

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**

<b>Course code</b>	<b>UNIT</b>	<b>Topic</b>	<b>Credits</b>	<b>L/week</b>
<b>USBT501</b>	<b>I</b>	Cytoskeleton and signal transduction	2.5	1
	<b>II</b>	Cell membrane and apoptosis		1
	<b>III</b>	ATC		1
	<b>IV</b>	ATC		1
<b>USBT502</b>	<b>I</b>	Introduction to Immunology	2.5	1
	<b>II</b>	Immunotechnology		1
	<b>III</b>	Carbohydrate metabolism		1
	<b>IV</b>	Lipid metabolism		1
<b>USBT503</b>	<b>I</b>	Genetic mapping	2.5	1
	<b>II</b>	Transgenic Plants		1
	<b>III</b>	Transgenic animals		1
	<b>IV</b>	Operon Concept		1
<b>USBT504</b>	<b>I</b>	Dairy Microbiology	2.5	1
	<b>II</b>	Fermentations: Beverages		1
	<b>III</b>	Bioreactors		1
	<b>IV</b>	Down- stream processing		1
<b>USBT505</b>	<b>Practicals of Course USBT501 + Course USBT502</b>		3	8
<b>USBT506</b>	<b>Practicals of Course USBT503 + Course USBT504</b>		3	8

<b>Course code</b>	<b>Title</b>	<b>Credits</b>
<b>USBT501</b>	<b>Cell biology and ATC</b>	<b>2.5</b>
<b>Unit I</b>	<b>Cytoskeleton:</b> Microtubules, microfilaments, and intermediate filaments. Polymerization dynamics. Role of microtubules in mitosis, cell motility and as drug target.	
	<b>Signal transduction:</b> Protein kinase. G protein and secondary messengers such as cAMP, calmodulin and Calcium, phosphatidyl inositol	
<b>Unit II</b>	<b>Cell membrane:</b> 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.	
	<b>Apoptosis:</b> Process, factors which regulate apoptotic death in normal cells. Significance	
<b>Unit III</b>	<b>Animal tissue culture:</b> Introduction to tissue culture. Advantages and limitations. Application of tissue culture	
	<b>Design and layout:</b> Sterile handling area, incubation, hot room, service bench, preparation, storage.	
	<b>Equipments, glassware and Sterilization:</b> Bio safety Cabinet, CO <sub>2</sub> incubator, autoclave, hot air oven, etc. Glassware, plastic ware, pipetting device, tissue culture vessels	
<b>Unit IV</b>	<b>Tissue culture media:</b> Physiochemical properties, Balance Salt Solution, complete media, Serum, Serum Free Medium -Advantages and Disadvantages	
	<b>Types of cell culture:</b> 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	<b>Immunology and Biochemistry</b>	<b>2.5</b>
<b>Unit I</b>	<b>Innate and acquired immunity:</b> First, second and third line of defence. Mechanism of innate immune response. Natural - Active and passive immunity. Artificial immunity - Active and passive immunity.	
	<b>Cells and organs of immune system:</b> Cells of immune system – lymphoid cells, NK cells, mononuclear phagocytes, granulocytic cells Organs of immune system – primary lymphoid organs, secondary lymphoid organs	
	<b>Antigens and Antibodies:</b> Properties of antigen, adjuvant, epitopes. Basic structure classes & sub- classes of antibodies with their biological activity (tabulated), complement, antigenic determinants on immunoglobulins.	
<b>Unit II</b>	<b>Membrane receptors for antigens:</b> 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	
	<b>Immunotechnology:</b> Principles of Antigen-antibody interaction. Types of reactions - precipitation, agglutination, flocculation reaction. Immunoassay - RIA with types, ELISA with types and ELISPOT Immunoprecipitation. Immunofluorescence – direct, indirect, FACS. Immunoblotting. Diagnostic tests – complement fixation test, Coomb’s test.	
<b>Unit III</b>	<b>Carbohydrate metabolism:</b> Biosynthesis of starch, sucrose, glycogen from glucose. Gluconeogenesis. Conversion of galactose into glucose, galactosemia. Biosynthesis of heteropolysaccharides - peptidoglycan synthesis	
<b>Unit IV</b>	<b>Lipid metabolism:</b> 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	

<b>Course code</b>	<b>Title</b>	<b>Credits</b>
<b>USBT503</b>	<b>Genetics and Molecular Biology</b>	<b>2.5</b>
<b>Unit I</b>	<b>Genetic mapping in bacteria and bacteriophages:</b> Molecular basis of transformation, conjugation and transduction. Mapping genes in bacteriophages, fine structure analysis of r II mutants	
<b>Unit II</b>	<b>Transgenic plants:</b> 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.	
<b>Unit III</b>	<b>Transgenic animals:</b> Fish, Mice and Sheep, transgenic mice methodology, retroviral method, DNA microinjection method, engineered embryonic stem cell method.	
<b>Unit IV</b>	<b>Operon concept:</b> Regulation of gene expression in bacteria - Lac operon and trp operon. <b>Transposable elements in prokaryotes and Eukaryotes:</b> Transposons, IS elements, Jumping genes in Maize.	

