

**BHARATHIAR UNIVERSITY, COIMBTORE.**

**M.Sc. MICROBIOLOGY**

**SCHEME OF EXAMINATION (CBCS PATTERN)**

**For the students admitted during the academic year 2014-2015 Batch onwards**

Study Components	Course Title	Ins. hrs / week	Exam				Credit
			Dur. Hrs.	CIA	Uni. exam	Total	
<b>Semester I</b>							
Paper I	Fundamentals of Microbiology and Bioinformatics	5	3	25	75	100	4
Paper II	Microbial Physiology and Biochemistry	5	3	25	75	100	4
Paper III	Applied Biotechniques	5	3	25	75	100	4
Paper IV	Environmental and Agricultural Microbiology	5	3	25	75	100	4
Practical	Practical I	5	-	-	-	-	-
Elective	Paper I	5	3	25	75	100	4
<b>Semester II</b>							
Paper V	Molecular Genetics	5	3	25	75	100	4
Paper VI	Virology and Nanotechnology	5	3	25	75	100	4
Paper VII	Bioprocess Technology	5	3	25	75	100	4
Paper VIII	Engineering of Genes and Proteins	5	3	25	75	100	4
Practical	Practical I	-	9	40	60	100	4
Practical	Practical II	5	9	40	60	100	4
Elective	Paper II	5	3	25	75	100	4
<b>Semester III</b>							
Paper IX	Immunology and Immunotechnology	5	3	25	75	100	4
Paper X	Medical Microbiology	5	3	25	75	100	4
Paper XI	Biotechnology and IPR	5	3	25	75	100	4
Paper XII	Microbial Food Technology	5	3	25	75	100	4
Paper XIII	Biostatistics and Research Methodology	5	3	25	75	100	4
Practical	Practical III	5	-	-	-	-	-
<b>Semester IV</b>							
Elective	Paper III	5	3	25	75	100	4
Practical	Practical III	5	9	40	60	100	4
Project	Project and viva voce	-	-	-	-	200*	8
Training	Industrial training and viva voce @	-	-	50	-	50*	2
Elective	Paper IV -Practical	5	9	40	60	100	4
Total						2250	90

\* Project Report – 160 Marks, Viva voce- 40 Marks

\* Students should undergo an institutional/industrial training relevant to any one of theory paper for a continuous period of 15 days before semester IV and submit report along with attendance certificate. Training Report – 40 Marks, Viva voce- 10 Marks.

@ No University Examinations. Only Continuous Internal Assessment (CIA).

**List of Group Elective papers (Colleges can choose any one of the Group papers as electives)**

	GROUP A	GROUP B	GROUP C
Paper I/Sem I	Principles of Quality Assurance	Environment and Health	Basic Biological Sciences
Paper II/Sem II	Quality Assessment in Pharmaceuticals	Communicable and Non-communicable diseases	Biophysics and Biochemistry
Paper III/Sem IV	Total Quality Management (TQM)	Health care of the community	Molecular Cytology and Tissue Engineering
Paper IV/Sem IV	Practical	Practical	Practical

**Guidelines for the Project Work:**

Two reviews be conducted with all the students & staff members in the month of Jan. & Feb.  
2<sup>nd</sup> review if necessary an external expert may be called.

## **SEMESTER I: PAPER I - FUNDAMENTALS OF MICROBIOLOGY & BIOINFORMATICS**

### **UNIT I**

Basic concepts – Spontaneous generation- Germ theory of diseases – Cell theory – Contributions of Antony van leuwenhoek – Joseph Lister – Robert Koch – Louis Pasteur – Edward Jenner – John Tyndall – Sergei N. Winogradsky – Salmon Awaksman – Alexander Flemming- Paul Erlich – Fannie Hessie – Elie Metchnikoff - Kary Mullis. Development of pure culture methods.

### **UNIT II**

Sterilization and disinfection – Definitions – Principles – Methods of sterilization -: Physical methods – Heat –Filtration – Radiation and Chemical methods. Control of sterilization and Testing of sterility. Microscopy – Principles, Light microscope, Phase Contrast, Dark field, Bright field, Fluorescent – Interference microscope (Stereo microscope), Con focal scanning microscope – Inverted microscope - Electron microscope – TEM, SEM. and Micrometry. Staining: Simple, Gram staining, Negative staining, Capsule staining, Spore staining, Flagellar staining, Nuclear staining and Acid fast staining.

### **UNIT III**

Taxonomy – Principle and its types (Classical approach – Numerical, Chemical, Serological and Genetic). Bacterial taxonomy – Bergey's manual of Systematic Bacteriology (Eubacteria and Archaeobacterium)

### **UNIT IV**

Fungal taxonomy – Alexopolus, Algal taxonomy – Classes, Ultra structure and general characteristics. Outline classification of Protozoa – general characters and importance. Economic importance of algae and fungi.

### **UNIT V**

Introduction to bioinformatics – Classification of Biological data bases – Biological data formats – Applications of Bioinformatics in various fields – Data retrieval – Entrez and SRS. Introduction to sequence alignment. Data base search for similar sequences using FASTA and BLAST programmes.

### **References:**

- Pelczar. M.J. Jr, E.C.S. Chan Moel: Microbiology Mc Graw Hill Book R Kreig, 1986.  
Prescott. L.M. J.P. Harley and C.A. Klein, 2004. Microbiology VI edition.  
Atlas R.M. 1997. Principles of Microbiology. II ed. WCB, Mc Graw Hill.  
Black,J.G.1999. Microbiology. Principles and explorations, 4<sup>th</sup> ed, Hall International, inc.  
Brook T.D., 1995, Biology of Microorganisms VI ed,  
S.C. Rastogi, Namita Mendiratta,, Bioinformatics – Concepts, Skills and Applications.

## **SEMESTER I: PAPER II - MICROBIAL PHYSIOLOGY AND BIOCHEMISTRY**

### **UNIT I**

Microbial cell – Ultra structure of Prokaryotic and Eukaryotic cell. Sub cellular structures and cell envelope, Slime layer, Capsules, Cell wall, Pili, Flagella, Cell - inclusions, Endospores, Cell membrane – Liposomes – Uptake of nutrients by the cell – Facilitated diffusion – Active transport – Group translocation , Iron uptake. Pinocytosis and Phagocytosis.

