

B.Sc. SEMESTER PATTERN IN

MICROBIOLOGY

SEMESTER IV

GONDWANA UNIVERSITY

GADCHIROLI

INDIA

www.oxpof.com

Gondwana University, Gadchiroli
Teaching & Examination Scheme
Bachelor of Science
Three Year (SIX SEMESTER) Degree course

MICROBIOLOGY

1. There shall be total six Semesters. Total 3000 Marks.
2. The Division / Grade of the student shall be calculated on the basis of Science subjects as per the previous yearly pattern.
3. Each semester shall comprise of 90 teaching days.
4. Semester I and II shall be of 600 Marks
5. Semester III to VI shall be of 450 Marks
6. Microbiology subject in each semester will comprise of
 - a. Two theory papers – 50 Marks each
 - b. One internal assessment based on two theory papers for 10 Marks each. Total 20 Marks.
 - c. One practical / Laboratory work – Total 30 marks
7. In addition to above Semester I and II will have
 - a. One compulsory English paper of 60 marks with 15 marks internal assessment.
 - b. One second language paper (Supp Eng / Hindi / Marathi / Urdu / etc) of 60 Marks with 15 marks internal assessment.
8. The Internal assessment shall be conducted by the University approved teachers in the relevant subjects.
9. The internal assessment shall be done by the respective college one month prior to the final exam of each semester. The Marks shall be sent to the university immediately after the internal assessment is over.
10. The pattern of Internal assessment and guidelines for the same shall be prepared by the respective subject Board of Studies
11. All Theory papers shall be divided into four units. Each unit shall be covered in 7.5 hours.
12. The theory question papers shall be of 3 hours duration and comprise of 5 questions with internal choice and with equal weightage to all units. (as per the previous pattern)
13. Practical exam shall be of 10 hours duration , 5hrs each for two consecutive days.
14. Table of teaching and examination scheme attached.

Teaching & Examination Scheme
Bachelor of Science (Microbiology)
Three Year (SIX SEMESTER) DEGREE COURSE
B. Sc. Part II (Semester III and IV)

S. No.		Subject	Teaching scheme			Examination scheme										
			Th + Tu (Periods)	Pr (Periods)	Total Periods	Theory					Practical					Total Marks / credits (Th, Pr, IA)
						Duration Hrs	Max Marks Th paper	Min Passing Marks Th	Max Marks Int Assessment	Min Passing IA	Total	Min passing Marks	Duration Hrs	Max marks practical	Min passing marks	
1	Semester-III	Microbiology Paper I- Enzymology And Metabolism	3+@	-	6+@	3	50	18	10	4	120	22	-	-	-	150
2		Microbiology Paper II- Industrial And Food Microbiology	3+@	-		3	50	18	10	4		22	-	-	-	
3		Practical	-	6		6	-	-	-	-		-	-	-	10*	
4	Semester-IV	Microbiology Paper I- Microbial Genetics	3+@	-	6+@	3	50	18	10	4	120	22	-	-	-	150
5		Microbiology Paper II- Applied Microbiology	3+@	-		3	50	18	10	4		22	-	-	-	
6		Practical	-	6		6	-	-	-	-		-	-	-	10*	
Grand Total of Semester III & IV: 450 each semester = TOTAL - 450 Marks per semester																

Note: Th = Theory; Pr = Practical; Tu = Tutorial; IA = Internal Assessment; @ = Tutorials wherever applicable; * = If required, for two days.

MICROBIOLOGY
B. Sc. Semester IV

Paper I : Microbial Genetics

Unit I : Gene and Gene Action

- a. Concept of gene, genome.
- b. Muton, recon and cistron
- c. Monocistronic and polycistronic concept, central dogma of gene action
- d. Split gene , gene within gene.
- e. Gene regulation- Lac operon (in brief).

Unit II : Mutation

- a. Spontaneous versus induced mutations.
- b. Molecular basis of mutation- Types of mutation-base pair substitution, frame shift mutation, point, non sense, missense, silent
- c. Mutagenic agents- Physical and chemical.
- d. Mutation rate , Ames test.

