

BHARATHIAR UNIVERSITY, COIMBATORE.
B.Sc. MICROBIOLOGY WITH NANOTECHNOLOGY DEGREE COURSE
COMPULSORY DIPLOMA IN DIAGNOSTIC MICROBIOLOGY
SCHEME OF EXAMINATION - CBCS PATTERN (AFFILIATED COLLEGES)
For the students admitted during the academic year 2009 – 2010 batch onwards

Part	Study Components	Course title	Ins. hrs/ week	Examinations				Credit
				Dur.Hr	CIA	Marks	Total Marks	
	Semester I							
I	Language – I		6	3	25	75	100	3
II	English – I		6	3	25	75	100	3
III	Core Paper I - Fundamentals of Microbiology		6	3	25	75	100	4
	Practical I and Viva Voce		4	-	-	-	-	-
	Allied A : Paper I – Biostatistics and Computer Applications I		4	3	25	75	100	4
	Allied Practical		2	-	-	-	-	-
IV	Environmental Studies #		2	-	-	50	50	2
	Semester II							
I	Language – II		6	3	25	75	100	3
II	English – II		6	3	25	75	100	3
III	Core Paper II - Microbial Diversity		4	3	25	75	100	4
	Core Paper III - Cell Biology		3	3	25	75	100	4
	Core Practical I and Viva Voce		3	3	40	60	100	3
	Allied A : Paper II - Biostatistics and Computer Applications II		4	3	25	75	100	4
	Allied Practical		2	3	20	30	50	2
IV	Value Education – Human Rights #		2	3	-	50	50	2
	Semester III							
I	Language – III		6	3	25	75	100	3
II	English – III		6	3	25	75	100	3
III	Core Paper IV - Microbial Physiology		4	3	25	75	100	4
	Core Practical II		3	3	-	-	-	-
	Allied B: Paper I – Biochemistry I		4	3	20	55	75	4
	Allied Practical		2	-	-	-	-	-
IV	Skill based Subject I Diploma in Diagnostic Microbiology – Organization of Clinical Microbiology Laboratory		3	3	25	75	100	3
	Tamil @ / Advanced Tamil# (OR) Non-major elective - I (Yoga for Human Excellence)# / Women’s Rights#		2	3	75		75	2
	Semester IV							
I	Language – IV		6	3	25	75	100	3
II	English – IV		6	3	25	75	100	3
III	Core Paper V – Basics of Material Sciences		4	3	25	75	100	4
	Core Practical – II		3	6	40	60	100	3
	Allied B : Paper II – Biochemistry II		4	3	20	55	75	4
	Allied Practical		2	3	20	30	50	2

IV	Skill based Subject 2 - Diploma in Diagnostic Microbiology – Diagnostic Microbiology I (Bacteriology and Serology)	3	3	25	75	100	3
	Tamil @ /Advanced Tamil # (OR) Non-major elective -II (General Awareness #)	2	3	75		75	2
	Semester V						
III	Core Paper VI - Microbial Genetics	5	3	25	75	100	4
	Core Paper VII – Principles of Immunology	4	3	25	75	100	4
	Core Paper VIII– Food Microbiology	4	3	25	75	100	4
	Core Paper IX – Introduction to Nanomaterials	4	3	25	75	100	4
	Elective 1	4	3	25	75	100	5
	Core Practical - III	6	3	-	-	-	-
IV	Skill based Subject 3 Diploma in Diagnostic Microbiology – Diagnostic Microbiology II (Virology and Mycology, Parasitology)	3	3	25	75	100	3
	Semester VI						
III	Core Paper X – Nanobiotechnology	4	3	25	75	100	4
	Core Paper XI – Environmental and Agricultural Microbiology	4	3	25	75	100	4
	Core Paper XII – Biomedical Applications of Nanomaterials	4	3	25	75	100	4
	Core Practical – III	6	9	40	60	100	4
		-	-	-	-	50 *	2
	Elective – II	4	3	25	75	100	5
	Elective – III	4	3	25	75	100	5
IV	Skill Based Subject 4 Diploma in Diagnostic Microbiology – Practical I & II	4	3	40	60	100	3
V	Extension Activities @	-	-	-	-	50	1
	Total					3800	140

* - Students has to submit a record of work done during their training period which will be evaluated through *viva voce* along with the core practical III examination.