### **UNIT II**

Microbial nutrition – Nutritional groups, Common nutrient requirements, Growth factors – Microbial growth – Growth curve – Measurement of microbial growth. Growth kinetics – Batch, Continuous and Synchronous cultures. Factors influencing the growth of microorganisms.

### **UNIT III**

Carbohydrate metabolism – EMP, HMP and ED pathway – Kreb's Cycle – Glyoxylate cycle – Aerobic respiration – Substrate level and Oxidative phosphorylation – ATP generation. Lipid catabolism –  $\beta$ -oxidation. Anaerobic respiration – Sulphur compounds – Nitrate and Carbon -di -oxide as electron acceptors. Fermentation.

### **UNIT IV**

Enzymes and co –enzymes: IUBMB classification and nomenclature of enzymes, active site, Lock and key Mechanism and induced fit hypothesis, Enzyme kinetics- negative and positive co-operatively, enzyme inhibition: Reversible – Competitive, Noncompetitive, uncompetitive, Irreversible inhibition. Protein structures, Biosynthesis – Aminoacids: Aspartic and serine families. Fatty acid synthesis, Nucleotide biosynthesis.

### **UNIT V**

Autotrophs – Photoautotrophs – Oxygenic and Anoxygenic. Photosynthesis – Assimilation of  $\text{CO}_2$ . Chemoautotrophs, Bioluminescence. Archaeobacteria – Adaptations to extreme environments.

### **References:**

- Caldwell. D.R. 1995. Microbial Physiology and metabolism, Wm C. Brown Publishers.  
Moat. A.G. and Foster. J.W. 1988. Microbial Physiology, John Wiley sons.  
White J.D. Motteshead. D.W. Harrison S.J. Environmental system 2 ed. 1992.  
Stainier R.Y. Ingraham, J.L. Wheelis, H.H. and Painter. P.R. 1986. Microbiology.  
Principles of Biochemistry – Lehninger, Nelson, Cox, CBS publishers.  
Harpers Biochemistry, R.K. Murray, D.K. Granner, P.A. Mayes and V.W. Rodwell, Practise Halt International  
Biochemistry – Stryer.

## **SEMESTER I: PAPER III - APPLIED BIOTECHNIQUES**

### **UNIT I**

Fundamental building blocks – Atoms – Bonds and molecules. Macromolecules – Chemical nature and functions of Carbohydrate, Lipids, Proteins and Nucleic acids. Radioisotopes – Measurement, uses and safety aspects. Autoradiography, GM counter, Scintillation – Instrumentation and applications.

### **UNIT II**

Colorimetry: Principles, Instrumentation and Applications– Beer Lambert's law and deviation – Analysis – Qualitative and Quantitative. Basic principles of spectrophotometry: The laws of absorption, principles and instrumentation for UV- visible and IR spectroscopy. Principles, theory and applications of spectrofluorometry, and Flame photometry, NMR, 3D structure by x- ray diffraction, ESR - Principles, Instrumentation and Applications. Analysis – Qualitative and Quantitative.

### **UNIT II**

Centrifugation: Principles – Instrumentation – Types – Methods and Factors affecting sedimentation co-efficient - Applications.

### **UNIT IV**

Chromatography: Principles, Instrumentation, Types and Detection methods – Paper, TLC, HPLC, GC, Ion-exchange, Column ,Gel permeation, Chiral, Hydroxyapatite, Immuno adsorption and Affinity Chromatography – Applications.

### **UNIT V**

Electrophoresis – Principles, Instrumentation, Types. Staining and Detection methods – Isoelectrophoresis – isoelectric focusing – Applications.

### **References:**

Physical Biochemistry: David Freifelder.

Practical Biochemistry, Boyer.

Practical Biochemistry, Keith Wilson and John Walker, 4 ed 1994.

Foundation in Microbiology, Kathleen Talaro and Arthur Talaro, WCB Publishers 1993.

## **SEMESTER I: PAPER IV – ENVIRONMENTAL AND AGRICULTURAL MICROBIOLOGY**

### **UNIT I**

Aerobiology-Microbial contamination of air-Sources of contamination-Biological indicators of air pollution. Enumeration of bacteria from air, Air sampling devices. Significance of air Microflora, Outline of Airborne diseases (Bacterial, Fungal and Viral), Air sanitation. Effect of Air pollution of plants and Humans.

### **UNIT II**

Soil Microbiology-Structure, Types, Physical and Chemical properties-Soil microbes (Types and Enumeration)-Weathering and Humus formation, Soil pollution-Sources. Biogeochemical cycling-Nitrogen, Carbon, Phosphorous, Sulphur, Iron cycles and its importance.

### **UNIT III**

Aquatic Microbiology-Microbiology of water (Aquatic environment-Fresh and Marine)-Water Pollution and Waterborne Pathogens. Assessment of water quality (Chemical and Microbial) Bacteriological examination of water-Indicator organisms. Microbiology of Sewage-Waste water treatment –BOD and COD.

### **UNIT IV**

Microbial interaction-among microbes, with plants, Phyllosphere, Rhizosphere, Mycorrhizae-Symbiotic and free-living nitrogen fixers (*Rhizobium*, *Azotobacter*, *Azospirillum*, *Frankia*, *BGA* and *Azolla* -Phosphate solubilizers (*Phosphobacterium* and *Aspergillus*)-Phytopathogens-Bacterial, Fungal, Viral diseases (Wilt, Blight, Canker, Mosaic) - Control measures.

### **UNIT V**

Recycling of Liquid and Solid wastes-Composting-Biogas, Mushroom and SCP production from Waste. Biodegradation of Complex Polymers (Cellulose, Hemicellulose, Lignin, Chitin and Pectin), Bioremediation (In-situ, Ex-situ, Intrinsic, Engineered, Solid phase, Slurry phase, Mobilization and Immobilization systems) Bioaugmentation and Biostimulation, Bioleaching (Copper and Uranium) -Xenobiotics degradation (Heavy metals, Radionuclides, Recalcitrants, Halogenated compounds). GMOS and Environment. Applications of GIS and RS techniques in Environmental monitoring.

