**AC 27/2/13**
**Item No. 4.1**

# UNIVERSITY OF MUMBAI


## Syllabus for Sem V & VI

## Programme B.Sc.

## Course: Biotechnology

**(Credit based semester and grading system**

**with effect from academic year 2013-2014)**

**T.Y.B.Sc. Biotechnology Syllabus**

**Credit Based and Grading System**

**(To be implemented from the Academic year 2013-2014)**

**Semester V**

| Course code | UNIT | Topic | Credits | L/week |
|---|---|---|---|---|
| **USBT501** | **I** | Cytoskeleton and signal transduction | 2.5 | 1 |
| | **II** | Cell membrane and apoptosis | | 1 |
| | **III** | ATC | | 1 |
| | **IV** | ATC | | 1 |
| | | | | |
| **USBT502** | **I** | Introduction to Immunology | 2.5 | 1 |
| | **II** | Immunotechnology | | 1 |
| | **III** | Carbohydrate metabolism | | 1 |
| | **IV** | Lipid metabolism | | 1 |
| | | | | |
| **USBT503** | **I** | Genetic mapping | 2.5 | 1 |
| | **II** | Transgenic Plants | | 1 |
| | **III** | Transgenic animals | | 1 |
| | **IV** | Operon Concept | | 1 |
| | | | | |
| **USBT504** | **I** | Dairy Microbiology | 2.5 | 1 |
| | **II** | Fermentations: Beverages | | 1 |
| | **III** | Bioreactors | | 1 |
| | **IV** | Down- stream processing | | 1 |

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| **USBTP05** | **Practicals of Course USBT501 + Course USBT502** | 3 | 8 |
| **USBTP06** | **Practicals of Course USBT503 + Course USBT504** | 3 | 8 |

| Course code | Title | Credits |
|---|---|---|
| **USBT501** | **Cell biology and ATC** | **2.5** |
| **Unit I** | **Cytoskeleton:** Microtubules, microfilaments, and intermediate filaments. Polymerization dynamics. Role of microtubules in mitosis, cell motility and as drug target. | |
| | **Signal transduction:** Protein kinase. G protein and secondary messengers such as cAMP, calmodulin and Calcium, phosphatidyl inositol | |
| **Unit II** | **Cell membrane:** Fluid mosaic model, Cell permeability, Transport mechanism. Differentiation of the cell membrane: microvilli, tight junction, desmosomes. Intercellular communications and gap junctions. Cell coat, extracellular material, functions of cell coat and cell recognition: recognition molecule, cellular interaction and cAMP. | |
| | **Apoptosis:** Process, factors which regulate apoptotic death in normal cells. Significance | |
| **Unit III** | **Animal tissue culture:** Introduction to tissue culture. Advantages and limitations. Application of tissue culture | |
| | **Design and layout:** Sterile handling area, incubation, hot room, service bench, preparation, storage. | |
| | **Equipments, glassware and Sterilization:** Bio safety Cabinet, $CO_2$ incubator, autoclave, hot air oven, etc. Glassware, plastic ware, pipetting device, tissue culture vessels | |
| **Unit IV** | **Tissue culture media:** Physiochemical properties, Balance Salt Solution, complete media, Serum, Serum Free Medium -Advantages and Disadvantages | |
| | **Types of cell culture:** Organ culture, primary cultures and cell lines with examples, Stem cell cultures - therapeutic cloning, carcinoma stem cells, germ cell culture, and uses. | |