Students should undergo an institutional training for a continuous period of 15 days before semester VI

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

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List of Elective papers (Colleges can choose any one of the paper as electives)		
Elective – I	A	Recombinant Dna Technology
	B	Virology
	C	Bioinstrumentation – Principles and Applications
Elective – II	A	Fermentation Technology
	B	Dairy Microbiology
	C	Plant Biotechnology
Elective - III	A	Medical Microbiology
	B	Medical Biochemistry
	C	Entrepreneurial Microbiology

SEMESTER - I

CORE PAPER I : FUNDAMENTALS OF MICROBIOLOGY

UNIT – I

History and Scope of Microbiology – Spontaneous generation theory – conflict – Contribution of Leuwenhoek, Louis Pasteur, Robert Koch, Edward Jenner, Joseph Lister, Winogradsky, Waksman, John Tyndall.

UNIT – II

Microscopy and Staining -Microscopy – Principles and application – Bright field, Dark field, Phase contrast, Fluorescence, SEM & TEMS- Specimen preparation of electron microscopy – freeze etching- Staining- Stains and Staining reactions – Types of staining – Simple, Differential (Gram's, Spore, AFB₁), Capsule staining, Nuclear and Flagella staining-Albert.

UNIT – III

Sterilization and Disinfection- Principles- Methods of Sterilization – Physical methods – Dry heat- Moist heat, Filtration (Membrane & HEPA) - Radiation – Chemical Sterilization -Chemical agents Mode of action – Phenol coefficient test- Sterility testing.

UNIT – IV

Culture techniques -Media preparation -Solid and Liquid- Types of Media – Crude, Semi Synthetic, Synthetic, Enriched, Enrichment, Selective, Differential and Special Purpose Media (one eg for each type). Anaerobic culture technique-- Wright's tube, Roll tube, McIntost fildes jar method -Pure culture technique – Tube dilution, Pour, Spread, Streak and Micromanipulator.

UNIT – V

Estimation of Microbes- Direct Microscopic count, Turbidometric assay, TVC- Indirect Method- CO₂ liberation -Protein estimation- Maintenance and Preservation -Short term – Slant, Stab, Mineral oil overlay -Long term – Lyophilization, Cryo preservation, Storage in sterile soil, Storage in silica gel.

References

1. Prescott, L.M J.P. Harley and C.A. Klein 1995. Microbiology 2nd edition Wm, C. Brown publishers.
2. Salle A.J. : Fundamental Principles of Bacteriology 7th edition, Tata Mc Hill Publishing Company Ltd.,
3. Michael J. Pelczar, Jr. E.C.S. Chan, Moel : Microbiology Mc Graw Hill Book R. Krieg, 1986 Company
4. Stainer R.Y. Ingraham J.L. Wheolis H.H and Painter P.R. 1986 The Microbial world, 5th edition. Eagle Works Cliffs N.J. Prentica Hall..
5. William claus. G.W. 1989. Understanding Microbes – A Laboratory textbook for Microbiology, W.H. Freeman and Co., New York.
6. Wilson. K and Goulding. K.H. 1986. A Biologist's Guide to Principles and Techniques of Practical Biochemistry, ELBS, London.
7. Tauro P., Kapoor, K.K. Yadav, K.S. An introduction to Microbiology first Edition, New Age International Publishers.

SEMESTER -II
CORE PAPER II : MICROBIAL DIVERSITY

UNIT – I

Taxonomy – Principles – Modern approaches-Numerical- Genetic, Serotaxonomy and Chemotaxonomy.

UNIT – II

Taxonomy of Eubacteria and Actinomycetes – Detailed classification upto genus level with general characters of each group – Bergey's Manual and its importance.

UNIT – III

Taxonomy of Photosynthetic Eubacteria and Archaeobacteria- General characteristics.

UNIT – IV

Taxonomy of Fungi (Alexopolous) -General Characteristics-Life Cycles of Mucor, Neurospora, Agaricus, Dictyostelium.

UNIT – V

Taxonomy of Algae -General Characters and its importance –Chlorophyta-Euglenophyta – Chrysophyta- Phaeophyta -Rhodophyta – Pyrrophyta-Taxonomy of Protozoa – General characters and its importance – Mastigophora, Rhizopoda, Ciliata, Sporozoa.

