapeutics.

### Unit III:

#### Pharmacology of drugs

Physicochemical Properties in Relation to Biological Action, Effects of route of administration, Drug Targets, Validation techniques of Pharmaceutical targets, Pharmacokinetics and pharmacodynamics of drugs, Drug Toxicity.

Basic terminologies in drug delivery and drug targeting, Doses forms, Various routes of administration of drugs (just introduction), Strategies for enhanced therapeutic efficacies (Basic principles)

DNA vaccines, Vaccines & Monoclonal antibody based pharmaceuticals, Antibiotics, Characterization and Bioanalytical aspects of Recombinant proteins as pharmaceutical drugs.

### Unit IV:

#### Formulations

Formulation of Biotechnological Products, Drug Delivery, Examples of some Biotechnological products in clinical development.

### Unit V: Regulations

Role of FDA, ICH Guidelines, The Regulation of Pharmaceutical Biotechnological Products and Ethical Issues.

### **TEXT AND REFERENCES:**

- Drug Delivery and Targeting, A.M. Hillery, A.W. Lloyd and J. Swarbrick, Harwood Academic Publisher
- Pharmaceutical Dosage Forms and Drug Delivery Systems, H.C. Ansel, L.V. Allen and N.G. Popovich, Lippincott Williams and Wilkins Publisher
- Applications of Targeted Nano Drugs and Delivery Systems, Shyam Mohapatra, Shivendu Ranjan, Nandita Dasgupta, Raghvendra Mishra and Sabu Thomas (EDs.), Elsevier, 2019.
- Introduction to Biophysical Methods for Protein and Nucleic Acid Research, J.A. Glasel



and

M.P. Deutscher, Academic Press.

## UNIT II

**PHARMACEUTICAL PRODUCTS:** Therapeutic categories such as laxatives - analgesics - non steroidal contraceptives - external antiseptics - antacids and other, antibiotics - biological - hormones - vitamins with respect to system. **Pharmaceutical Development:** Introduction to drug regulations, pre-clinical and clinical trials.

## UNIT III

Protein mode of action and pharmacodynamics- Overview of the mode of action of a biopharmaceutical Pre-clinical studies- -Toxicity (Reproductive toxicity and Teratogenicity, Mutagenicity, Carcinogenicity and Other tests); Clinical trials - Clinical trial design, Trial size design and study population.

## UNIT IV

Detail contents: Introduction: History and scope of medical biotechnology, current status and future prospects. Classification of genetic diseases: Chromosomal disorders – Numerical disorders e.g. trisomies & monosomies, Structural disorders e.g deletions, duplications, translocations & inversions, Chromosomal instability syndromes. Gene controlled diseases – Autosomal and X-linked disorders, Mitochondrial disorders.

## UNIT V

Molecular basis of human diseases: - Pathogenic mutations Gain of function mutations: Oncogenes, Huntingtons Disease, Pittsburg variant of alpha 1 antitrypsin. Loss of function - Tumour Suppressor. Genomic. Dynamic Mutations - Fragile- X syndrome, Myotonic dystrophy. Mitochondrial diseases

## **References**

- 1.Gary Walsh. (2007). Pharmaceutical Biotechnology-Concepts and Applications, John Wiley & Sons Ltd.,
- 2.Laurence Brunton, Bruce A Chabner, Bjorn Knollman. (2013). Goodman & Gillman's. The Pharmacological Basis of Therapeutics, 12th Edition, McGraw-Hill

Education.

3. Roop K Khar, Vyas SP, Farhan J Ahmad, Gaurav K Jain. (2013).

Lachman/Liebermans: The Theory and Practice of Industrial Pharmacy, 4th Edition, CBS Publishers and Distributors.

4. Barar FSK. (2013). Textbook of Pharmacology, 1st Edition, S. Chand Publishing.

5. Leon Lachman Theory and Practice of Industrial Pharmacy, 3rd Edition, Lea and Febiger, 1986. 2. Remington's Pharmaceutical Sciences, 17th Edition, Mark Publishing & cop 1985 3.

6. Gary Walsh, Biopharmaceuticals: Biochemistry and Biotechnology. Wiley - Blackwell 2003

7. Diagnostic and Therapeutic Antibodies (Methods in Molecular Medicine by Andrew J.T. George (Editor), Catherine E. Urch (Editor) Publisher: Humana Press; edition (2000)

8. Molecular Diagnosis of Infectious Diseases (Methods in Molecular Medicine) by Jochen Decker, U. Reischl Amazon

9. Human Molecular Genetics by T. Strachan, Andrew Read Amazon Sales Rank

### **Web Sources**

<https://www.industrialinfo.com/database/pharmaceutical/>

[https://guides.lib.berkeley.edu/pharma\\_medical\\_devices](https://guides.lib.berkeley.edu/pharma_medical_devices)

<https://www.ebsco.com/corporations/industries/pharmaceutical-biotechnology>

## **RB100905-NANOBIOTECHNOLOGY**

### **UNIT I**

**12**

Introduction: Definition, interdisciplinary nature, learning from nature (linear and rotary molecular motors, abalone shells) and scope.