| Course code | Title | Credits |
|---|---|---|
| **USBT502** | **Immunology and Biochemistry** | **2.5** |
| **Unit I** | **Innate and acquired immunity:** First, second and third line of defence. Mechanism of innate immune response. Natural - Active and passive immunity. Artificial immunity - Active and passive immunity. | |
| | **Cells and organs of immune system:** Cells of immune system – lymphoid cells, NK cells, mononuclear phagocytes, granulocytic cells<br>Organs of immune system – primary lymphoid organs, secondary lymphoid organs | |
| | **Antigens and Antibodies:** Properties of antigen, adjuvant, epitopes. Basic structure classes & sub- classes of antibodies with their biological activity (tabulated), complement, antigenic determinants on immunoglobulins. | |
| **Unit II** | **Membrane receptors for antigens:** MHC–Class I and class II molecule. TCR– structure of TCR and its role, TCR accessory membrane molecule–CD4 and CD8. BCR– structure with the heterodimer, and accessory membrane molecule–B7 | |
| | **Immunotechnology:** Principles of Antigen-antibody interaction. Types of reactions - precipitation, agglutination, flocculation reaction. Immunoassay - RIA with types, ELISA with types and ELISPOT Immunoprecipitation. Immunoflorescence – direct, indirect, FACS. Immunobloting. Diagnostic tests – complement fixation test, Coomb's test. | |
| **Unit III** | **Carbohydrate metabolism:** Biosynthesis of starch, sucrose, glycogen from glucose. Gluconeogenesis. Conversion of galactose into glucose, galactosemia. Biosynthesis of heteropolysaccharides - peptidoglycan synthesis | |
| **Unit IV** | **Lipid metabolism:** Lipogenesis – fatty acyl synthase complex, synthesis of palmitic acid from acetyl CoA. Synthesis of unsaturated, even, odd fatty acids. Synthesis of triacylglycerol. Synthesis of membrane phospholipids. Cholesterol synthesis from acetyl CoA; atherosclerosis | |

| Course code | Title | Credits |
|---|---|---|
| **USBT503** | **Genetics and Molecular Biology** | **2.5** |
| **Unit I** | **Genetic mapping in bacteria and bacteriophages:** Molecular basis of transformation, conjugation and transduction. Mapping genes in bacteriophages, fine structure analysis of r II mutants | |
| **Unit II** | **Transgenic plants:** Artificial (Direct DNA uptake by protoplast, electroporation, liposome mediated, and particle gun transformation) and Natural method of gene transfer (Agrobacterium and virus). Transgenic plants for improving seed quality protein, insect resistance (Bt genes), and golden rice, Edible vaccines. | |
| **Unit III** | **Transgenic animals:** Fish, Mice and Sheep, transgenic mice methodology, retroviral method, DNA microinjection method, engineered embryonic stem cell method. | |
| **Unit IV** | **Operon concept:** Regulation of gene expression in bacteria - Lac operon and trp operon.<br>**Transposable elements in prokaryotes and Eukaryotes:** Transposons, IS elements, Jumping genes in Maize. | |

| Course code | Title | Credits |
|---|---|---|
| **USBT504** | | **2.5** |
| **Unit I** | **Dairy microbiology:** Milk - normal flora, changes in the flora, enumeration, oxidation reduction potential, factors affecting bacteriological quality, pasteurization,<br>Fermented milk products- cultured butter milk, yogurt.<br>Butter- composition, types, manufacture, sweet cream and ripened cream butter, spoilage and defects in butter.<br>Cheese- Principle of cheese making, steps of manufacture, types, spoilage and defects. | |
| **Unit II** | **Beverages: Beer- types, element of the brewing process, fermentation, spoilage.**<br>Wine- introduction, parameters, yeast, bacterial processes during wine making-malolactic fermentation, wine defects.<br>**Other fermentations:** Ethanol, penicillin, semi-synthetic penicillin, streptomycin, vinegar, citric acid, | |
| **Unit III** | **Types of Bioreactors and control:** Tower fermenter, Air-lift fermenter, deep-jet fermenter, bubble column fermenter, Membrane bioreactor, packed column fermenter. Sensor probes, foam control. | |
| **Unit IV** | **Process development and Down stream processing:** Scale up and scale down- Scale up of aeration/agitation regimes in stirred tank reactors, the scale-up of air-lift reactors, scale down method.<br>Recovery and purification, strategies, separation of insoluble products (filteration), cell disruption, separation of soluble products (centrifugation, chromatography, solvent extraction), finishing steps for purification(drying, crystallization)<br>Whole broth processing. | |