References

1. Prescott, L.M J.P. Harley and C.A. Klein 1995. Microbiology 2nd edition Wm, C. Brown publishers.
2. Michael J. Pelczar, Jr. E.C.S. Chan, Moel : Microbiology Mc Graw Hill Book R. Krieg, 1986 Company
3. Stainer R.Y. Ingraham J.L. Wheelis H.H and Painter P.R. 1986 The Microbial world, 5th edition. Eagle Works Cliffs N.J. Prentice Hall..

SEMESTER -II
CORE PAPER III :CELL BIOLOGY

UNIT – I

Ultrastructure of Eubacteria-Cell wall – Cell membrane- Extra mural layer - Slime – Capsule – Cytoplasmic inclusions – Mesosomes – Nuclear material – Reserve materials - Pigment – Cell appendages – Flagella – Pili.

UNIT – II

Ultrastructure and functions of Eukaryotic cell organelles – Cell wall – Cell membrane - Mitochondria – Chloroplast – Endoplasmic reticulum – Golgicomplex – Nucleus – Ribosomes – Other cell inclusions and Flagella.

UNIT III

Cell division in Bacteria – Binary fission - Cell division of Eukaryotes – Mitosis and Meiosis.

UNIT IV

Transport mechanisms – Diffusion - Facilitated diffusion – Active transport – Group translocation – Phagocytosis – Pinocytosis.

UNIT V

Archaeobacterial cell wall and cell membranes of Methanogens - Halophiles - Thermoacidophiles.

References

1. Prescott, L.M J.P. Harley and C.A. Klein 1995. Microbiology 2nd edition Wm, C. Brown publishers.
2. Michael J. Pelczar, Jr. E.C.S. Chan, Moel : Microbiology Mc Graw Hill Book R. Krieg, 1986 Company
3. Stainer R.Y. Ingraham J.L. Wheelis H.H and Painter P.R. 1986 The Microbial world, 5th edition. Eagle Works Cliffs N.J. Prentica Hall..

SEMESTER II CORE PRACTICAL 1

1. Laboratory precautions
2. Preparation of cleaning solutions
3. Antiseptics and disinfectants
4. Principles of aseptic techniques
5. Culture media preparation – Liquid and Solid medium
6. Selective and differential media
7. Methods of sterilization and testing of sterility
8. Enumeration of Bacteria, Fungi and Actinomycetes from soil
9. Pure culture techniques – pour plate, spread plate and looping method
10. Phenol co-efficient test
11. Cultural characteristics of microorganisms-colony morphology on nutrient agar slants, nutrients broth
12. Maintenance and preservation of cultures
13. Staining of bacteria-Simple, Negative, Gram, Spore and AFB, Fungal wet mount –LCB-Slide culture method
14. Isolation of halophiles and thermophiles
15. Cultivation of anaerobic micro organisms – Wrights tube – McIntosh fildes jar
16. Micrometry
17. Observation of representative forms of (algae) –Diatoms-Chlamydomonas-Volvox-Cyanobacteria-Oscillatoria-Nostoc-Anabaena-(Fungi)-Aspergillus-Pencillium-Rhizopus-Yeast-(Protozoa)-Amoeba-Plasmodium.

References

1. Prescott, L.M J.P. Harley and C.A. Klein 1995. Microbiology 2nd edition Wm, C. Brown publishers.
2. Salle A.J. : Fundamental Principles of Bacteriology 7th edition, Tata Mc Hill Publishing Company Ltd.,
3. Michael J. Pelczar, Jr. E.C.S. Chan, Moel : Microbiology Mc Graw Hill Book R. Krieg, 1986 Company
4. Stainer R.Y. Ingraham J.L. Wheolis H.H and Painter P.R. 1986 The Microbial world, 5th edition. Eagle Works Cliffs N.J. Prentica Hall..
5. William claus. G.W. 1989. Understanding Microbes – A Laboratory textbook for Microbiology, W.H. Freeman and Co., New York.
6. Wilson. K and Goulding. K.H. 1986. A Biologist's Guide to Principles and Techniques of Practical Biochemistry, ELBS, London.
7. Tauro P., Kapoor, K.K. Yadav,K.S.An introduction to Microbiology first Edition , New Age International Publishers.