Bio-nanostructures: Protein based nanostructures self-assembly engineered nanopores, protein micro-arrays, magnetosomes, bacteriorhodopsin and their application.

DNA based nanostructures: DNA-protein nanostructure, DNA-templated electronics, DNA Gold nanoparticle conjugates-chip based DNA detection, DNA Nanostructures for mechanics and computing, nanoparticles as non-viral transfection agent.

**UNIT II** **11**

\Silica nanoparticles for analytical microbial biofilms structure and applications, artificial cells. Nanostructured fluids and soft material: Applications in drug solubilization and delivery, nutraceuticals enhanced oil recovery, antimicrobial and cosmetic nanoemulsions, food colloids, templating of nanoparticles.

**UNIT III** **11**

DNA-Nanotechnology: Structural DNA assembly, nanopore DNA sequencing, DNA coupled to carbon nanotubes, DNA-modified surfaces, polyelectrolyte behavior in DNA, self-assembling toroidal nanoparticles. Applications of nanoparticles: Nanoparticles for biological assays, as drug delivery vehicles and as contrast agent.

**UNIT IV** **12**

Application of nanotechnology/ nanobiology/ nanotechnology in bio-mineralization, medicine and surgery (stem cell biology, artificial organs, tissue engineering, cardiology and cardiac surgery, organ transplantation and cancer).

***Suggested books [Latest edition]***

1. Nanobiotechnology. Concepts. Applications & Perspectives: CM Niemeyer and CA Mirkin, Wiley VCH-Verlag.
2. From Biology to Biotechnology & Medical Applications: E Bauerlin, Biomineralization - Wiley VCH-Verlag.
3. Nano & Microscience, Engineering Technology and Medical Series: Lyshevski, Sergey Edward, CRC Press.
4. Nanostructures and Nanomaterials: G Cao, Imperial College Press.
5. Nanoscale Technology in Biological Systems: RS Greco, FB Prinz and RL Smith. CRC Press.

**RB101001-ENVIRONMENTAL BIOTECHNOLOGY**

**UNIT-1:**

Environmental and Biosensors                      Reducing environmental impact of industrial effluents  
Toxic sites reclamation, removal of spilled oil and grease deposits and pollutants. Microbial degradation of textile dyes, timber petroleum products, leather plastics and food product  
Biosensors, recent approaches and applications

**UNIT-2:**

Bio fertilizers Use of mycorrhizae in forests, Biofertilizers and biopesticides Role of *Dienococcus* sp. in bioremediation of radioactive waste. Molecular mechanisms of radiation resistant

**UNIT-3:**

Environment and energy Renewable source of energy: Biomass production and Biogas production. Generation of energy and fuel using microorganisms (Hydrogen production and Methane production) Brief account of alternative energy source: Biofuel etc.  
Conservation of energy: Global Warming and carbon credit Heavy metals and its effect on microbes and higher organisms

#### UNIT-4:

Biodiversity, bioethics Biodiversity & species concept role of Biodiversity, Factors threatening Biodiversity Endangered species management & Biodiversity protection

#### Books/Authors.

1. Introduction to environmental Biotechnology. Chatterji, A.K.
2. Test Book of Environmental Biotechnology. P.K. Mohapatra  
I.K. International Publishers
3. Environmental Biotechnology. Alan H.  
Scragg.O.U.Publishers.

### RB101002-BIOPROCESS ENGINEERING

#### UNIT I Introduction

Definition, Scope and chronological development of the fermentation industry, the component parts of a fermentation process.

#### UNIT II Media design

Introduction, typical media - energy sources, carbon and nitrogen sources and other components

#### UNIT III Sterilization

Medium sterilization, design of a batch and continuous sterilization processes, holding time, Scale up of sterilization.

#### UNIT IV Improvement of industrial micro-organisms

Isolation of industrially important micro-organisms – Screening, selection of mutants overproducing primary metabolites, selection of mutants overproducing secondary metabolites, use of recombination systems for the improvement of industrial micro-organisms and by modifying properties other than the yield of product. Maintenance and preservation of microorganisms

#### UNIT V Fermenter design

Basic concepts of fermenter-batch,continuous, fed batch, packed bed, bubble column, fluidised bed, trickle, plug flow reactors. Fermentations-Submerged and solid state, body construction, aeration and agitation.