### **REFERENCES:**

- Mitchell. R. 1974. Introduction to environmental microbiology.  
Atlas R.N. and Bartha. R. 1993. Microbial Ecology-Fundamentals and Applications, 3 ed.  
Campbell. R. 1983. Microbial Ecology, 2 ed.  
Reiheimer. G. 1991. Aquatic Microbiology, 4 ed.  
Dart. R.K. and Shettron R.J. 1980. Microbiological aspects of pollution control. 2 ed.  
Martin Alexander, 1997. Introduction to Soil Microbiology.  
Subbha Rao, M.S. 1995. Soil microorganisms and plant growth

## M.Sc. MICROBIOLOGY

### PRACTICAL I

1. Sterilization – Principles and methods.
2. Media preparation – Liquid and Solid media, Agar deep, slant and plate.
3. Pure culture techniques – Streak plate, pour plate, spread plate, decimal dilution.
4. Microscopy – Bright field
5. Micrometry – measurement of microorganisms.
6. Motility determination- Hanging drop and soft agar inoculation.
7. Enumeration of microorganisms from soil: Bacteria, Fungi and Actinomycetes.
8. Morphology of fungi: Yeast and Algae.
9. Staining: Smear fixation, simple, gram, acid-fast, spore, capsule and negative.
10. Growth curve: Direct microscopic (Haemocytometer, Viable count)
11. Effect of various intrinsic factors on the growth of bacterium and fungi – pH, Temperature, Osmotic pressure and nutrients.
12. Anaerobic culture techniques; RCM (*Clostridium* sp). Mc Intosh Fildes anaerobic jar (Total anaerobes), Wright's tube method.
13. Phenol Co-efficient test.
14. IMViC test
15. Hydrogen sulphite test
16. Oxidase test
17. Catalase test
18. Urease test
19. Nitrate reduction test
20. Polymer degradation – Starch, Gelatin, Casein.
21. Carbohydrate fermentation.

## **SEMESTER II: PAPER V - MOLECULAR GENETICS**

### **UNIT I**

Genetics – Historical introduction – Mendelian Principles – DNA as a genetic material – Duplex DNA. Chemical composition, Physical structures of DNA, Circular and Superhelical DNA.

### **UNIT II**

DNA replication – Enzymes of replication – Rolling circle model – DNA damage and Repair. Mutation- Spontaneous – Origin of bacterial mutations – Mutagenesis –Induced mutations – Physical and chemical agents. Mutant selection – Carcinogenicity testing. Recombination – Homologous recombination, Site-specific recombination and Transposition.

### **UNIT III**

Genetic transfers in bacteria – Transformation – Transduction and Conjugation. Linkage and genetic maps. Phage genetics, Phage T mutants, Genetic recombination, Genetic mapping of T-4 Phage .

### **UNIT IV**

Genetic code – Nature - Features: Codons, Anticodons, Universality, Overlapping, Non-overlapping, Redundancy. DNA transcription – RNA translation – Polypeptide synthesis.

### **UNIT V**

Regulation of gene activity – Operan model (Lac, Trp), Autoregulation – translational regulation.

### **References:**

- Freifelder. D. 1995, Molecular Biology  
Maloy, S.R. Cronan. J.E. Jr and David Freifelder, Microbial genetics, 2 ed.  
Benjamin Lewin. Genes VII. 1996.  
Tamarin. R.H. 1996. Principles of Genetics. 5 ed.  
Klug, W.S. and Cummings. M.R. 1996. Essentials of Genetics.

## SEMESTER II: PAPER VI - VIROLOGY AND NANOTECHNOLOGY

### UNIT I

History and scope of Virology. Viruses – Definitions – Structures – General properties and Classifications. Classification - General properties, structure, genome replication, protein synthesis and assembly of: DNA containing bacteriophages – T4, lambda, Mu, ΦX174 & M13 phages and RNA containing bacteriophages - MS2 and Φ6 group.

### UNIT II

Classification - General properties, structure, genome replication, protein synthesis and assembly of: DNA containing plant viruses – CaMV and Gemini Virus - RNA containing plant viruses - TMV, *Cowpea mosaic viruses*, *bromo mosaic viruses* and satellite viruses

### UNIT III

Classification - General properties, structure, genome replication, protein synthesis and assembly, pathogenesis and laboratory diagnosis of : DNA containing animal viruses - Adeno viruses, *Herpes viruses*, *Hepatitis-B virus*, *Pox viruses*, *Papova viruses* and *Parvovirus*; RNA containing animal viruses: *Picornavirus*, *Rhabdo virus*, *Hepatitis viruses*, *Orthomyxo virus*, *Paramyxovirus*, *Retroviruses* and *Rubella virus*. Prions.

### UNIT IV

Techniques in virology – Cultivation of viruses – Isolation and Purification of Viruses. Characterization and Enumeration of viruses – Quantitative assay.

### UNIT V

Nanotechnology Timeline and Milestones – Nanobiomaterials: biocompatibility – antibacterial activity. Biomaterial nanocircuitry; DNA nanostructures; DNA based nanomechanical devices – Interaction between biomolecules and nanoparticles – hybrid nano assemblies. Potential uses of nanomaterials and nanoprobe in analytical applications - medical diagnostics and biotechnology. Current status of nanobiotechnology – nanosensors. Pollution by Nano-particles.

### References:

- Luria. S.E. Darnall. J.E. Baltimore. D. and Compare. A. 1978. General Virology, 3 ed.  
Freidfelder ,D. 1995. Microbial genetics.  
Grierson. D. and S.Convey, 1989. Plant Molecular Biology, 2 ed.  
Hayes. W. 1968. The Genetics of Bacteria and their Viruses.  
Mundahar. C.L. 1987. Introduction to plant viruses. 2 ed.  
Nanotechnology: Basic science and emerging technologies- Mick Wilson, Kamali Kannangara *et al.*, Overseas Press (2005).  
Introduction to nanotechnology , Charles. P. Poole, Frank.J.Owens (2003).  
[www.nanonet.rice.edu/intronanosci/](http://www.nanonet.rice.edu/intronanosci/)  
Nanotechnology: A gentle introduction to the Next Big Idea, Mark.A.Ratner *et al.*,(2002)  
Bandyopadhyay, A.K. Nano Materials. New Age Publishers.  
Pradeep, T.2007. Nano Essentials understanding nanscience and Nanotechnology. 1st Ed. TMH publications.

## **SEMESTER II: PAPER VII - BIOPROCESS TECHNOLOGY**

### **UNIT I**

An introduction to Fermentation Process. The range of Fermentation Process (Microbial biomass, Enzymes, Metabolites, Recombinant products, Transformation processes). Chronological development-Component parts of Fermentation process-Fermentation Economics.