# Practicals Semester V

| USBTP05 | Practical's of Course USBT501 + Course USBT502 | 3 Credit |
|---|---|---|
| **Practicals of USBT501** | 1. To determine the total count of RBC and WBC<br>2. Determination of Differential count of WBCs<br>3. To determine percentage viability of cells.<br>4. Osmotic fragility of RBC<br>5. Study of instruments and equipment used in animal cell culture (Inverted microscope, $CO_2$ incubator, Laminar air flow, bacteria proof filter, T flask)<br>6. Trypsinization of tissues and viability testing. | |
| **Practicals of USBT502** | 1. Determination of antigen identity by Ouchterlony's method.<br>2. Qualitative and Quantitative determination of Typhoid using Widal test.<br>3. Determination of human blood group by ABO and Rh antigen.<br>4. Estimation of sugar by GOD-POD<br>5. Estimation of serum cholesterol. | |
| **USBTP06** | **Practical's of Course USBT503 + Course USBT504** | **3 Credits** |
| **Practicals of USBT503** | 1. To construct restriction map from the provided data.<br>2. Explain genetic phenomenon<br>3. To isolate gDNA from plant source. | |
| **Practicals of USBT503** | 1. Sterilization techniques (dry, wet, chemical and membrane)<br>2. Microbiological analysis of milk by MBRT and RRT<br>3. Phosphatase test for milk<br>4. Isolation of antibiotic producing organism-(Wilkins overlay)<br>5. Bioassay of Penicillin.<br>6. Encapsulation of Yeast and estimation of invertase | |

**T.Y.B.Sc. Biotechnology Syllabus**

**Credit Based and Grading System**

**(To be implemented from the Academic year 2013-2014)**

**Semester VI**

| Course code | UNIT | Topic | Credits | L/week |
|---|---|---|---|---|
| **USBT601** | I | Medical microbiology | 2.5 | 1 |
| | II | Antimicrobial Drugs | | 1 |
| | III | Biostatistics | | 1 |
| | IV | Bioinformatics | | 1 |
| | | | | |
| **USBT602** | I | Amino acid derived hormones | 2.5 | 1 |
| | II | Steroid hormones | | 1 |
| | III | Centrifugation and chromatography | | 1 |
| | IV | Spectrophotometer and Tracer techniques | | 1 |
| | | | | |
| **USBT603** | I | Enzymes in gene cloning | 2.5 | 1 |
| | II | Cloning vectors | | 1 |
| | III | cDNA and genomic DNA cloning | | 1 |
| | IV | Applications of r DNA technique | | 1 |
| | | | | |
| **USBT604** | I | PTC | 2.5 | 1 |
| | II | Biofertilizer and biopesticide | | 1 |
| | III | Renewable energy sources and industrial waste management | | 1 |
| | IV | Ethical and regulatory issues | | 1 |

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|---|---|---|---|
| **USBTP07** | **Practicals of Course USBT601 + Course USBT602** | 3 | 8 |
| **USBTP08** | **Practicals of Course USBT603 + Course USBT604** | 3 | 8 |

| Course code | Title | Credits |
|---|---|---|
| **USBT601** | | **2.5** |
| **Unit I** | **Medical microbiology:** Origin of normal flora, normal flora and human host, Gnotobiotic life, distribution and occurrence of the normal flora, skin, eye, respiratory tract, mouth, intestinal tract, GI tract.<br>Bacterial infections-Typhoid (Sal. typhi, S. para A and S.paraB) and Tuberculosis. Fungal infection- Candidiasis (oral and vaginal) and Tinea infection (Tinea pedis, Onychomycosis, Tinea corporis, Tinea capitis)<br>Life cycle of Protozoans- Amoebiasis and Malaria | |
| **Unit II** | **Antimicrobial Drugs:** Spectrum of Antimicrobial activity, Mode of action of Antimicrobial drugs - Inhibition of Cell wall Synthesis (Penicillin, Ethambutal)<br>- Inhibitors of Protein Synthesis(Aminoglycosides, Tetracyclines, Chloramphenicol,)<br>- Injury to Plasma membrane (Polymyxin B)<br>- Inhibitors of Nucleic Acid Synthesis<br>( Nalidixic Acid, Norfloxacin, Ciprofloxacin)<br>- Competitive Inhibitors (Sulfonamides)<br>Concept of drug resistance | |
| **Unit III** | **Biostatistics:** Central tendency, standard deviation, coefficient of correlation, regression analysis, chi square, hypothesis testing, Z-test, t-test. | |
| **Unit IV** | **Bioinformatics:** Introduction to Bioinformatics, Scope of bioinformatics, bioinformatics and the internet, useful bioinformatics and sites on the www, data explosion**,** sequencing DNA,RNA and proteins, | |