SEMESTER –III **CORE PAPER IV : MICROBIAL PHYSIOLOGY**

UNIT – I

Nutrition: Nutritional requirements of microorganisms – Autotrophs, Heterotrophs, Photoautorophs, Chemoautotrophs, Copiotrophs, Oligotrophs, Endospore formation in Bacteria.

UNIT – II

Different phases of growth – growth curve – generation time – factors influencing microbial growth – temperature, pH, pressure , salt concentration , nutrients – synchronous growth and continous cultivation . Diauxic growth.

UNIT -III

Metabolism – EMP – HMP – ED pathways – TCA cycle- Electron transport chain – Oxidative and Substrate level phosphorylation.

UNIT- IV

Anaerobic respiration – sulphur , nitrogenous compounds and Co₂ as final electron acceptor- Fermentation – alcoholic, propionic and mixed acid fermentation.

UNIT- V

Photosynthesis – Oxygenic and Anoxygenic , Carbon dioxide fixation, Biosynthesis of bacterial cellwall, biosynthesis of aminoacids (glutamic acid family)- Bioluminescence.

References

1. Prescott, L.M J.P. Harley and C.A. Klein 1995. Microbiology 2nd edition Wm, C. Brown publishers.
2. Tortora , Funke and case . Microbiology , *8th edition
3. Doelle . H.W.1975.Bacterial Metabolism . 2nd edition .Academic Press.
4. Moat. A.G. J.W.Foster. 1988.Microbial physiology. 2nd edition .Springer – Verlag.
5. Caldwell. D.R.1995, Microbial physiology and Metabolism . Wm. C Brown Publishers, England.

SEMESTER –IV **CORE PAPER V: BASICS OF MATERIAL SCIENCE**

UNIT I

Atomic structure and Electronic Configuration: Introduction – Atomic Structure – Electron – Properties of Cathode Rays – Nucleus – Atomic Number - Atomic Weight – Isotope – Isobar – Avogadro Number – Atomic Model - Vector Model – Quantum Numbers – Pauli Exclusion principle.

UNIT II

Crystal Structure : Introduction – Crystal Structure – Space Lattice – Unit Cell – Crystal Systems – Atomic Packing – Coordination Number – Crystal Symmetry – Atomic Radius – Atomic Packing factor.

UNIT III

Bonds in Solids : Introduction – Types of bond – Mechanism of Bond Formation – Ionic Bond – Covalent Bond – Metallic Bond – Comparison of bonds – Secondary Bonds – Mixed Bonds – Chemical Bonding and Properties of Solid Materials.

UNIT IV

Semiconducting materials: Introduction - Types of Semiconductors on the basis of Fermi level and Fermi Energy – Transistor – Piezoelectricity and Ferroelectricity.

UNIT V

Organic Materials : Introduction – Polymers – Mechanism of Polymerization – Additions in Polymers – Polymer Structure – Plastics – Elastomers and Rubbers – Fibers and Filaments – Composite Materials – Single Crystals – Accommodated Structures – protective Coatings

REFERENCE:

1. Materials Science, G. K. Narula, K. ion. S. Narula, V. K. Gupta, Tata Mc Graw Hill Publications.
2. Fundamentals of materials Science and Engineering, William D. Callister, Jr., John Wiley & sons, 2001.

SEMESTER IV CORE PRACTICAL II

1. pH measurements
2. Spectrophotometry
3. Protein estimation (Lowry *et al* / Bradford)
4. Paper chromatography
5. Thin layer chromatography
6. Electrophoresis - Proteins
7. Measurement of microbial growth – viable count – direct count – turbidity methods – determination of generation time
8. Extraction of pigments
9. Physiological characterization : Indole, MR, VP, Citrate utilization tests, Carbohydrate fermentation tests – TSI – H₂S production – Starch hydrolysis – Catalase – Oxidase – Urease – Nitrate – Gelatin and Casein hydrolysis tests
10. Preparation of Buffers – Acidic and Alkaline range
11. Preparation of Molar solutions
12. Preparation of 0.1 and 1 Normal solutions

SEMESTER -V CORE PAPER VI - MICROBIAL GENETICS

UNIT-I

DNA-the genetic material, RNA-the genetic material, characters of a genetic material, chemistry & molecular structure of DNA, special structure of DNA, structure and types of RNA.

UNIT-II

Bacterial chromosome, organization of genes in prokaryotes, DNA – replication in prokaryotes – Meselson and Stahl experiment- mechanism & enzymology of replication – theta replication & rolling circle replication.