Unit III : DNA Replication and Protein Synthesis

- a. Replication of DNA-general features, enzyme involved, modes of replication, rolling circle, knife and fork
- b. Repair of damaged DNA (NER, BER)
- c. Genetic code : characteristics
- d. Transcription- enzyme involved , promoter, initiation of synthesis, elongation, termination, reverse transcription
- e. Translation in prokaryotes, general features, enzyme and factors involved

Unit IV: Genetic Recombination

- a. Transformation- Competence, DNA uptake, artificially induced competence, Griffith experiment
- b. Transposable elements.
- c. Transduction- U tube experiment, Generalized and specialized transduction, Abortive and complete transduction.
- d. Conjugation- F factor, characters of donor and recipient.
- e. Sexduction, formation of Hfr and F prime cells.

MICROBIOLOGY
B. Sc. Semester IV

Paper II: Applied Microbiology

Unit I : Air and Soil Microbiology

- a. Microorganisms present in air
- b. Significance of microbial analysis of air
- c. Solid and liquid impingement technique(Lemon sampler, Anderson sampler)
- d. Room sterilization techniques(radiation, fumigation, laminar air flow)
- e. Biogeochemical cycles- nitrogen cycle, carbon cycle, sulfur cycle, phosphorus cycle

Unit II: Water Microbiology

- a. Collection and handling of water sample
- b. Indicators of excretal pollution
- c. Bacteriological analysis of water for coliforms(MTDI , MPN)
- d. Identification of faecal and non faecal coliforms(IMViC and Eijkmann test)
- e. Water treatment using RSF
- f. Chlorination of water (mechanism), different methods

Unit III: Waste Water Treatment

- a. Sewage: definition and types, composition and characterization of sewage (ThOD, BOD, COD)
- b. Objective of sewage treatment
- c. Preliminary (screening and grit removal) and primary treatment (Septic tank, Imhoff tank)
- d. Biological or secondary treatment: trickling filter, activated sludge, oxidation pond, rotating biological contactor(RBC)

Unit IV: Environmental Biotechnology

- a. Microbial leaching - bioleaching of copper and Uranium
- b. Microbial enhanced oil recovery (MEOR).
- c. Bioremediation, Acid mine drainage, desulfurization of coal
- d. Biogas plant ,construction and working mechanism

Practical Course for Semester IV (Based on theory paper I & II)
Marks :30

1. Isolation of microorganisms from water and sewage
2. Isolation of microorganisms from air .
3. *Detection of coliforms
 - a. Multiple tube dilution technique(MPN)
 - b. IMViC Test
4. *Determination of DO, alkalinity, residual chlorine
5. Determination of BOD and COD of sewage
6. *Isolation of phosphorous solubilizing bacteria/fungus from soil sample.
7. Isolation of antibiotic resistant bacterial mutants by chemical/ physical method
8. Testing of chemicals for mutagenesis by Ames test
9. Demonstration of UV induced mutagenesis in *E.coli*
10. Demonstration of denitrification / nitrate reduction
11. Estimation of organic carbon from soil
12. Determination of Nitrogen in soil by Kjeldahl method
13. Determination of phosphorus and potassium in soil
14. Transformation
15. Conjugation

- Note:** 1. Underlined experiments are treated as major experiments.
2. Students should perform atleast 4 major and 6 minor experiments
3. Practicals with asteric mark are compulsory.

Distribution of marks during Practical examination of B.Sc. Microbiology Semester IV

1. One major experiment	10
2. Two minor experiment	2x5= 10
3. Viva voce	5
4. Practical record	5

30

(Duration of exam will be 10hrs., 5 hrs. each for two consecutive days)