| Course code | Title | Credits |
|---|---|---|
| **USBT602** | | **2.5** |
| **Unit I** | **Amino acid derived hormones, peptide, protein hormones:** Introduction, classification-based on structure, mode of action. Active form, storage, release, transport, physiological action and disorder of thyroxine, oxytocin, vasopressin, insulin, glucagon, adrenalin and nor-adrenalin. | |
| **Unit II** | **Steroid hormones:** Active form, storage, release, transport, physiological action and disorder of steroid hormones - Sex hormones, Menstrual cycle, adrenal cortex hormones. | |
| **Unit III** | **Centrifugation:** Principle of centrifugation. Rotor design and selection. Preparative centrifugation - differential, rate-zonal, isopycnic, equilibrium isodensity centrifugation with applications. Density gradient centrifugation – nature of gradient, formation, sample application and collection.<br>**Column Chromatography:** Principle, working and applications of GC, affinity, ion exchange, gel permeation, HPLC | |
| **Unit IV** | **Spectroscopy and Tracer technique:** Principle of Beer and Lambert's law. Visible and ultraviolet spectroscopy – instrumentation, applications. Double beam spectroscope<br>Detection techniques – GM counter, scintillation counter, autoradiography. | |

| Course code | Title | Credits |
|---|---|---|
| **USBT603** | | **2.5** |
| **Unit I** | **Details of enzymes involved in gene cloning and their mode of action:** Restriction endonucleases - types, nomenclature, target sites, nature of cut ends, host control restriction and modification, star activity, isoschizomers, application of RE<br>Ligases – activity, blunt and sticky end ligation, source and applications.<br>Alkaline phosphatases, polynucleotide kinase, Terminal transferase, Reverse transcriptase – source, Mode of action and applications.<br>DNA Polymerase with applications – Klenow fragment (synthesis of probe using random priming and nick translation), T4 DNA polymerase, Taq polymerase.<br>Nuclease –DNAse I, SI nuclease, Mung bean nuclease, RNAse H | |
| **Unit II** | **Cloning vectors:** High & Low copy number plasmids (regulating factor). Plasmid cloning vectors – pUC 19 and pBR322, Lambda phage, M13 bacteriophage vector, Cosmid vector, Shuttle vector, Ti plasmid. | |
| **Unit III** | **cDNA and genomic DNA cloning:** Cloning of cDNA, construction of cDNA and genomic libraries. Analysis of gene and transcripts-Southern hybridization, DNA sequencing (Sanger's and Maxam Gilbert method), Polymerase chain reaction, DNA fingerprinting | |
| **Unit IV** | **Application of recombinant DNA technology:** Diagnosis of genetic diseases – Sickle cell anaemia<br>Gene therapy – somatic and germ line gene therapy, Commercial products – insulin<br>Vaccines: Subunit Vaccines -HSV, Peptide Vaccines, Attenuated Vaccines-Cholera, Vector Vaccines-Vaccinia virus, Genetic Immunization. | |

| Course code | Title | Credits |
|---|---|---|
| **USBT604** | | **2.5** |
| **Unit I** | **Introduction to PTC:** Historical aspect of plant cell, tissue and organ culture. PTC lab, aseptic techniques, nutritional components of tissue culture medium.<br>Initiation and maintenance of callus, organogenesis, virus elimination.<br>Plant cell culture as a system for production of fine chemicals, why culture plant cells, plant suspension cultures, elicitation, permeabilisation of plant cell for product release, biotransformation and hairy root cultures.<br>Micropropagation, somatic embryogenesis, synthetic seed. | |
| **Unit II** | **Biofertilizer and biopesticide:** Introduction, advantages over chemical, enlist and production of Rhizobium and Bacillus thuringenesis | |
| **Unit III** | **Renewable energy sources:** Hydrogen gas production, biogas production, Biofuel<br>**Industrial waste and their management:** Nature of industrial waste, industrial waste treatment of dairy, distillery (brewery), antibiotic industry. Monitoring methods and criteria used for measure success of waste treatment, COD, BOD, Total solid, pH, temp, TDS, heavy metals. Phytoremediation and microbial remediation. | |
| **Unit IV** | **Ethical and regulatory issues:** Intellectual property rights-introduction, trade secret, patents, copyright, plant variety protection, patenting genes and DNA sequences, gene patents and genetic resources, patenting related to genetically modified organisms, management of IPR. | |