### **UNIT II**

Fermentor Design and Construction, Fermentor types – For Microbial and Animal cell culture-Bioreactors for Aerobic fermentation, Stirred bioreactors, Reactors for immobilized cells, Productivity, Yield coefficients, Heat production, Stirring and Mixing, Gas exchange and Mass transfer. Instrumentation and Computer applications in Fermenter technology.

### **UNIT III**

Industrially important Microorganisms. Isolation (Primary and Secondary screening), Preservation and Improvement of Industrially important Strains (Mutation, Recombination, Regulation, Gene technology and Use of Genetic methods). Upstream processing-Development of Inoculum for Fermentation process- Media for Industrial Fermentation – Formulation, Optimization and Sterilization, Various stages in Upstream (Inoculum preservation, Growth of the inoculum, Fermenter preculture and Production fermentation).

### **UNIT IV**

Fermentation Types and Cultures –Batch, Continuous, Fed-batch, -Basic Growth Kinetics- Submerged and Solid state Fermentation -Downstream Processing-Recovery and Purification of Intracellular and Extracellular Products (Flocculation, Flotation, Filter systems, Centrifugation, Disintegration, Chromatography, Extraction, Crystallization, Precipitation and Drying).

### **UNIT V**

Microbial production of Organic acids (Citric and Acetic) Enzymes (Amylase and Protease) Aminoacids (Lysine and Glutamic acid), Antibiotics (Penicillin, Streptomycin and Griseofulvin), Vitamins ( Riboflavin, Cyanocobalamine and Ascorbic acid)-Biosynthesis of Ergot alkaloids-Microbial transformation-Steroids and Sterols, Non-steroid compounds, Antibiotics and Pesticides.

### **References:**

- Stanbury P.F.A. Whitaker S.J. Hall, 1995 Principles of Fermentation Techniques 2 ed.  
Cruger and Cruger. A. Textbook of Industrial Microbiology 2 ed.  
Cassida, J.E. 1968. Industrial Microbiology.  
Prescott and Dunns, Industrial Microbiology.  
Pepler. H.J. 1979. Microbial Technology. Vol I & II.  
Demain A.J. and Solomon INA, 1986. Manual of Industrial Microbiology and Biotechnology.

## **SEMESTER II: PAPER VIII - ENGINEERING OF GENES AND PROTEINS**

### **UNIT I**

Cloning: Isolation and purification of nucleic acids (chromosomal DNA, RNA & Plasmids) – Methods of handling and quantification of DNA and RNA. Blotting – types of blotting – Southern, Northern and Western Blotting. Chromosome walking.

### **UNIT II**

Restriction endonucleases – types and characteristics - DNA methylases - Ligases – Adapters, Linkers and Homopolymer tailing – Transformation techniques: electroporation, microinjection, protoplast fusion and microparticle bombardment - Screening: Direct: Insertional inactivation, plaque phenotype and indirect methods: Immunochemical detection, nucleic acid hybridisation, Dot and Colony Blotting. Genomic DNA libraries - cDNA libraries.

### **UNIT III**

Vectors – properties - types of vectors – plasmids– host range and incompatibility – Vectors constructed based on bacteriophages (M13 & Lambda), cosmids, phasmids, phagemids and BACs - Eukaryotic vectors - Yeast vectors – animal and plant vectors – expression vectors - shuttle vectors - Expression of genes in bacteria, animal, plant, algae & fungi.

### **UNIT IV**

Characterization of cloned DNA: Restriction mapping - restriction fragment length polymorphism (RFLP) - Polymerase chain reaction (PCR) - Types of PCR and their applications. DNA sequencing: Primer walking, Maxam and Gilbert method, dideoxy method, automated sequencing and micro array.

### **UNIT V**

Design and construction of novel proteins and enzymes, Basic concepts in enzyme engineering, engineering for kinetic properties of enzymes. Protein structure based drug design, protein folding, protein sequencing, peptide sequence data, protein crystallization. Data analysis- Mass spectrometry based methods for protein identification, MALDI-TOF, 2D gel electrophoresis.

### **References:**

- Old ..R. W. and Primrose S.B. 1995. Principles of gene manipulations – An introduction to genetic engineering , 5 ed.
- Winnacker E.L, 1987, From Genes to Clones. – Introduction to gene technology.
- Nicholl. D.S.T, 1994. An introduction to genetic engineering.
- Brown. T.A. 1995. Gene Cloning.
- Pinler. A. 1993. Genetic engineering of microorganisms.
- Protein Structure, Stability and Folding by Kenneth P. Murphy. Published by Humana Press Inc. 2001.
- Protein Engineering Principles and Practice by Jeffrey L. Cleland and Charles S. Craik. Published by Wiley-Liss Inc., 1996.
- Protein Engineering and Design by Paul R. Carey. Published by Academic Press Inc., 1996.

## **M.Sc. MICROBIOLOGY**

### **PRACTICAL II**

1. Wine production
2. Organic acid production – Citric acid – Solid state and Submerged fermentation.
3. Amino acid production – Glutamic acid.
4. Production of Extra cellular enzymes – Protease by submerged fermentation – Cellulose by solid state fermentation.
5. Isolation of nitrogen fixers – free living, symbiotic, ammonification, nitrification, denitrification.
6. Isolation of Phosphate solubilizers.
7. Isolation of Coliphage.
8. Decolorisation of dyes and dye containing effluents.
9. Phage titration.
10. TMV transformation
11. Isolation of mutants: Induced - Auxotrophic, Antibiotic resistant and Replica plating technique. Spontaneous - Gradient plate technique.
12. Isolation of Plasmids and chromosomal DNA from microbes.
13. Size determination and fractionation of nucleic acids and proteins – Agarose gel electrophoresis, SDS – PAGE.
14. Gradient Gel electrophoresis.
15. Restriction mapping of  $\gamma$  of Vector DNA.

## **SEMESTER III PAPER IX - IMMUNOLOGY & IMMUNOTECHNOLOGY**

### **UNIT I**

Historical background and scope of immunology, Immunohaematology - ABO and Rh factor. Cells and organs of immune system. Non immunological defence mechanism - Barriers, Phagocytosis, inflammation, fever. Types of immunity - HI and CMI

### **UNIT - II**

Antigens - properties, Epitopes, haptens, adjuvant, cross reactivity. Antibodies - properties, structure (primary & secondary) and isotypes. Diversity and specificity. Anti antibodies.