Books Recommended for Theory & Practical Microbiology B.Sc. Sem. IV

1. Fundamental Principles of Bacteriology, Author- A.J. Salle. Tata Mcgraw Hill.
2. Stanier, R.Y., *et al*, General Microbiology, 5thed Macmillan press.
3. Pelczar M., *et al* Microbiology, 5thed., 2000, Tata Mcgraw Hill.
4. Atlas RM, Principles of Microbiology, 2thed, 1997 Tata Mcgraw Hill.
5. Prescott LM, Microbiology, 6thed, 2005 Tata Mcgraw Hill.
6. Dube R C and Maheswari,DK Text book of Microbiology ,S. Chand and Co.
7. Lodish , et. Molecular cell biology ,WH Freeman;2003
8. Molecular Biology of the Gene(5th edition) : By James D watsonetal
9. Biotechnology – Expanding Horizon by B.D. Singh, 1st Ed.,KalyaniPub., Delhi.
10. Microbiology- Tortora, G.J., Funke, B.R., Case, C.L.
11. Elementary Microbiology- H. A. Modi
12. General Microbiology- Powar and Daginawala.
13. Fundamentals in Microbiology- Frobisher and Hinsdinn.
14. Waste water Microbiology- Gabriel Bitton
15. Genes XI, Author- B. Lewin.
16. Molecular characterization of bacterial isolates from RAM(measuring microbiome)- Vijay wadhai and HariomPowar- Lambert Academic Press, Germany
17. Principles of Genetics- Gardner, Simmons and Snustad.
18. Concepts of Genetics, Authors- Klug and Cummings.
19. Microbial Genetics- Freifelder.
20. Genetics- Arora and Sandhu.
21. Introduction to soil Microbiology- M.A.Alexander
22. An introduction to Industrial Microbiology- Michal J Waites
23. Soil microorganism and plant growth- N.S. Subbarao, Oxford and IBH Pub. co. Delhi
24. Nature and properties of soil- N.C.Brady
25. InduShekhar Thakur- Environmental Biotechnology, IK International Pvt. Ltd.New Delhi
26. Keya Choudhary, Genetics, The Energy & Resources Institute, New Delhi

MICROBIOLOGY
B. Sc. Semester V

Paper I: Medical Microbiology

Unit I: Epidemiology and Host-Parasite Relationship

- a. Explanation of medical terms
 - i) Infection, types of infections, primary infection, Secondary infection, Acute and chronic infection, Local and systemic infection, Fulminating infection, Nosocomial infection, Iatrogenic infection, Teratogenic infection, Congenital infection
 - ii) Disease, Sign, Symptoms, Syndrome, Types of disease, Epidemic, Endemic, Pandemic, Prosodemic, Sporadic, Exotic, Venereal, Zoonotic, Epizootic, Exotic
 - iii) Infection process(pathogenesis)- Bacteremia, Septicemia, Pyaemia, Sappremia, Toxemia, Viremia
- b. Stages of Infectious disease- Incubation period, Prodromal phase, invasive phase, decline phase, convalescence.
- c. Control of communicable diseases, different methods.
- d. Normal flora of human body- characteristic of normal flora, beneficial and harmful effects of normal flora, Normal flora of skin, eye, respiratory tract, digestive tract, urino-genital tract, blood and tissues.

Unit II: Dynamics of Disease Transmission

- a. Causative/etiological agents of various diseases, bacterial, viral, fungal, protozoan, rickettsial, waterborne, foodborne, airborne (list only).
- b. Sources/reservoir of infections- endogenous sources, exogenous sources, case, carriers, animals, insect, non-living sources.
- c. Portals of exit, Portals of entry.
- d. Modes of transmission- Contact, Vehicle, Vector, airborne, Trans-placental, Laboratory, Hospital.
- e. Susceptibility of host.

Unit III: Microbial Mechanism of Pathogenicity

- a. Pathogenicity and Virulence, difference
- b. Variation of virulence, Exaltation, Attenuation, methods of attenuation.
- c. Virulence determining factors
 - i) Infectivity – MID, MLD, ID50, LD50
 - ii) Invasiveness, factors responsible (aggresins)
 - iii) Toxicogenicity – Exotoxin, Endotoxin, comparison, enterotoxin.
 - iv) Vaccine and toxoid, types