## PRACTICALS SEMESTER VI

| USBTP07 | Practicals of Course USBT601 + Course USBT602 | 3 Credits |
|---|---|---|
| **Practicals of USBT601** | 1. Antibiotic sensitivity test using agar cup method,<br>2. Antibiotic sensitivity test using paper disc method<br>3. Antibiotic sensitivity test using ditch method.<br>4. To determine synergistic action of two drugs.<br>5. Central tendency: mean, median and mode<br>6. Data representation, frequency polygon, histogram, pie diagrams<br>7. Regression analysis<br>8. Normal deviate test (z-test)<br>9. Test of significance of means paired and unpaired t test<br>10. Internet usage, search of data bases. | |
| **Practicals of USBT602** | 1. Preparation of molar and normal solutions.<br>2. Density gradient centrifugation for separation of blood cells.<br>3. Estimation of proteins by Lowry's method.<br>4. To quantify plasmid DNA by UV spectrophotometry.<br>5. Estimation of SGOT and SGPT | |
| **USBTP08** | **Practicals of Course USBT603 + Course USBT604** | **3 Credits** |
| **Practicals of USBT603** | 1. To isolate plasmid DNA from bacteria.<br>2. To sequence DNA by Sanger's method from the given autoradiogram.<br>3. To transfer DNA by Southern blotting (demonstration)<br>4. Demonstration of PCR<br>5. To isolate antibiotic resistant mutants by Replica Plate technique<br>6. DNA estimation by DPA method<br>7. Sterility testing of vaccines. | |
| **Practicals of USBT604** | 1. To prepare medium for Plant tissue culture.<br>2. Sterilization of seeds and aseptic germination of seeds<br>3. Callus induction and Organogenesis.<br>4. Determination of BOD in the given water sample.<br>5. Determination of COD in the given water sample<br>6. Extraction of biopolymer.<br>7. Production of biofertilizers. | |

**REFERENCE:**


| Sr. No | Name of the Books | Author | Publishers |
|---|---|---|---|
| 1 | Cell And Molecular Biology | De Robertis | Lippincott Williams & Wilkins |
| 2 | Cell And Molecular Biology: Concepts and Experiments *5th Edition* | Gerald Karp | Wiley International Student version |
| 3 | Lehninger Principles Of Biochemistry *5th Edition* | Michael M. Cox, David L Nelson | W H Freeman and Company |
| 4 | Molecular Biology Of The Cell *3rd Edition* | Bruce Alberts , Dennis Bray, Julian Lewis, Martin Raff, Keith Roberts, James Watson | Garland Publishing, Inc |
| 5 | Principles and Practice of Animal Tissue Culture | Sudha Gangal | Universities Press |
| 6 | Culture Of Animal Cells *4th Edition* | Ian Freshney | A John Wiley & Sons, Inc., Publication |
| 7 | Basic Cell Culture *2nd Edition* | J M Davis | Oxford University Press |
| 8 | Alcamo's Fundamentals Of Microbiology *5th Edition* | Jeffrey C Pommerville | Jones and Bartlett Publishers |
| 9 | Microbiology *6th Edition* | Prescott, Harley, Klein | McGraw-Hill Higher Education |
| 10 | Foundations In Microbiology *2nd Edition* | K. Talaro and A. Talaro | Wm. C. Brown Publishers |
| 11 | Microbial Life | Jerome Perry, James Staley,Stephen Lory | Sinauer Associates, Publishers |
| 12 | Microbiology *4th Edition* | Michael Pelczar, Roger Reid E Chan | TATA McGRAW Hill Publishings |
| 13 | An introduction to Biostatistics *2nd Revised Edition* | N. Gurumani | MJP Publishers |
| 14 | Basic Biostatistics: Statistics for Public Health Practice | B. Burt Gerstman | Jones and Bartlett Publishers |
| 15 | Methods in Biostatistics | B K Mahajan | Jaypee Brothers |
| 16 | Biostatistics: A Foundation for Analysis in the Health Sciences *7th Edition* | Wayne W Daniel | John Wiley & Sons, Inc., Publication |
| 17 | Biostatistics: The Bare essentials *2nd Edition* | Geoffrey Norman, David Streiner | BC Decker Inc |
| 18 | Bioinformatics *2nd Edition* | A. Baxevanis and Ouellette | John Wiley & Sons, Inc., Publication |
| 19 | Bioinformatics And Molecular Evolution | Paul Higgs and Teresa Attwood | Blackwell Publishing |
| 20 | Introduction to Bioinformatics | T K Atwood and D J Parry-Smith | Pearson Education Ltd |
| 21 | Bioinformatics Instant Notes | D RnWesthead, J H Parish and R M Twyman | Viva Books Private ltd |
| 22 | Bioinformatics: Sequence, Structure and databanks *Indian Edition* | Des Higgins and Willie Taylor | Oxford University Press |
| 23 | Microbiology: An Introduction | G. Tortora, B. Funke, C. | Benjamin-Cummings |