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

## Practicals Semester V

<b>USBTP05</b>	<b>Practical's of Course USBT501 + Course USBT502</b>	<b>3 Credit</b>
<b>Practicals of USBT501</b>	<ol style="list-style-type: none"> <li>1. To determine the total count of RBC and WBC</li> <li>2. Determination of Differential count of WBCs</li> <li>3. To determine percentage viability of cells.</li> <li>4. Osmotic fragility of RBC</li> <li>5. Study of instruments and equipment used in animal cell culture (Inverted microscope, CO<sub>2</sub> incubator, Laminar air flow, bacteria proof filter, T flask)</li> <li>6. Trypsinization of tissues and viability testing.</li> </ol>	
<b>Practicals of USBT502</b>	<ol style="list-style-type: none"> <li>1. Determination of antigen identity by Ouchterlony's method.</li> <li>2. Qualitative and Quantitative determination of Typhoid using Widal test.</li> <li>3. Determination of human blood group by ABO and Rh antigen.</li> <li>4. Estimation of sugar by GOD-POD</li> <li>5. Estimation of serum cholesterol.</li> </ol>	
<b>USBTP06</b>	<b>Practical's of Course USBT503 + Course USBT504</b>	<b>3 Credits</b>
<b>Practicals of USBT503</b>	<ol style="list-style-type: none"> <li>1. To construct restriction map from the provided data.</li> <li>2. Explain genetic phenomenon</li> <li>3. To isolate gDNA from plant source.</li> </ol>	
<b>Practicals of USBT503</b>	<ol style="list-style-type: none"> <li>1. Sterilization techniques (dry, wet, chemical and membrane)</li> <li>2. Microbiological analysis of milk by MBRT and RRT</li> <li>3. Phosphatase test for milk</li> <li>4. Isolation of antibiotic producing organism-(Wilkins overlay)</li> <li>5. Bioassay of Penicillin.</li> <li>6. Encapsulation of Yeast and estimation of invertase</li> </ol>	

**T.Y.B.Sc. Biotechnology Syllabus****Credit Based and Grading System****(To be implemented from the Academic year 2013-2014)****Semester VI**

<b>Course code</b>	<b>UNIT</b>	<b>Topic</b>	<b>Credits</b>	<b>L/week</b>
<b>USBT601</b>	I	Medical microbiology	2.5	1
	II	Antimicrobial Drugs		1
	III	Biostatistics		1
	IV	Bioinformatics		1
<b>USBT602</b>				
<b>USBT602</b>	I	Amino acid derived hormones	2.5	1
	II	Steroid hormones		1
	III	Centrifugation and chromatography		1
	IV	Spectrophotometer and Tracer techniques		1
<b>USBT603</b>				
<b>USBT603</b>	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
<b>USBT604</b>				
<b>USBT604</b>	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

<b>USBTP07</b>	<b>Practicals of Course USBT601 + Course USBT602</b>	3	8
<b>USBTP08</b>	<b>Practicals of Course USBT603 + Course USBT604</b>	3	8

Course code	Title	Credits
USBT601		2.5
<b>Unit I</b>	<p><b>Medical microbiology:</b> 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.</p> <p>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)</p> <p>Life cycle of Protozoans- Amoebiasis and Malaria</p>	
<b>Unit II</b>	<p><b>Antimicrobial Drugs:</b> Spectrum of Antimicrobial activity, Mode of action of Antimicrobial drugs - Inhibition of Cell wall Synthesis (Penicillin, Ethambutal)</p> <ul style="list-style-type: none"> <li>- Inhibitors of Protein Synthesis(Aminoglycosides, Tetracyclines, Chloramphenicol,)</li> <li>- Injury to Plasma membrane (Polymyxin B)</li> <li>- Inhibitors of Nucleic Acid Synthesis ( Nalidixic Acid, Norfloxacin, Ciprofloxacin)</li> <li>- Competitive Inhibitors (Sulfonamides)</li> </ul> <p>Concept of drug resistance</p>	
<b>Unit III</b>	<p><b>Biostatistics:</b> Central tendency, standard deviation, coefficient of correlation, regression analysis, chi square, hypothesis testing, Z-test, t-test.</p>	
<b>Unit IV</b>	<p><b>Bioinformatics:</b> Introduction to Bioinformatics, Scope of bioinformatics, bioinformatics and the internet, useful bioinformatics and sites on the www, data explosion, sequencing DNA,RNA and proteins,</p>	