Unit IV: Microbial Diseases of Human

- a. Diseases of skin, eye, digestive tract, respiratory tract, urinary tract, reproductive system, nervous system, cardiovascular and lymphatic system (only list with causative organism).
- b. Study of pathogenic organisms (Morphology, cultural and biochemical characteristics, Pathogenesis, laboratory diagnosis, prevention)
 - i. *Salmonella typhi* ii) *Mycobacterium tuberculosis* iii) *Shigella dysentery* iv) Plasmodium
 - v) Chickungunia virus vi) Dengue virus vii) HIV

www.oxpdf.com

MICROBIOLOGY
B. Sc. Semester V

Paper II: Bioinstrumentation

Unit I: Spectrophotometry

- a. Concept of electromagnetic radiation, spectrum of light
- b. Beer's law and deviations, extinction coefficient
- c. Difference between spectrophotometer and colorimeter.
- d. Construction and working of UV and visible Spectrophotometry.
- e. Applications in biological science.

Unit II: Chromatography

- a. Partition principle, partition coefficient, nature of partition force
- b. Brief account of paper chromatography, application
- c. Thin layer chromatography- Application
- d. Column chromatography- Principle and application of gel filtration, Ion-exchange, Affinity chromatography

Unit III: Electrophoresis & Blotting of Biomolecules

- a. Electrophoresis- Migration of ions under electric field, factors affecting electrophoretic mobility,
- b. Paper electrophoresis, cellulose acetate electrophoresis, application
- c. Gel electrophoresis-Types of gels, solubilizers, procedure, column, slab gels application
- d. SDS-PAGE electrophoresis- principle, procedure and applications
- e. Blotting technique-Southern blotting, Northern blotting, Western blotting (in brief)

Unit IV: Centrifugation & Isotopic Tracer Technique

- a. Centrifugation: Basic principles, concept of RCF, Sedimentation coefficient
- b. Types of centrifuges- clinical, high speed and ultracentrifuge- application, Density gradient centrifugation
- c. Radioactive and stable isotopes, rate of radioactivity decay, units of radioactivity
- d. Radioisotope methods, types of radioactive decay - Half life and radioactivity- GM counter – Scintillation counter – Autoradiography

Practical Course for Semester V (Based on Paper I & Paper II)

Marks: 30

1. *Laboratory diagnosis of i) *E.coli* ii) *P. vulgaris* iii) *S. typhi*
2. *Isolation and detection of *S. aureus* from pus sample.
3. To study normal flora of skin and oral cavity.
4. Detection of Malarial parasite from blood sample.
5. Detection of Chikungunia and Dengue fever (demonstration only)
6. *Determination of Minimum Inhibitory Concentration(MIC) of Antibiotics.
7. *Estimation of Blood sugar by GOD-POD method
8. *Liver function test - SGOT and SGPT
9. Kidney function test- Creatinine , Urea
10. Detection of Bilirubin.
11. *Estimation of Blood cholesterol.
12. Estimation of blood urea by Diacetylmonoxime method (DAM)
13. *Paper chromatography of amino acids/sugars.
14. *TLC of lipid/amino acids.
15. Demonstration of separation of components by paper electrophoresis
16. Separation of protein by SDS-PAGE (Sodium dodecyl sulfate-Polyacrylamide gel electrophoresis)
17. Blotting of DNA by Southern Blotting technique

- Note:** 1. Underlined experiments are treated as major experiments.
2. Students should perform atleast 4 major and 6 minor experiments
3. Practicals with asteric mark are compulsory.

Distribution of marks during practical examinations of B.Sc. Semester V

1. One major experiment		10
2. Two minor experiment	2 X 5	= 10
3. Viva voce-		5
4. Practical record-		5

Total		30

(Duration of Practical exam will be 10 hrs., 5 hrs. each for two consecutive days)