### **UNIT - III**

Serology - Introduction and classification of antigens and antibody reactions - Agglutination and precipitation reaction. Strength of antigen and antibody bindings - affinity & avidity. Therapeutic applications of monoclonal antibodies. Complement pathway and complement fixation reaction. Immunofluorescence RIA, RAST, ELISA and Flowcytometry.

### **UNIT - IV**

MHC antigens - types and functions. Regulation and response of immune system. Response of B Cell to antigens. T cell products. Immunity to infectious diseases - Viral, bacterial and protozoan. Hyper sensitivity reactions.

### **UNIT V**

Transplantation immunology - Tissue transplantation and grafting. Mechanism of graft acceptance and rejection. HLA typing Tumor immunology. Immunodeficiency diseases and auto immunity. Vaccines - Types and vaccination methods.

### **References :**

Coleman, R.M., Lourbard, M.F and Sicard, R.E., 1992 Fundamental immunology, 2nd

Kuby, J. 1997, Immunology, W.H Freeman and co., New York.

Roitt, I.M 1988 Essential of Immunology, Black Well Scientific Publishers.

Tizard, R.I. 1983. Immunology - An introduction, Saunder's College publishers Philadelphia.

## SEMESTER III: PAPER – X - MEDICAL MICROBIOLOGY

### UNIT I

Introduction to medical microbiology - Infectious Diseases process – Diagnosis – Process of sample collection, transport and examinations of the specimens, Antibigram and serological test.

### UNIT II

Bacteriology: Gram positive organisms - Morphology, cultural characteristics, pathogenicity and laboratory diagnosis of *Staphylococcus aureus*, *Streptococcus pyogenes*, *Pneumococcus*, *Bacillus anthracis*, *Corynebacterium diphtheriae*, *Clostridium tetani*, *Clostridium botulinum*, *Mycobacterium tuberculosis*, *Mycobacterium leprae*, *Spirochaetes* – *Treponema pallidum* and *Leptospira icterohaemorrhagiae*.

### UNIT III

Bacteriology: Gram negative organisms:- Morphology, cultural characteristics, pathogenicity and laboratory diagnosis of *E.coli*, *Klebsiella sp*, *Salmonella typhi*, *Shigella dysenteriae*, *Pseudomonas aeruginosa*, *Vibrio cholerae*, *Bordetella pertusis*, *Yersinia pestis* and *Neisseria gonorrhoea*, *Neisseria meningitidis*.

### UNIT IV

Virology: Basic concepts of virology - General properties of Human viruses, Approaches to viral diagnosis- Serological and Molecular techniques, Pathogenicity and Laboratory diagnosis of viral infections - Hepatitis, Polio, Rabies, Influenza, Measles, Mumps, Rubella, Dengue virus and HIV.

### UNIT V

Mycology : General properties and approaches to laboratory diagnosis. Mycosis – Superficial, Subcutaneous and Systemic infections – *Cryptococcosis*, *Madura mycosis*, *Histoplasmosis*, *Candida albicans*, *Aspergillosis*.

Parasitology: Pathogenicity and laboratory diagnosis of *Entamoeba histolytica*, *Taenia solium*, *Plasmodium vivax*, *Wucheraria bancrofti*, *Leishmania donovani* and *Trichomonas vaginalis*.

### References:

Textbook of Microbiology – Ananthanarayanan and Jayaram Panicker.  
Essentials of Diagnostic Microbiology – Lisa Anne Shimeld, Anne T. Rodgers,  
Manual of Clinical Microbiology – Lenetle,E, BalowsH.A.  
Textbook of Medical Parasitology – Subash.C.Parija.  
Medical Microbiology - Geo. F. Brooks.s  
Medical Mycology – Jagadesh Chander.  
Medical Virology - Murrae

## **SEMESTER III: PAPER XI - BIOTECHNOLOGY AND IPR**

### **UNIT I**

Microbial synthesis of commercial products: Protein pharmaceuticals: interferons and growth hormones – Antibiotics: novel antibiotics – Biopolymers: gum, melanin, PHB, adhesives- Molecular diagnostic system of genetic disease – PCR/OLA assay

### **UNIT II**

Vaccines – submit vaccines – live recombinant vaccines – attenuated vaccines- vector vaccines- anti idiotypic vaccines – Monoclonal antibodies, Bioremediation and Biomass utilization – Microbial degradation of Xenobiotics – Utilization of starch and sugars, cellulose

### **Unit III**

Plant growth promoting bacteria – N<sub>2</sub> fixation- nitrogenase – Hydrogenase. Nodulation Siderophores – Microbial insecticides - Insecticidal toxin of BT. Mode of action - genetic engineering of B.T. strains – Baculovirus as biocontrol agents.

### **Unit IV**

Transgenic plants and animals – Ti.Plasmid – Derived Vector systems – methods of transferring genetic plants – Developing plant strains by genetic engineering. Insect resistant, virus resistant, herbicide resistant. Transgenic animals methods – The human somatic cell gene therapy – invitro gene therapy – Invivo gene therapy – Antisense therapy.

### **Unit V**

Intellectual Property Rights (IPR)- different types of IPRs, studies on patents granted in India and other countries, special studies on technology evaluation, analyses of patent applications filed in India in various technology areas, international treaties and conventions and patent laws in other countries - Regulating the use of biotechnology – rDNA technology – Food and Agricultural ingredients – patenting Biotechnology invention.

### **References:**

Glick, B R and J J Pasternak 1994. Molecular biotechnology – Principles and applications of recombinant DNA. ASM press Washington D.C.

Winnacker E.L. 1987 from Genes to Clones – Introduction to Gene Technology. VCH Weinherm

Old R W and Primrose S B 1995 Principles of Gene Manipulation - An introduction to genetic engineering. 5th edition Blackwell scientific publications London.

Intellectual Property Rights (IPR) bulletin

[http://www.indianembassy.org/policy/ipr/ipr\\_2000.htm](http://www.indianembassy.org/policy/ipr/ipr_2000.htm).

## **SEMESTER III: PAPER XII - MICROBIAL FOOD TECHNOLOGY**

### **UNIT I**

Food as a substrate – Incidence and types of microorganisms in food – Contamination and Spoilage of Meat, Poultry, Sea foods, Vegetables, Fruits. Principles of food preservations: Asepsis, Preservation by use of High temperature, Low temperature, Canning, Drying, Radiation and Food additives.