Course code	Title	Credits
USBT602		2.5
<b>Unit I</b>	<b>Amino acid derived hormones, peptide, protein hormones:</b> 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.	
<b>Unit II</b>	<b>Steroid hormones:</b> Active form, storage, release, transport, physiological action and disorder of steroid hormones - Sex hormones, Menstrual cycle, adrenal cortex hormones.	
<b>Unit III</b>	<b>Centrifugation:</b> 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. <b>Column Chromatography:</b> Principle, working and applications of GC, affinity, ion exchange, gel permeation, HPLC	
<b>Unit IV</b>	<b>Spectroscopy and Tracer technique:</b> Principle of Beer and Lambert's law. Visible and ultraviolet spectroscopy – instrumentation, applications. Double beam spectroscope Detection techniques – GM counter, scintillation counter, autoradiography.	

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

Course code	Title	Credits
<b>USBT604</b>		<b>2.5</b>
<b>Unit I</b>	<p><b>Introduction to PTC:</b> Historical aspect of plant cell, tissue and organ culture. PTC lab, aseptic techniques, nutritional components of tissue culture medium.</p> <p>Initiation and maintenance of callus, organogenesis, virus elimination.</p> <p>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.</p> <p>Micropropagation, somatic embryogenesis, synthetic seed.</p>	
<b>Unit II</b>	<p><b>Biofertilizer and biopesticide:</b> Introduction, advantages over chemical, enlist and production of Rhizobium and Bacillus thuringensis</p>	
<b>Unit III</b>	<p><b>Renewable energy sources:</b> Hydrogen gas production, biogas production, Biofuel</p> <p><b>Industrial waste and their management:</b> 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.</p>	
<b>Unit IV</b>	<p><b>Ethical and regulatory issues:</b> 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.</p>	

**PRACTICALS SEMESTER VI**

<b>USBTP07</b>	<b>Practicals of Course USBT601 + Course USBT602</b>	<b>3 Credits</b>
<b>Practicals of USBT601</b>	<ol style="list-style-type: none"><li>1. Antibiotic sensitivity test using agar cup method,</li><li>2. Antibiotic sensitivity test using paper disc method</li><li>3. Antibiotic sensitivity test using ditch method.</li><li>4. To determine synergistic action of two drugs.</li><li>5. Central tendency: mean, median and mode</li><li>6. Data representation, frequency polygon, histogram, pie diagrams</li><li>7. Regression analysis</li><li>8. Normal deviate test (z-test)</li><li>9. Test of significance of means paired and unpaired t test</li><li>10. Internet usage, search of data bases.</li></ol>	
<b>Practicals of USBT602</b>	<ol style="list-style-type: none"><li>1. Preparation of molar and normal solutions.</li><li>2. Density gradient centrifugation for separation of blood cells.</li><li>3. Estimation of proteins by Lowry's method.</li><li>4. To quantify plasmid DNA by UV spectrophotometry.</li><li>5. Estimation of SGOT and SGPT</li></ol>	
<b>USBTP08</b>	<b>Practicals of Course USBT603 + Course USBT604</b>	<b>3 Credits</b>
<b>Practicals of USBT603</b>	<ol style="list-style-type: none"><li>1. To isolate plasmid DNA from bacteria.</li><li>2. To sequence DNA by Sanger's method from the given autoradiogram.</li><li>3. To transfer DNA by Southern blotting (demonstration)</li><li>4. Demonstration of PCR</li><li>5. To isolate antibiotic resistant mutants by Replica Plate technique</li><li>6. DNA estimation by DPA method</li><li>7. Sterility testing of vaccines.</li></ol>	
<b>Practicals of USBT604</b>	<ol style="list-style-type: none"><li>1. To prepare medium for Plant tissue culture.</li><li>2. Sterilization of seeds and aseptic germination of seeds</li><li>3. Callus induction and Organogenesis.</li><li>4. Determination of BOD in the given water sample.</li><li>5. Determination of COD in the given water sample</li><li>6. Extraction of biopolymer.</li><li>7. Production of biofertilizers.</li></ol>	