UNIT-III

Transcription in prokaryotes – genetic code – translation of proteins – regulation of gene expression in prokaryotes – Operon concept – lac & trp Operon.

UNIT-IV

Mutation-spontaneous and induced-mutagen & mutagenesis – DNA repair mechanism.

UNIT-V

Genetic exchange – transduction(specialized & generalized), transformation, conjugation & Hfr mapping , genetic recombination.

References

1. Gardner, E. J., Simmons, M J & D P Snustard ,1991 , Principles of Genetics, 8th edition. John Wiley & Sons.NY.
2. Freifelder .S ,1987 Microbial Genetics, Jones & Bartlett, Boston.
3. Robert H .Tamarin. Principles of Genetics, 5th edition, Cm Brown Publishers.
4. Lewin.B, 1990. Genes, 6th edition, Oxford University Press.
5. Klug .W.S. & Cummings,MR, 1996, Essentials of Genetics, Mentics Hail. NewJersey.

SEMESTER -V **CORE PAPER VII - PRINCIPLES OF IMMUNOLOGY**

UNIT- I

History and Scope of Immunology-The basis of defence mechanisms-Cell and Organs involved in immune system-Phagocytosis.

UNIT- II

Types of immunity-antigen-antibody-types-complement pathways-classical and alternate-Immunoglobins-structure and functions.

UNIT- III

Allergy and hypersensitivity-classification types and mechanisms-autoimmunity-mechanisms and autoimmune response diseases.

UNIT -IV

Quantitative study of antigen-antibody reactions –agglutination, precipitation ELISA-radioimmune assay(RIA)-monoclonal antibodies and its applications(Hybridoma technology)

UNIT –V

Immunohematology-blood transfusion-ABO grouping-Rh factor-Tissue transplantation-HLA typing-mechanism of acceptance and rejection.

References

1. Kuby.J.1997 . ,Immunology,W.H.Freeman,NY
2. Tizard,I R 1998.Immunology An Introduction ,Second edition.W.B.Saunders,Philadelphia.
3. Roitt, IM 1991.Essentials of Immunology,seventh edition Blackwell Scientific Publications.
4. Nandhini Shetti,1993.Immunology,Introductory Text Book.New Age International Limited.

SEMESTER –V

CORE PAPER VIII - FOOD MICROBIOLOGY

UNIT – I

Food and microorganisms – Important microorganisms in food (Bacteria, mold and yeasts) ; factors affecting the growth of microorganisms in food – pH, moisture , oxidation – reduction potential , nutrient content and inhibitory substances and biological structure.

UNIT – II

Principles of food preservation – general principles and application methods – Asepsis - Techniques of removal – use of temperature (low & high). Drying, radiation and chemical preservatives.

UNIT -III

Spoilage of food - cereals , vegetables , fruits , egg and milk – canned foods .

UNIT-IV

Fermented food – pickled cucumber , saurkraut- soysauce , Bread , Idli – Fermented dairy products – Yoghurt and cheese.

UNIT- V

Food borne diseases – food poisoning and food borne infections – bacterial and mycotoxins- Investigation of food poisoning outbreaks- food standards, quality control.

References

1. Frazier. W.C and D.C Westhoff . 1978. Food Microbiology . 3rd ed. Tata Macgraw Hill Publishing Co., New Delhi.
2. Jay,J.M .1991 . Modern Food Microbiology 4th edition , Van Nostra and Rainhokdd Co.
3. Adams. M. R and M. D Moss . 1995. Food Microbiology . New Age International limited

SEMESTER –V

CORE PAPER IX - INTRODUCTION TO NANOMATERIALS

UNIT I

Introduction and Classification: What is nanotechnology – Classification of Nanostructures - 1D, 2D and 3 D nanomaterials – Nanoscale Architecture.

UNIT II

Synthesis of Nanomaterials: Top down – ball milerling; Bottom up – co-precipitaion – sol-gel – electrodeposition – using natural nanoparticles – chemical vapor deposition.

UNIT III

Characterization: X-ray diffraction – Scherrer's formula – Scanning Electron Microscopy – Transmission Electron Microscopy – Fluorescence Microscopy.

UNIT IV

The Carbon Nanotube – New Forms of Carbon – Types of Nanotubes – Formation of Nanotubes – Uses for nanotubes – Biological Applications.