### **UNIT II**

Food poisoning – Food borne diseases- Bacterial and Non- Bacterial. Fermented foods - Meat and fishery products – Country cured hams, Dry sausages, Katsubushi. Fermented milk products – Butter, Butter milk, Sour cream, Youghurt, Cheese, Kefir, Koumiss, Taette and Tarhama.

### **UNIT III**

In house Committee for quality assurance, Persons involved, Internal Microbial Quality control Policy, Quality Check at every step from collection of raw materials till it reaches the customer , Implementation of ISO standards and history, definitions, principles and use of HACCP in Food Industry .

### **UNIT IV**

Indicator organisms – Direct examination – culture techniques – enumeration methods – plate – Viable & Total Count; Alternative methods – Dye reduction tests , electrical methods , ATP determination: Rapid methods, immunological methods – DNA / RNA methodology – Laboratory accreditation.

### **UNIT V**

#### **Food laws and regulations**

- A. National – PFA Essential Commodities Act (FPO, MPO etc.)
- B. International – Codex Alimentarius, ISO – 9000 series , ISO 22000 & BS 5750.
- C. Regulatory Agencies – WTO

Consumer Protection Act - Relevance of Microbiological standards & criteria for food safety – Sampling plans – Microbiological guidelines

#### **Hygiene and sanitation in food sector**

General Principles of Food Hygiene, GHP for commodities, equipment, work area and personnel, cleaning and disinfect ion (Methods and agents commonly used in the hospitality industry), Safety aspects of processing water (uses & standards) and Waste Water & Waste disposal

#### **References:**

- James. M. Jay, 1992, Modern food microbiology 4ed.  
Frazier, W. C. and Westhoff D.C. 1989. Food Microbiology 8 ed.  
Dubey. R.C. and Maheswari. D.K. A Textbook of Microbiology, 1999. 1 ed.  
Water Analysis – A practical guide to Physico – Chemical & Microbiological water examination and Quality assurance – W.Schneider, W.Fresenius & K.E. Quentin Springer – Verlag Pub. Heidelberg.  
Food Microbiology. 2 nd Edition – M.R.Adams & M.O.Moss – Panima Publishers.

## **SEMESTER IV: PAPER XIII - BIOSTATISTICS AND RESEARCH METHODOLOGY**

### **UNIT I**

Definition – Scope of Biostatistics, Probability analysis ,Variables in Biology-Collection, Classification and Tabulation of data. Graphical and diagrammatical representation –Scale diagram - Histogram- frequency curve.

### **UNIT II**

Measures of central tendency- Arithmetic mean, Median, Mode. Calculation of Mean, median, Mode in series of individual observations, discrete series, continuous, open end classes, measure of dispersion, standard deviation, standard error.

### **UNIT III**

Simple correlation coefficient of correlate regression- simple and linear regression.

### **UNIT IV**

Basic ideas of significant test-Hypothesis testing, Level of significant test, test based on studies-t-test- chi square , Goodness of fit.

### **UNIT V**

Plagiarism and research ethics. Selection of research problem – Formulation of research objectives - project design - review of literature writing - Sources of data collection for biosciences research - processing of data - presentation of data - editing – preparation of master's thesis. Presenting the research findings in open defense.

### **References:**

- 1.S.P.Guptha-Statistical Methods
- 2.Palanisamy and Manoharan-Statistical methods of Biology
- 3.Khan and Khan- Fundamentals of Biostatistics
- 4.Kothari-Research Methodology

**M.Sc. MICROBIOLOGY  
PRACTICAL III**

1. Diagnostic microbiology: Isolation and interpretation of clinical specimens from the following systems: – Respiratory tract, Gastrointestinal tract, Urinary tract, Skin infections, Circulatory system, Central nervous system and from organs like eye, ear and nose. Tuberculosis and anaerobic infections.
2. Isolation and identification of clinically important fungi- *Candida albicans*, *Aspergillus sp*, *Cryptococcus neoformans*
3. Antibiotic susceptibility test. - Kirby Bauer technique
4. Identification and enumeration of Lymphocytes.
5. Examination of blood smear study for *Plasmodium sp*
6. Isolation and characterization of antigens
7. Development of polyclonal antibodies
8. Purification of immunoglobulins and their sub units.
9. Serological tests: Blood grouping, Widal, VDRL, RA, ASO, CRP, ELISA
10. Immunoelectrophoresis
11. Ouchterlony's immunodiffusion
12. Separation techniques: Chromatography- Paper, TLC and Column.
13. Virus cultivation – Egg inoculation.

**ELECTIVE GROUP A**  
**PAPER I: PRINCIPLES OF QUALITY ASSURANCE**

**UNIT I**

Quality assurance – Introduction and overview – Definition. Designing of microbiology laboratory – Control of quality – Applications.

**UNIT II**

Quality assessment of Equipments, chemicals, glass wares and laboratory environments – Variance – Quality control calculations – Quality management – Maintenance of records and reports.

**UNIT III**

Quality assurance in sterilization and disinfection - Preservation of stock cultures, media and diagnostic kits – Quality control of media and stains.

**UNIT IV**

Quality assessment of disposal – decontaminated matters and other biological effluents – Quality management in transportations of cultures. National control of biologicals – Biological references and standards.

**UNIT V**

Good laboratory practices – Management of laboratory hazards and knowledge in First aid procedures.

**References:**

Rajesh Bhatia and Rattan lal Ichhpujani. 1995. I ed. “Quality assurance in Microbiology”

**ELECTIVE GROUP A**  
**PAPER II - QUALITY ASSESSMENT IN PHARMACEUTICALS**

**UNIT I**

An introduction to pharmaceutical microbiology. Chemical growth control. Chemical antimicrobial agents for external use, synthetic antimicrobial drugs, naturally occurring antimicrobial drugs: Antibiotics. Antibiotics from prokaryotes, antiviral drugs, antifungal drugs, antimicrobial drug resistance, the search for new antimicrobial drugs.

**UNIT II**

Types of spoilage, Factors affecting microbial spoilage – assessment of microbial spoilage – preservation. Ecology of microorganisms as it affects the pharmaceutical industry – Sterile pharmaceutical products – injections, Non injectable sterile fluids, Ophthalmic preparations, dressings & implants.

**UNIT III**

Sterilization control - methods of sterility testing- sterilization monitors and Quality assurance of products. The microbiological quality and regulatory requirements for natural and nutraceutical products, The regulatory control and quality assurance of immunological products, Containment system integrity – sterile products, Regulatory guidelines (microbiology) for veterinary antimicrobial products.