#### UNIT VI Recovery and purification of fermentation products

Removal of microbial cells and other solid matter, foam separation, precipitation, filtration, centrifugation, cell disruption, Liquid- liquid extraction, drying and crystallization.

#### UNIT VII Microbial production

Penicillin, Riboflavin, citric acid, vinegar, beer and whisky, Glutamic acid, Bread and Mushroom production

#### UNIT VIII Effluent treatment

Treatment and Disposal of effluents, B.O.D. and C.O.D.

List of suggested reading:

1. Biochemical Reactors Atkinson, B. Pion Ltd London
2. Biochemical Engineering Fundamentals Baily, J.F. and D F Ollis, D.F.
3. Bioprocess Technology-Fundamentals and Applications KTH Stockholm
4. Principles of fermentation technology Stanbury, P.F. and Whitakar, A.
5. Bioprocess Engineering principles, Pauline M. Doran, Academic Press.

### RB101003-FUNDAMENTALS OF NUTRITION SCIENCE

#### Unit-I

Basic concepts — Function of nutrients. Measurement of the cal values of foods. Direct and indirect calorimetry. Basal metabolic rate: factors affecting BMR, measurement and calculation of BMR. Measurement of energy requirements.

#### Unit-II

Elements of nutrition — Dietary requirement of carbohydrates, lipids and proteins. Biological value of proteins. Concept of protein quality. Protein sparing action of carbohydrates and fats. Essential amino acids, essential fatty acids and their physiological functions.

#### Unit-III

Minerals — Nutritional significance of dietary calcium, phosphorus, magnesium, iron, iodine, zinc and copper. Vitamin — Dietary sources, biochemical functions, requirements and deficiency diseases associated with vitamin B complex, C and A. D, E & K vitamins.

#### Unit-IV

Malnutrition — Prevention of malnutrition, improvement of diets. Recommended dietary allowances, nutritive value of common foods. Protein-calorie malnutrition. Requirement of proteins and calories under different physiological states- infancy, childhood, adolescence, pregnancy, lactation and ageing.

## Unit-V

Obesity: Definition, Genetic and environmental factors leading to obesity. Starvation: Techniques for the study of starvation. Protein metabolism in prolonged fasting.

Suggested Readings:

- Loin Brody: Nutritional Biochemistry (Second Edition), Academic Press.
- IIA VID A. BENDER: Nutritional Biochemistry of the Vitamins. SECOND EDITION, Min iversity College London. Cambridge University Press.

## RB0101004 –MEDICAL BIOTECHNOLOGY( IMMUNO-DIAGNOSTICS)

### UNIT-I:

Modern Immunological Therapy: Kinetics of immune response and memory; Hybridoma technology; production and purification of monoclonal antibodies; Antibody engineering, Antibody as in vitro and in vivo probes; Immunotoxins, Immunodiagnostics and Immunotherapeutics. Immunoassay: solid immunoassay & their chemistry, Immunocytochemistry, Immunohistochemistry, Immunoediting, Immune surveillance theory.

### UNIT-II:

Molecular Oncology: Detection of recognized genetic aberrations in clinical samples; types of cancer causing alterations revealed by next generation sequencing of clinical isolates; predictive biomarkers for personalized oncotherapy of human disease such as chronic myeloid leukemia, colon, breast, lung cancer and melanoma as well as matching targeted therapies with patients and preventing toxicity of standard systemic therapies; Tumor evasion of the immune system, Cancer immunotherapy.

### UNIT-III:

Commercial Immunodiagnostic kits for common diseases: Dengu, HIV/AIDS, Chikungunya, ELISA kit, Rapid diagnostic test kit, BCG, Typhoid.

### UNIT-IV:

Common Vaccine development: Licensed vaccines, Viral Vaccines (Poliovirus vaccine-inactivated and Live, rabies vaccines, Hepatitis A& B vaccines), Bacterial Vaccine (Anthrax vaccines, Cholera vaccines, Diphtheria toxoid), Parasitic vaccine (Malaria Vaccine).

#### UNIT-V:

Vaccine Production: The vaccine industry, vaccine manufacturing, Evolution of adjuvants across the centuries, New generation vaccines (bacterial, viral), Edible vaccines, Vaccine additives and manufacturing residuals, Regulation and testing of vaccines.