Books Recommended for Theory & Practical Microbiology B.Sc. Sem. V

1. Ananthnarayan and Panikars, Textbook of Microbiology (8th edition), University Press, Hyderabad
2. Jayaram Paniker CK (2004). Text book of Medical Parasitology. Fifth edition, Jaypee Brothers Medical Publishers (P) Ltd., New Delhi.
3. Essentials of Medical Microbiology. 4th Edition. Rajesh Bhatia. JAYPEE Publisher
4. Tortora G.J., Funke B.R., Case C.L. (2006). Microbiology: an Introduction. 8th edition. Pearson Education Inc.
5. Powar and Dagainawala General Microbiology Vol. I & II (Himalaya Publication)
6. Dubey R. C. and Maheshwari D.K. Text Book of Microbiology, S. Chand Publisher
7. Pelzar, Chan and Kreig, Microbiology 5th edition, TMH Publisher
8. Frobisher, Hindsill et al., Fundamentals of Microbiology : W.B. Saunders Company, 7th edition USA, Topman co. Ltd. Japan
9. Stainer, Roger et al., General Microbiology
10. Atlas R.A. Microbiology- Fundamental and Applications, Macmillan
11. Salle A.J. Fundamental Principles of Bacteriology, Tata McGraw-Hill Publishing Co. Ltd, New Delhi.
12. Brock T.D. and Madigan M.T. Biology of Microorganisms, Prentice Hall of India Private Limited
13. Alcamo, Fundamentals of Microbiology
14. Purohit, Microbiology fundamentals and applications
15. Davis, Dulbecco, Microbiology
16. Thomas, Clinical Microbiology, University Press, Hyderabad
17. Ramkrishnan, Textbook of Medical Biochemistry University Press, Hyderabad
18. Medical Microbiology and parasitology, Day and Day, Himalaya Publisher
19. Manual of Practical Microbiology and Parasitology, P. Chakroborty. NCBA, Kolkata
20. Upadhyay & Nath, Biophysical Chemistry, Himalaya publishing house, New Delhi, 2009
1. Bajpai PK (2010). Biological Instrumentation and Methodology. Revised edition, S. Chand & Co. Ltd., New Delhi.
2. Palanivelu P (2004). Analytical Biochemistry and Separation techniques. Third edition, MKU Co-op, Press Ltd., Palkalai Nagar, Madurai.
3. Subramanian MA (2005). Biophysics – Principles and Techniques. First edition, MJP Publishers, A Unit of Tamil Nadu Book House, Chennai
4. Aneja KR (2005). Experiments in Microbiology, Plant pathology and Biotechnology. Fourth edition, New Age International Publishers, Chennai.
5. Dubey RC and Maheswari DK (2004). Practical microbiology First edition, S Chand and Company Ltd., New Delhi.
6. James G Cappuccino and Natalie Sherman (2004). Microbiology: A laboratory manual. Sixth edition, Published by Pearson Education
7. Jayaraman., Lab Manual in Biochemistry
8. David T. Plummer, An Introduction to Practical Biochemistry
9. Curikshank, Medical Microbiology
10. Parasitology, Chatterjee

MICROBIOLOGY
B. Sc. Semester VI

Paper I : Recombinant DNA Technology

Unit I : Fundamentals of r DNA Technology

- a. History and fundamentals of r DNA technology
- b. Tools for rDNA technology- DNA manipulative enzymes :Restriction enzymes, Ligases and other DNA modifying enzymes
- c. Cloning vectors: salient features, Plasmid-properties, types (pBR322 and pUC 18), Bacteriophage vectors (Lambda),Cosmid, Phagmid, Artificial chromosome (BAC,YAC)
- d. Characteristics of ideal host: *E.coli*

Unit II: Construction of rDNA and its Transfer to Host Cell

- a. *In vitro* construction of rDNA molecule-isolation of passenger DNA from host (gene of interest from host) and isolation of vector DNA
- b. Cutting of DNA molecules- enzymatic methods & joining of DNA molecules
- c. Homopolymer tails, Linkers, Adapters
- d. Transfer of rDNA into suitable host cell- transfection, gene gun (biolistic method), microinjection, protoplast fusion and electroporation
- e. Screening and selection of recombinant host cells : insertional inactivation , colony/ DNA hybridization