**UNIT IV**

The role of the Qualified Person in microbiological quality assurance, Safety in microbiology, Rapid enumeration and identification methods, Selection and use of cleaning and disinfection agents in pharmaceutical manufacturing, Prevention and elimination of microbial biofilms in the manufacturing environment using Clean-in-Place, Cleanroom design, operation and regulatory standards.

**UNIT V**

Microbiological quality assurance. Validation of aseptic processing and media fills, International disinfectant testing protocols, Measurement of biocide effectiveness, Microbiological quality and regulatory requirements for biotherapeutics and manufactured products, The role of the microbiologist in HACCP, Auditing the pharmaceutical microbiology department.

**References:**

1. Pharmaceutical Microbiology – W.B.Hugo & A.D.Russel, 4 th Ed, Blackwell Scientific Publications.
2. INDUSTRIAL PHARMACEUTICAL MICROBIOLOGY – Vol I & Vol II: standards & Controls Editors – Dr Norman Hodges and Professor Geoff Hanlon (University of Brighton) ,(REF ; [www.euromed.uk.com](http://www.euromed.uk.com))
3. Biology of Microorganisms – BROCK-Madigan M.T. 11<sup>th</sup> Edition (2006) Pearson-Prentice Hall, USA

## **ELECTIVE GROUP A - PAPER III - TOTAL QUALITY MANAGEMENT (TQM)**

### **UNIT – I**

**Concepts in TQM-** Tools & techniques of TQM – Requirements for implementing TQM – Steps for implementing TQM – Questionnaire, Assessment through questionnaire – Mission statement – Benefits of TQM – Check list for implementing TQM – Case study.

### **UNIT -II**

Types of Data, tabular and **Graphical summarization of numeric data:** - Histograms & Stem and Leaf displays : **Graphs for categorical data** – Bar, Pie charts & Pareto diagrams.

### **UNIT – III**

**Graphs for time ordered data** – Run charts, Cause effect diagrams – Check Sheets

### **UNIT –IV**

**Numeric data summarization** - The mean, mode & Median; The Standard deviation, Variance, Range & Percentiles.

### **UNIT -V**

**Graphic display of numeric summaries:-**The box plot and the scatter diagram. Skewness, T – test, Anova,

### **Reference:**

1. Twelve Management skills for success – Ram Narain , Viva books private limited – Chennai.
2. A cross functional perspective Total Quality Management – Rao, Carr, Dambolena and Kopp- John Wiley & Sons, New York .

**ELECTIVE GROUP A**  
**PAPER IV - PRACTICAL**

1. Microbiological laboratory safety- General rules & Regulations.
2. Staining Techniques (Grams and LPCB)–Food samples- vegetables and packed foods.
3. Sterility tests for Instruments – Autoclave & Hot Air Oven
4. Disinfection of selected instruments & Equipments
5. Sterility of Air and its relationship to Laboratory & Hospital sepsis.
6. Sterility testing of Microbiological media
7. Sterility testing of Pharmaceutical products –Antibiotics, Vaccines & fluids
8. Standard qualitative analysis of water.
9. Quantitative analysis of water – Membrane filter method
10. Analysis of food samples for Mycotoxins (Afla toxins)
11. Enumeration of microbes from industrial effluents.
12. Evaluation of Drug potency by MIC.
13. Isolation & characterization of Bacteria from wood and Paints.
14. Assay of microorganisms from biomedical waste.
15. Water quality analysis – MPN.
16. Estimation of BOD and COD.
17. Isolation of microorganisms from spoiled foods – Meat, milk, Cereals and Bread.
18. Milk quality – Dye reduction test.
19. Thermal death point and thermal death time.

**Reference**

- Microbiology - A laboratory manual, Cappuccino & Sherman , 6 th Ed, Pearson Education
- Manual of diagnostic microbiology, Dr.B.J.Wadher & Dr.G.L.Bhoosreddy, First .Ed., Himalaya publishing house, Nagpur.
- Pharmaceutical Microbiology – W.B. Hugo
- Pharmaceutical Microbiology – Purohit
- Laboratory Exercises in Microbiology, George.A.Wistreich & Max.D.Lechtman, 3 rd Ed, Glencoe press, London.

**ELECTIVE GROUP B**  
**PAPER I - ENVIRONMENT AND HEALTH**

**UNIT I**

Water pollutants – Purification – Mechanical and Chemical methods.

**UNIT II**

Air pollutants – Control of air pollution – Disinfection of air – Ventilation, UV radiation.

**UNIT III**

Noise pollution – Control measures, Radiations – Causes and Control

**UNIT IV**

Medical entomology: Vector control – Flies, fleas and Rodent Control

**UNIT V**

Environmental sanitation – Waste disposal – Sewage, Sludge and Hospital waste disposal

**REFERENCES**

1. Park's Text book of Preventive and social medicine by Dr. Jahan Evertt Rark
2. Environmental Biology by S. K. Dubey
3. Environment Pollutants and Women's Health by Mahendra Pandey
4. Waste water Treatment by Sheela Sanghvi
5. Environment and Pollution by N. Arumugam and V. Kumerasan
6. Ecology and Ethology by V. K. Agarwal & Usha Gupta

**ELECTIVE GROUP B**  
**PAPER II - COMMUNICABLE AND NON-COMMUNICABLE DISEASES**

**UNIT I**

Respiratory infections – Influenza, Mumps, Measles, Rubella, Acute respiratory infections and TB.

**UNIT II**

Intestinal infections – Polio, Cholera, Acute diarrhea diseases, Food poisoning, Typhoid, Amoebiasis, Ascariasis, Hook worm, Tapeworm, Pinworm infections.

**UNIT III**

Vector borne Infections – Leprosy, STD – AIDS – Diagnostic Techniques and Treatment.

**UNIT IV**

Superficial mycoses – Dermatophytoses – Opportunistic fungal infections – Candidiasis – Diagnostics Techniques and Treatment.

**UNIT V**

Non-communicable diseases – Hyper Tension – Diabetes – Coronary Heart diseases – Cancer, Obesity, Blindness, Accidents – Preventive measures.

**REFERENCES**

1. Park's Text Book of preventive and social medicine
2. Medical Microbiology by K.C.Sawant
3. Virology by K.C.Sawant
4. Bacteriology by Subrata Bhattacharjee
5. Text book Microbiology by Ananthanarayan
6. Medical Microbiology by Panicker
7. A Text book of Microbiology by R.c.Dubey and D.K.Maheswari

**ELECTIVE GROUP B**  
**PAPER III - HEALTH CARE OF THE COMMUNITY**

**UNIT I**

Nutrition and health - Balanced Diet, food surveillance, food fortifications- addition of vitamins and minerals - Adulteration and preventive steps.