**REFERENCE:**

<b>Sr. No</b>	<b>Name of the Books</b>	<b>Author</b>	<b>Publishers</b>
1	Cell And Molecular Biology	De Robertis	Lippincott Williams & Wilkins
2	Cell And Molecular Biology: Concepts and Experiments <i>5<sup>th</sup> Edition</i>	Gerald Karp	Wiley International Student version
3	Lehninger Principles Of Biochemistry <i>5<sup>th</sup> Edition</i>	Michael M. Cox, David L Nelson	W H Freeman and Company
4	Molecular Biology Of The Cell <i>3<sup>rd</sup> Edition</i>	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 <i>4<sup>th</sup> Edition</i>	Ian Freshney	A John Wiley & Sons, Inc., Publication
7	Basic Cell Culture <i>2<sup>nd</sup> Edition</i>	J M Davis	Oxford University Press
8	Alcamo's Fundamentals Of Microbiology <i>5<sup>th</sup> Edition</i>	Jeffrey C Pommerville	Jones and Bartlett Publishers
9	Microbiology <i>6<sup>th</sup> Edition</i>	Prescott, Harley, Klein	McGraw-Hill Higher Education
10	Foundations In Microbiology <i>2<sup>nd</sup> Edition</i>	K. Talaro and A. Talaro	Wm. C. Brown Publishers
11	Microbial Life	Jerome Perry, James Staley, Stephen Lory	Sinauer Associates, Publishers
12	Microbiology <i>4<sup>th</sup> Edition</i>	Michael Pelczar, Roger Reid E Chan	TATA McGRAW Hill Publishings
13	An introduction to Biostatistics <i>2<sup>nd</sup> Revised Edition</i>	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 <i>7<sup>th</sup> Edition</i>	Wayne W Daniel	John Wiley & Sons, Inc., Publication
17	Biostatistics: The Bare essentials <i>2<sup>nd</sup> Edition</i>	Geoffrey Norman, David Streiner	BC Decker Inc
18	Bioinformatics <i>2<sup>nd</sup> Edition</i>	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 <i>Indian Edition</i>	Des Higgins and Willie Taylor	Oxford University Press
23	Microbiology: An Introduction	G. Tortora, B. Funke, C.	Benjamin-Cummings

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

**REFERENCE:**

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

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

## REFERENCES

<b>Sr. No</b>	<b>Name of the Books</b>	<b>Author</b>	<b>Publishers</b>
1	Essential iGenetics	Peter J Russell	Pearson Education
2	Principles of Genetics <i>8<sup>th</sup> Edition</i>	Eldon Gardner, Michael Simmons and Peter Snustad	John Wiley & Sons, Inc
3	Microbial Genetics <i>2<sup>nd</sup> edition</i>	Stanly Maloy, John Cronan and David Freifelder	Narosa Publishing House
4	Gene Transfer To Animal Cells	R M Twyman	Bios Scientific Publishers
5	Genetics <i>3<sup>rd</sup> Edition</i>	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 <i>3<sup>rd</sup> Edition</i>	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 <i>6<sup>th</sup> Edition</i>	S B Primrose, r M Twyman and R W Old	Blackwell Scientific Publications
13	Gene Cloning & DNA Analysis <i>5<sup>th</sup> Edition</i>	T A Brown	Blackwell Publishing
14	Genomes <i>3<sup>rd</sup> Edition</i>	T A Brown	Bios Scientific Publishers Ltd

## REFERENCE

Sr. No	Name of the Books	Author	Publishers
1	Biotechnology: Environmental Process I <i>Volume 11a</i>	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 <i>2<sup>nd</sup> Edition</i>	Colen Ratledge and Bjorn Kristiansen	Cambridge University Press
5	Experiments in Plant Tissue Culture <i>2<sup>nd</sup> Edition</i>	John Dodds and Lorin Roberts	Cambridge University Press
6	Plant Biotechnology	K G Ramavat	S Chand & Company Ltd
7	Handbook of Plant Tissue Culture Plant 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 <i>2<sup>nd</sup> Edition</i>	Elmer H Marth and James L. Steele	Mercel Dekker Inc, New York
11	Fundamentals of Food Microbiology <i>4<sup>th</sup> Edition</i>	Bibek Ray and Arun Bhunia	CRC Press
12	Biotechnology: A Textbook of Industrial Microbiology <i>2<sup>nd</sup> Edition</i>	Wulf Crueger and Anneliese Crueger	Panima Publishing Corporation
13	Fermentation: A Practical Approach <i>Indian Edition</i>	B McNeil and L M Harvey	Oxford University Press
14	Molecular Biotechnology: Principles and Applications of Recombinant DNA Technology <i>3<sup>rd</sup> Edition</i>	Bernard Glick and Jack Pasternak	ASM Press
15	Pharmaceutical Microbiology <i>7<sup>th</sup> Edition</i>	Hugo Russell's	Edited by Stephen P. Denyer, Hodges and Sean P. Gorman
16	Environmental Biotechnology <i>2<sup>nd</sup> Edition</i>	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 <i>2<sup>nd</sup> Edition</i>	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.

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