UNIT V

Applications of Nanomaterials: Insulation material – biosensor – phosphors – batteries – high power magnets – medical implants – other medical uses.

REFERENCE:

1. NANOTECHNOLOGY: Basic science and emerging technologies, Mick Wilson, Kamali Kannagara, Geoff Smith, Michelle Simmons, Burkhard Raguse, Overseas Press, 2005, First Indian Edition.
2. Nanoscale Science and Technology, Robert Kelsall, Ian Hamley, Mark Geoghegan, John Wiley & Sons, Ltd., 2005.

SEMESTER -VI **CORE PAPER X - NANOBIO TECHNOLOGY**

UNIT I

Biological Inspired Concepts: Biological Networks – Biological Neurons – The Function of Neuronal Cell – Biological neuronal cells on silicon – Modelling of Neuronal cells by VLSI circuits.

UNIT II

Biological and Quantum Mechanical Computers: DNA Computer – Information Processing with Chemical reaction – Nanomachines – Parallel Processing – Quantum Computer.

UNIT III

Nanobiometrics: Introduction – lipids as nano-bricks and mortar- Self assembled nanolayers - the bits that do things - proteins – DNA Computer

UNIT IV

Natural nanocomposites : Introduction - natural nanocomposite materials – biologically synthesized nanostructures – protein based nanostructure formation – Nanotechnology in Agriculture.

UNIT V

Nanoanalytics: Quantum dot Biolabelling – Nanoparticle Molecular labels – Analysis of Biomolecular Structure by AFM.

REFERENCE:

1. Nanoelectronics and Nanosystems: From transistors to molecular devices. K.Goser, P. Glosekotter, J. Dienstuhl, Springer (2004)
2. NANOTECHNOLOGY: Basic science and emerging technologies, Mick Wilson, Kamali Kannagara, Geoff Smith, Michelle Simmons , Burkhard Raguse, Overseas Press, 2005, First Indian Edition.

SEMESTER -VI
CORE PAPER XI
ENVIRONMENTAL AND AGRICULTURAL MICROBIOLOGY

UNIT -I

Distribution of microorganisms in nature – Microbial communities in soil- factors Influencing the microbial density in soil- zymogenous and autochthonous flora in Soil-Microbial associations – symbiotic proto cooperation, ammensalism, Commensalism, syntropism, parasitism and predation with suitable examples.

UNIT -II

Microbial decomposition; cellulose, Hemi cellulose, lignin, pectin and chitin. –Factors influencing degradation- acetate utilization -bioconversion of organicwastes- sugarcane wastes- coir pith composition- composting, principles and Applications- conversion process

UNIT- III

Microorganisms in the decomposition of organic matter- carbon cycle – nitrogen Cycle- nitrogen fixing microorganisms- root nodule bacteria – non symbiotic Nitrogen fixers – biofertilizers in agriculture- Rhizobium and phosphate solubilisers- Mycorrhizial association – phosphorous cycle.

UNIT- IV

Water microbiology, algae, phytoplankton- eutrophication- water treatment - Primary, secondary and tertiary. Drinking water- Portability- MPN technique.

UNIT-V

Aero microbiology- aerosol, droplet nuclei, air pollution- sources (Microbiological) – air quality analysis- air sampling devices.

References

1. Atlas R. M. and Bartha. R 1992, Microbial Ecology . Fundamental and application . 3rd edition Bengamin and Cummings.
2. Alexander A M 1987. Introduction to Soil Microbiology, 5th edition John Wiley and sons,

3. Alexander, A M 1974. Microbiology Ecology, Jhon Willy & Sons.
4. Mitchell R 1974, Introduction to Environmental Microbiology, Prentice Gall Inc., Englewood Cliffs.
5. Rangasamy, G and D J Bagyaraj, Agricultural microbiology, Asia Publishing House, New Delhi.
6. Rheinhermer , G. 1986 . Aquatic Microbiology , John Wiley and Sons , NY.
7. Grant. W. D. P . E. Long . 1981 Environmental Microbiology, Thomson Litho Ltd.

SEMESTER -VI

CORE PAPER XII – BIOMEDICAL APPLICATIONS OF NANOMATERIALS

UNIT I

Nanomedicine : History of the idea – Nanomedicine Taxonomy – Bio Pharmaceuticals – Implantable Materials – Surgical Aids – Diagnostic Tools – Imaging.