**UNIT II**

Physical health-care of skin, hair, teeth, eyes. ears, hands and feet-physical exercises and their importance - Walking and jogging – Yoga and meditation – stress Relief.

**UNIT III**

Health Programmes and health education – Malaria control – TB control – AIDS control programmes and Immunization programmes.

**UNIT IV**

Social sciences and mental health – Sociology; Social structure, culture and customs – social problems-Mental health – cases of mental illness Alcoholism and drug dependence – prevention Rehabilitation.

**UNIT V**

Family planning, Maternal and child health – Antenatal and Postnatal care – Reproductive and child Health programme (RCH).

**REFERENCES**

1. Park's Text books of preventive and social medicine
2. Immune – biotechnology by Naha & Narain
3. Immunology by Dulsy Fatima & N.Arumugam
4. Food and Nutrition by L.Swaminathan
5. Dietics by Srilakshmi
6. Practice of fertility control & Comprehensive manual 6th edition by S.K.Choudhary

### **ELECTIVE GROUP B - PRACTICAL**

1. Water Analysis : Physicochemical parameters
2. Bacteriology: Hanging drop method, Gram's staining, and pasteurization of milk.
3. Diagnostic test : Diabetic test, Hypertension test, Widal test, VDRL test
4. Sterilization techniques: Autoclave, Hot Air oven
5. Food Adulteration Any four Food Stuffs
6. ELISA test, RIA test (Demonstration only)
7. Microscopic examination of Infectious Agents- Entamoeba, Ascaris, Hook worm, Pinworm, Tape worm, malarial parasite and Filarial parasite.

## ELECTIVE GROUP C

### PAPER I - BASIC BIOLOGICAL SCIENCES

#### UNIT-I

**Cell Biology** - Structure and function of cells and intracellular organelles (of both prokaryotes and eukaryotes): mechanism of cell division including (mitosis and meiosis) and cell differentiation: Cell-cell interaction; Dosage compensation and mechanism of sex determination.

#### UNIT-II

**Biochemistry:** Structure of atoms, molecules and chemical bonds; Principles of physical chemistry: Thermodynamics, Kinetics, dissociation and association constants; Nucleic acid structure, genetic code, replication, transcription and translation: Structure, function and metabolism of carbohydrates, lipids and proteins; Enzymes and coenzyme; Respiration and photosynthesis.

#### UNIT-III

**Physiology:** Response to stress: Active transport across membranes; Plant and animal hormones: Nutrition (including vitamins); Reproduction in plants, microbes and animals.

#### UNIT-IV

**Evolutionary Biology:** Origin of life (including aspects of prebiotic environment and molecular evolution); Concepts of evolution; Theories of organic evolution; Mechanisms of speciation; Hardyweinberg genetic equilibrium, genetic polymorphism and selection; Origin and evolution of economically important microbes, plants and animals.

#### UNIT-V

**Environmental Biology:** Concept and dynamics of ecosystem, components, food chain and energy flow, productivity and biogeochemical cycles; Types of ecosystems, Population ecology and biological control; Community structure and organization; Environmental pollution; Sustainable development; Economic importance of microbes, plants and animals.

## **ELECTIVE GROUP C PAPER II – BIOPHYSICS AND BIOCHEMISTRY**

### **UNIT-I**

Principles of biophysical methods used for analysis of biopolymer structure, X-ray diffraction, Hydrodynamic methods; plasma emission spectroscopy.

### **UNIT-II**

Principles and techniques of nucleic acid hybridization and Cot curves; Sequencing of Proteins and nucleic acids; Methods for measuring nucleic acid and protein interactions. Structural polymorphism of DNA, RNA and three dimensional structure of tRNA;

### **UNIT-III**

Principles and applications of tracer techniques in biology; Radiation dosimetry; Radioactive isotopes and half life of isotopes; Effect of radiation on biological system.

### **UNIT-IV**

Interconversion of hexoses and pentoses; Amino acid metabolism; Coordinated control of metabolism; Oxidation of lipids; Biosynthesis of fatty acids; Triglycerides; Phospholipids; Sterols, Group transfer and Coupled reactions

### **UNIT-V**

Biochemistry and molecular biology of cancer; Oncogenes; Chemical carcinogenesis; Genetic and metabolic disorders; Hormonal imbalances; Drug metabolism and detoxification.

**ELECTIVE GROUP C - PAPER III**  
**MOLECULAR CYTOLOGY AND TISSUE ENGINEERING**

**UNIT-I**

Molecular basis of signal transduction in bacteria, plants and animals; Model membranes; protein sorting, secretory and endocytic pathways, cell cycle; Dosage compensation and sex determination and sex-linked inheritance

**UNIT-II**

The law of DNA constancy and C-value paradox; Numerical, and structural changes in chromosomes; Molecular basis of spontaneous and induced mutations and their role in evolution; polypoidy; Environmental mutagenesis and toxicity testing; Population genetics. Environmental regulation of gene expression

**UNIT-III**

Cell and tissue culture in plants and animals; Primary culture; Cell line; Cell clones; Callus cultures; Somaclonal variation; Micropropagation; Somatic embryogenesis; Haploidy; Protoplast fusion and somatic hybridization; Cybrides;

**UNIT-IV**

Gene transfer methods in plants and in animals; Transgenic biology; Allopheny; Artificial seeds; Gene targeting. Applications of genetic engineering in agriculture, health and industry.

**UNIT-V**

Histology –Basics of mammalian systems, nutrition, digestion and absorption; Circulation (open and closed circular, lymphatic systems, blood composition and function); Excretion and osmoregulation: Homeostatis (neural and hormonal); Bioluminescence.

### **ELECTIVE GROUP C PAPER IV – PRACTICAL**

Stages of cell division-mitosis and meiosis

1. Estimation of total carbohydrates and proteins
2. CS of dicot and monocot root and stem
3. Physical mutation with UV
4. Antagonistic activity of any one biocontrol agent.
5. Agarose gel electrophoresis
6. Agglutination-Blood grouping, Precipitation-ODD
7. Callus induction
8. Auxin production
9. Phenomenon of Bioluminescence.