Unit III: Sequence Analysis & Amplification of DNA Fragments

- a. Construction of gene libraries : genomic and cDNA libraries
- b. DNA sequencing and synthesis : Maxam- Gilbert and Sangers method, Automated sequencing, Human genome sequencing project
- c. Polymerase Chain reaction (PCR)- principle, method and application
- d. DNA fingerprinting

Unit IV : Product of rDNA Technology

- a. Application in medical field- gene therapy, Stem cells, introduction and application, Hybridoma technology , monoclonal antibody formation
- b. Application in agriculture field : transgenic plant- Bt Cotton
- c. Application in Pharmaceuticals : Interferon, Vaccines, Insulin, Human Growth hormone
- d. Genetically modified food (one example)

MICROBIOLOGY
B. Sc. Semester VI

Paper II: Immunology

Unit I: Structure and functions of Immune system

- a. General concept and short history of immunology
- b. Primary Lymphoid organs- Thymus and Bone marrow
- c. Secondary Lymphoid organs- Spleen and Lymph node
- d. Lymphoid tissues- MALT / GALT
- e. Cells of immune system- B Lymphocytes, T Lymphocytes, Comparison, Types of T lymphocytes,
- f. Other immune-competent cells- Monocytes, macrophages, Dendritic cells, Killer cells, Antigen presenting cells, Neutrophil, Eosinophil, basophil, Mast cell.

Unit II: Resistance/ Immunity of the host.

- a. Concept of body resistance/ Immunity, types of immunity.
- b. Non-specific resistance (Natural/ Innate immunity)- Species, racial and individual resistance.
- c. Factors influencing Innate immunity- Age, Sex, hormonal and nutritional.
- d. Mechanism of Innate immunity – anatomic and physiologic barriers, phagocytosis, inflammatory response, fever.
- e. Specific/Adoptive resistance(Acquired immunity)- Active and passive immunity, comparison, types,
- f. Humoral immune response, primary and secondary immune response
- g. Cell mediated immunity, mechanism, MHC complex and MHC molecules

Unit III: Antigens, Antibodies and Antigen-Antibody reactions.

- a. Definition of antigen, epitope, haptin, Types of antigen, Factors determining Antigenicity.
- b. Definition of Antibody, general structure, Classes of immunoglobulins, Structure and their functions
- c. Antigen-Antibody reactions.
 - i) Precipitation reaction- precipitation in liquid, immuno-diffusion.
 - ii) Agglutination reaction- Slide and Tube agglutination, Coomb's test.
 - iii) Complement fixation reaction- Wasserman test.
- d. Tagged Antibody test- ELISA, Radioimmunoassay (RIA), Immunofluorescence.

Unit IV: Hypersensitivity and Autoimmunity

- a. Definition of Hypersensitivity, Gell and Coomb's classification-Immediate(Type I ,Type II & Type III),Delayed hypersensitivity(Type IV), examples.
- b. Mechanism of hypersensitivity – Type I (Anaphylaxis), Type II (erythroblastosis fetalis), Type III (Arthus reaction, serum sickness), Type IV (Contact dermatitis, Mantoux test).
- c. Immunological tolerance
- d. Autoimmunity, mechanism , causes of autoimmunity, autoimmune disorders (Rheumatic arthritis and Myasthenia gravis)

Practical Course for Semester VI (Based on Paper I & Paper II) Marks: 30

1. Clinical investigations:

- a. *Blood group and Rh factor
- b. *Total Leucocyte count
- c. Differential Leucocyte count
- d. *Hemoglobin % in Blood.

2. Immunological tests:

- a. *Detection of Typhoid and Paratyphoid fever by slide/tube agglutination test (WIDAL)
- b. *Detection of Syphilis by TRUST antigen test.
- c. *Detection of Pregnancy in women by strip method
- d. Demonstration of HBsAg by Hepacard test
- e. *Estimation of Antigen by Single Radial Immune Diffusion(RIA).
- f. Detection of AIDS by ELISA test.
- g. Test for Rheumatoid arthritis (RA)