UNIT II

Nanosensors: Chemical and Molecular Sensors – Force Nanosensors – Pressure Sensing – Thermal Nanosensors – Electric and Magnetic Sensing – Cellular Bioscanning.

UNIT III

Nanoparticle : Implications for Drug Delivery : Introduction – Background – Studies on nanoparticle Flow – Convection and Diffusion – Bifurcations – Nanoparticles with Surface Ligands - Does Shape Matter ? .

UNIT IV

Polymer Micelles as Drug Carriers: Plomer Micelle Structures – Drug Loading and Release – Phramacokinetics and Biodistribution – Drug Delivery Applications – Clinical Trials.

UNIT V

Nanocapsules : Introduction – Preparation – Characterization – Drug Release – Applications.

REFERENCE:

1. Nanomedicines, Ed. By Parag Diwan and Asish Bharadwaj, Pentagon Press, 2006.
2. Nanoparticles as Drug Carriers, Ed. By Vladimir P Torchilin, Imperial College Press, North Eastern University, USA, 2006.

SEMESTER VI CORE PRACTICAL III

1. Isolation of Nucleic acids
2. Isolation of drug resistant mutants using UV and Chemical agents
3. Induction of Lac Operon – ONPG method
4. Isolation of *E. coli* plasmid DNA by agarose gel electrophoresis
5. Isolation and identification of major bacterial pathogens – *E. coli*, *Klebsiella pneumoniae*, *Proteus*, *Salmonella*, *Shigella*, *Pseudomonas*, *Staphylococcus aureus* and *Streptococcus pyogenes*.
6. Identification of clinically important fungi – *Candida albicans*, *Cryptococcus neoformans* and *Aspergillus*
7. Methylene blue reduction test
8. Microbial analysis of spoiled food – Bread and Vegetables
9. Identification of fungal food spoilers – *Aspergillus*, *Mucor*, *Penicillium*, *Rhizopus*
10. Direct microscopic examination of curd – observation of lactobacilli
11. Enzyme production and assay – protease and amylase
12. Alcohol production / wine
13. Immobilization- Demonstration
14. Isolation of free living nitrogen fixers – *Azotobacter*, *Azospirillum* – Phosphate solubilizers – *Rhizobium* from nodule
15. Observation of parasites – *Entamoeba*, *Plasmodium*, *Ascaris*, *Taenia*.
16. Isolation and titration of coliphages
17. Cultivation of animal viruses in embryonated eggs.

DIPLOMA IN DIAGNOSTIC MICROBIOLOGY SEMESTER III - DIPLOMA PAPER I

ORGANIZATION OF CLINICAL MICROBIOLOGY LABORATORY

UNIT – I

Diagnostic microbiology – Purpose and philosophy. Purpose of diagnostic microbiology – responsibility - specimen collection & transport – rejection of specimen – expediting results.

UNIT – II

Laboratory safety. General safety considerations – biohazards and practices specific to microbiology – classification of biological agents on the basis of hazards.

UNIT – III

Special precautions for specific areas of clinical Microbiology – Bacteriology, Mycobacteriology, Mycology, Parasitology, Virology and Serology.

UNIT –IV

Laboratory organization and quality assurance – specimen procurement and identification – laboratory requisition form – reporting results – procedure manual – Quality assurance and statistics.

UNIT – V

Management of clinical Microbiology laboratory – general approaches– rapid detection – speeding up of identification results and susceptibility results – computerization.

References

1. Diagnostic Microbiology, Bailey & Scott, s, 1990 8th edn. The Mosby Company.
2. Medical laboratory manual for tropical countries, Microbiology by Monica chees brough (ELBS) Tropical health technology butter worth's, 1985.
3. Review of medical microbiology, Jawetz, E.Melinic, J.C., and Adelbuerg, E.A., 1998, Large medical publications USA.
4. Manual of clinical Microbiology Lenetle, E., Balows, H.A., Hausler, W.J. and Shadomy, J., 1985. Bethesda American society of Microbiology.

DIPLOMA PAPER II **SEMESTER IV - DIAGNOSTIC MICROBIOLOGY – I** **(BACTERIOLOGY AND SEROLOGY)**

UNIT – I

Selection, collection and transport of specimens – Blood, Urine, Sputum, CSF, Pus & Faeces – transport media and storage. Microscopic examination of specimen for Bacterial pathogens – simple, differential staining and motility.