#### Suggested Readings (Latest Editions):

1. Riott I M ( 2003). Essentials of Immunology. Blackwell Scientific Publishers,London.
2. Murray PR, Pfaller MA, Tenover FC and Tenover RH (2007). Clinical
3. Microbiology. ASM Press.
4. Tizard Ian R (2009). Immunology. An introduction, 4<sup>th</sup> Edition.
5. Kenneth. J. Ryan (2010) Sheris's Medical Microbiology,Mc Graw Hill.
6. Kindt, Goldsby and d Osborne (2013). Kuby Immunology. MacMillan Higher Education.
7. Willey J, Sherwood L. and Woolverton C (2014). Prescott's Microbiology, 9<sup>th</sup> edi McGraw Hill.
8. Greenwood D (2015). Medical Microbiology, 18<sup>th</sup> Edition, Elsevier

### RB101005-CLINICAL BIOTECHNOLOGY

#### UNIT-I

Drug discovery and Preclinical toxicology  
Pre-Clinical toxicology: General Principals, Systemic toxicology, (Single dose and repeat dose toxicity studies), Carcinogenicity, Mutagenicity Teratogenicity, Reproductive toxicity, Local toxicity,Genotoxicity, animal toxicity requirements

#### UNITII

Introduction to Clinical trials  
Introduction to clinical trials, Historical guidelines in clinical research (Nuremberg code, Declaration of Helsinki and Belmonte report), ICH-GCP guidelines (E6-R1), Phases of clinical trials

### UNIT-III

#### Clinical study design

Clinical study methodology and regulations: Principles, types (single blinding, double blinding, open access, randomized trials and their examples),

Design of protocol, CRF, e-CRF, IB, ICF and preparation of trial reports, Regulations involved (ICMR guidelines) and ethics.

### UNIT-IV

#### Medical Writing

Medical Writing: Literature search and medical articles, contract writing, publication, abstracts, bibliography, clinical study reports, principles and softwares in CDM (Clinical Data Management)

## RB101006-BIOENTREPRENEURSHIP

### Unit 1

#### Intellectual Property Rights (10 hrs.)

1.1 IPRs – Implications for India, WTO, WIPO, GATT, TRIPS

1.2 Patenting and the Procedures Involved in the Applications for Patents and Granting of Patent

1.3 Compulsory Licenses, Patent Search. Special Application of Patent Laws in Patenting of Living Organisms, Plant Breeders Rights, Legal Implications, Traditional Knowledge, Commercial Exploitation, Protection

### Unit 2

#### Ethical Issues in Plant and Animal Research (10 hrs.)

2.1 Ethics: Regulations on Field Experiments and Release of GMO (Genetically Modified Organisms), International and Indian Regulatory Authority – BRAI, Labeling of GM (Genetically Modified) Foods

2.2 Impact of Gene Cloning, Legal, Social and Ethical Issues in Organ Transplantation

### Unit 3

#### Ethical Implications of Human Genome Project (8 hrs.)

3.1 Ethical Implications of Human Genome Project – International Ethical and Legal Issues Connected to HGP

3.2 Human Fetal Sex Determination – Implications in India Genetic Study on Ethnic Races

### Unit 4

#### Entrepreneurship (12hrs.)

4.1 Introduction, Concept and Theory, Entrepreneurial Traits and Motivation

4.2 Nature and Importance of Entrepreneurship in India, Promoting Entrepreneurship, Biotech Company Roadmap, Legal, Regulatory and Other Business Factors

4.3 Barriers in Entrepreneurship, Agreements, Valuation and Business Concerns

### Unit 5

#### Entrepreneurship Strategies (12 hrs.)

5.1 Funding of Biotech Business, MSME and Technology Incubator



5.2 Potential Entrepreneurship Activities in Biotechnology, Product Development, Marketing, Role of Knowledge centers and Research and Development (Knowledge Centers like Universities and Research Institutions, Role of Technology and Upgradation)

5.3 Biotech Parks, Biotechnology Industries in India and the Potential Job Opportunities  
TEXT BOOKS

Butler Gerard M. and Harris Antony. Bioethics guide to Pharmaceutical Manufacturers. U.K.: Medicines Control Agency, 2002.

Butler M. Animal Cell Culture and Technology. New Delhi: Bios International, 2000.

Damien Hine and John Kapeleris. Innovations and Entrepreneurship –An international perspectives. U.K.: Edward Elgar, 2006.

Jeffery M. Smith. Seeds of Deception U.S.A. : Chelsea Green, 2003.

Thomas Brenner and Holger Patzelt. Handbook of Bio-Entrepreneurship. U.S.A.: Springer, 2008.

Verma and Agarwal. Intellectual property Rights. New Delhi: I. K. International, 1992.