3. Molecular Biology Techniques

- a. *Isolation of plasmid DNA
- b. *Isolation of genomic DNA from bacterial cell and separation of isolated genomic DNA by agarose gel electrophoresis
- c. *Digestion of DNA using restriction enzyme and analysis by agarose gel electrophoresis
- d. Ligation of digested DNA fragment
- e. DNA amplification by PCR (Demonstration)
- f. Gene cloning- cloning of GFP gene

- Note:**
1. Underlined experiments are treated as major experiments.
 2. Students should perform atleast 4 major and 6 minor experiments
 3. Practicals with asteric mark are compulsory.
 4. An educational tour (visit to Pharmaceutical ,Dairy industry, Research institute) is compulsory in
V or VI semester
 5. For project a suitable microbial investigation involving laboratory work or survey work may be given to 1-3 students at the beginning of semester
 6. Report on project / review work preferably printed should be submitted duly certified by incharge teacher and head of the department

Distribution of marks during practical examinations of Microbiology B.Sc. Sem. -VI

1. One major experiment-	08
2. Two minor experiment- 2 X 4=	08
3. Project (lab or review work)	06
4. Viva voce-	4
5. Practical record-	4

Total	30

Duration of Practical examination will be 10hrs., 5 hrs. each for two consecutive days

Books Recommended for Theory & Practical Microbiology B.Sc. Sem. VI

1. Singh B.D.(2007),Biotechnology, Kalyani Publisher
2. Mitra (2005). Genetic engineering. Published by Macmillan India Ltd., Chennai.
3. Jogdand SN (2005). Gene biotechnology. Himalaya Publishing House, Mumbai
4. JOGDAND S.N. (2007) Advances in Biotechnology , Himalaya Publishing House, 2007
5. Satyanarayana (2005). Biotechnology. First edition, Books and Allied (P) Ltd., Kolkata.
6. Preeti Joshi (2002). Genetic engineering and its application. First edition, Agrobios (India).
7. Dubey RC (2005). A Text of Biotechnology. Multicolour Illustrative edition, S.Chand and Company Ltd., New Delhi.
8. Bernad R Glick (2003). Molecular Biotechnology - Principles and Applications of Recombinant DNA. Third edition, ASM Press, Washington, D.C.
9. Ramawat K and ShailyGoyal (2010). Molecular Biology and Biotechnology. First edition, S.Chand and company Ltd., New Delhi.
10. Dale J.W., Molecular Genetics of bacteria, 1994, John Wiley & Sons.
11. James D. Watson, Nancy H. Hopkins, Jeffrey W. Roberts, Joan ArgetsingerSteitz, Alan M. Weiner 1987, 4th edition. The Benjamin/Cummings Pub.
12. Lewin B. 2002 Genes VIII. Oxford.
13. Nancy Hopkins -Microbial genetics :.
14. Freifelder, D., 2000, Molecular Biology, second edition, Naros Publishing House, New Delhi.
15. Lehninger, 2010, Principles of Biochemistry, 5th edn., by Nelson & Cox, W.H. Freeman and Co.NYork.
16. Watson, J.D. *et.al.*, 2004, Molecular Biology of the Gene, 5th edn., Pearson pub.,
17. Brown, T.A. 2000, Gene Cloning, fourth edition, Chapman and Hall Publication, USA.
18. Old R.W. and PrimroseS.B.,1996, Prin.of Gene Manipulations, Blackwell Science Publications, London.
19. Mahadav Sharma &NirmalTripathi, Immunobiotechnolgy,
20. Kannan, Immunology
21. Roitt Ivan M. ,Brostoff Jonathan, Male DevidK.,Immunology 3rd edn,
22. Richard A. Goldsby, Thomas J. Kindt, JanisKuby Immunology 5th edn, .

23. Principles of Immunology, N.V. Shastri. Himalaya publisher.
24. P. Chakroborty. NCBA, Kolkata Manual of Practical Microbiology and Parasitology,
25. R.P. Singh ,Immunology and Medical Microbiology -Kalyani publishers
26. Bansal M P , Molecular Biology & Biotechnology, Basic exp. Protocol,TERI,New Delhi
27. Immunology and Microbiology, Dulsy Fatima, A. Mani. Saras Publication

www.oxpdf.com