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|---|---|---|---|
| | 8th Edition | Case | Publishing Company |

**REFERENCE:**


| Sr. No | Name of the Books | Author | Publishers |
|---|---|---|---|
| 1 | Immunology<br>*5th Edition* | Janis Kuby, Richard Goldsay, Thomas Kindt, Barbara Osborne | W H Freeman and Company |
| 2 | Immunology<br>*6th Edition* | Ivan Roitt, Jonathan Brostoff, and david Male | Mosby |
| 3 | Immunology : An Introduction<br>*4th Edition* | Ian Tizard | Thomson |
| 4 | Immunology: Essential and Fundamental<br>*2nd Edition* | S Pathak and U Palan | Capital Publishing Company |
| 5 | An Introduction to Immunology | C V Rao | NarosaPublishing House |
| 6 | Cellular and Molecular Immunology<br>*5th Edition* | Abul Abbas and Andrew Lichtman | Elsevier Saunders |
| 7 | Lehninger Principles Of Biochemistry<br>*5th Edition* | Michael M. Cox, David L Nelson | W H Freeman and Company |
| 8 | Biochemistry<br>3rd Edition | Voet Donald & Voet, Judith | John Wiley & Sons, Inc |
| 9 | Biochemistry: The Chemical Reactions of Living Cells. Volume-I & II<br>*2nd Edition* | David E Metzler | Academic Press |
| 10 | Principles of anatomy and Physiology<br>Volume 1 & 2<br>*12th Edition* | Gerard Tortora, Bryan Derrickson | John Wiley & Sons, Inc |
| 11 | Langman's Medical Embryology<br>*9th Edition* | T. W. Sadler. | Lippincott Williams & Wilkins |
| 12 | Essential Developemental Biology<br>*2nd Edition* 2006 | J. M. W. Slack | Blackwell Publishing |
| 13 | Developemental Biology<br>*8th Edition 2006* | Scott F. Gilbert | Sinauer Associates, Inc. |
| 14 | Fundamentals of Biochemistry | J L Jain, Sunjay Jain, Nitin Jain | S. Chand & Company Ltd |
| 15 | A biologists Guide to Principles and Techniques of Practical Biochemistry | William and Wilson | Edward Arnold Publishers Ltd |
| 16 | Harper's Illustrated Biochemistry<br>*26th Edition* | Rober Murray, Daryl granner, Peter Mayes, victor Rodwell | McGraw Hill |
| 17 | Bioinstrumentation | L Veerakumari | MJP Publishers |
| 18 | Practical Biochemistry: Principles and Techniques<br>*5th Edition* | Keith Wilson and John Walker | Cambridge University Press |

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| 19 | Biophysical Biochemistry: Principles and Techniques | Avinash Upadhyay, Kakoli Upadhyay and Nirmalendu Nath | Himalaya Publishing House |
| 20 | Anthony's Anatomy & Physiology *14th Edition* | Gary Thibodeau and Kevin Patton | Mosby |
| 21 | IPR: Unleashing the Knowledge Economy (2003) | Prabuddha Ganguli | Tata Mcgrow Hill publication |

## REFERENCES


| Sr. No | Name of the Books | Author | Publishers |
|---|---|---|---|
| 1 | Essential iGenetics | Peter J Russell | Pearson Education |
| 2 | Principles of Genetics<br>*8th Edition* | Eldon Gardner, Michael Simmons and Peter Snustad | John Wiley & Sons, Inc |
| 3 | Microbial Genetics<br>*2nd edition* | Stanly Maloy, John Cronan and David Freifelder | Narosa Publishing House |
| 4 | Gene Transfer To Animal Cells | R M Twyman | Bios Scientific Publishers |
| 5 | Genetics<br>*3rd Edition* | Monroe Strickberger | Prentice Hall of India |
| 6 | Gene Structure and Transcription | D Rickwood | IRL Press |
| 7 | Molecular Biotechnology: Principles and Applications of Recombinant DNA Technology<br>*3rd Edition* | Bernard Glick and Jack Pasternak | ASM Press |
| 8 | Gene IX | Benjamin Lewin | Jones and Bartlett Publishers |
| 9 | Basic Genetics | Daniel Harlt, David Freifelder and Leon Snyder | Jones and Bartlett Publishers |
| 10 | Principles of Plant Biotechnology: An Introduction to Genetic Engineering Of Plants | Mantell S H, Mathews J A and Mc Kee. | Blackwell Scientific Publications. |
| 11 | Plant Biotechnology: The Genetic Manipulation of Plant | Adrian Slater, Nigel Scott and Mark Fowler | Oxford University Press |
| 12 | Principals Of Gene Manipulation<br>*6th Edition* | S B Primrose, r M Twyman and R W Old | Blackwell Scientific Publications |
| 13 | Gene Cloning & DNA Analysis<br>*5th Edition* | T A Brown | Blackwell Publishing |
| 14 | Genomes<br>*3rd Edition* | T A Brown | Bios Scientific Publishers Ltd |

## REFERENCE


| Sr. No | Name of the Books | Author | Publishers |
|---|---|---|---|
| 1 | Biotechnology: Environmental Process I *Volume 11a* | H J Rehm and G Reed | Wiley -VCH |
| 2 | Plant Cell and Tissue Culture in Liquid Systems | G Payne, V Bringi, C Prince and M Shuler | Hanser Publishers |
| 3 | Product Recovery in Bioprocess Technology | Open Universiteit and Thames Polytechnic | Butterworth Heinemann. |
| 4 | Basic Biotechnology *2nd Edition* | Colen Ratledge and Bjorn Kristianse | Cambridge University Press |
| 5 | Experiments in Plant Tissue Culture *2nd Edition* | John Dodds and Lorin Roberts | Cambridge University Press |
| 6 | Plant Biotechnology | K G Ramavat | S Chand & Company Ltd |
| 7 | Handbook of Plant Tissue CulturePlant Cell | A F Mascarenhas | Indian Council of Agricultural Research |
| 8 | Plan Cell Culture: The Basics from Background to Bench | D E Evans, J O D Coleman and A Kearns | Bios Scientific Publishers |
| 9 | Plant Cell, Tissue and Organ Culture: Fundamental Methods | O L Gamborg and G C Phillips | Narosa Publishing House |
| 10 | Applied Dairy Microbiology *2nd Edition* | Elmer H Marth and James L. Steele | Mercel Dekker Inc, New York |
| 11 | Fundamentals of Food Microbiology *4th Edition* | Bibek Ray and Arun Bhunia | CRC Press |
| 12 | Biotechnology: A Textbook of Industrial Microbiology *2nd Edition* | Wulf Crueger and Anneliese Crueger | Panima Publishing Corporation |
| 13 | Fermentation: A Practical Approach *Indian Edition* | B McNeil and L M Harvey | Oxford University Press |
| 14 | Molecular Biotechnology: Principles and Applications of Recombinant DNA Technology *3rd Edition* | Bernard Glick and Jack Pasternak | ASM Press |
| 15 | Pharmaceutical Microbiology *7th Edition* | Hugo Russell's | Edited by Stephen P. Denyer, Hodges and Sean P. Gorman |
| 16 | Environmental Biotechnology *2nd Edition* | Alan Scragg | Oxford University Press |
| 17 | Environmental Biotechnology- Basic Concepts and Applications | Indu Shekhar Thakur | I. K. International Pvt. Ltd. |
| 18 | Environmental Biotechnology | M. H. Fulekar | Oxford & IBH Publishing |
| 19 | Fermentation Microbiology & Biotechnology | EL- Mansi & CFA Bryce | Taylor & Francis USA. |
| 20 | Bioprocess Engineering *2nd Edition* | M. Shuler & F. Kargi | Dorling Kindersley Pvt. Ltd. |
| 21 | Entrepreneurship & Business of Biotechnology | S N Jogdand | Himalaya publishing house |
| 22 | Manual of Industrial Microbiology & Biotechnology | Julian E Davies and Arnold L Demain | ASM press Washington. |

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|---|---|---|---|
| | *2nd Edition* | | |
| 23 | Process Biotechnology fundamentals *2nd Edition* | S N Mukhopadhyay | Viva books Pvt Ltd. |
| 24 | Principles of Fermentation Technology *2nd Edition.* | P. Stanbury, A. Whitaker, S. Hall | Butterworth Heineman An An Imprint of Elsevier Science |
| 25 | Prescott & Dunn's Industrial Microbiology *4th Edition* | Gerald Reed | CBS Publishers |
| 26 | Industrial Microbiology | L.E. Casida | John Wiley & Sons Inc |