UNIT – II

Cultivation and isolation of viable pathogens – Media used – differential, selective, enrichment and enriched media.

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Cultivation and isolation of viable pathogens – Media used – differential, selective, enrichment and enriched media.

UNIT – III

Biochemical tests – identification of organisms - Susceptibility testing, reporting of results and interpretation.

UNIT – IV

Serology – Antigen - antibody reactions – Agglutinations (blood grouping, WIDAL), Precipitation (VDRL), Immunodiffusion – mono and double immunodiffusion, Immunolectrophoresis (rocket, counter current).

UNIT – V

Advanced techniques – automated methods – ELISA, RIA. Applications of Nucleic acid hybridization, PCR and blotting in diagnosis.

References

1. Diagnostic Microbiology, Bailey and Scott's., 1990. Eighth edition. The C.V. Mosby Company.
2. Medical laboratory techniques, Abdul Khader, 2003, First edition. Frontline Publications, Hyderabad.
3. Medical laboratory manual for tropical countries. Microbiology by Monica chees brough (ELBS). Tropical Health Technology, Butter worths, 1985.
4. Manual of Clinical Microbiology, Lenetle, E., Balows, H.A., Hausler, W.J and Shadomy J., 1985. Bethesda American Society of Microbiology.

DIPLOMA PAPER III **SEMESTER V - DIAGNOSTIC MICROBIOLOGY –II** **(VIROLOGY, MYCOLOGY AND PARASITOLOGY)**

UNIT –I

Laboratory methods in basic Mycology –Collection and transport of clinical specimens –Direct Microscopic examination, culture media and incubation, Serological tests for fungi – Antifungal susceptibility testing

UNIT –II

Laboratory methods for parasitic infections – Diagnostic techniques for faecal, gastrointestinal and urino-genital specimen.

UNIT –III

Identification of Intestinal Protozoa –Amoeba, Blood protozoa – Malaria, Intestinal Helminthes and Blood Helminthes.

UNIT –IV

Laboratory methods in basic virology- detection of viral antigen (fluorescent antibody and solid phase immunoassays). Viral Serology- Special consideration- Hepatitis and AIDS.

UNIT –V

Viral culture- Media and cells used –Specimen processing – isolation and identification of viruses.

References

1. Diagnostic Microbiology, Bailey and Scott's., 1990. Eighth edition. The Mosby Company.

2. Medical laboratory techniques, Abdul Khader, 2003, First edition. Frontline Publications, Hyderabad.
3. Virology, Sawant, K.C., 2005, First edition, Dominant Publishers and distributors, Delhi.
4. Medical Parasitology, Rajesh Karyarkarte, Ajit Damla, 2004. Books and allied publishers Ltd. Kolkata.
5. Textbook of Medical Parasitology, Subash O. Barija , 1996. First edition. All India Publishers and Distributors Regd. 920 Poonamallee High Road, Chennai.
6. Rajesh Karyakarte and Ajith Damle (2005)Medical Parasitology, ooks and Allied(P)Ltd.

**SEMESTER VI
DIPLOMA PAPER IV**

DIPLOMA PRACTICAL –I

1. Collection and transport of clinical specimens –Urine, Blood, Sputum, Pus and Faeces.
2. Processing of specimen
 - 2.1- Gram's Staining
 - 2.2- Motility
 - 2.3-Culturing techniques-McConkey agar, Blood agar, Chocolate agar, Mannitol salt agar and XLD agar
3. Biochemical Characterization- IMViC, TSI, GLSM, Oxidase, Catalase, Urease and Coagulase.
4. Susceptibility testing- Kirby Bauer method.

DIPLOMA PRACTICAL –II

1. Slide agglutination -Blood grouping
2. Tube agglutination- WIDAL
3. Precipitation – RPR
4. Immunodiffusion- Radial, Ouchterlony's
5. Immunoelectrophoresis- Rocket and Counter current
6. ELISA
7. SDS-PAGE
8. Western blot
9. Observation of fungi- LCB or KOH mount
10. Observation of parasites- *Entamoeba*, *Plasmodium*, *Ascaris*, *Taenia*

ELECTIVE I – A

RECOMBINANT DNA TECHNOLOGY

UNIT –I

Nucleic acid purification – DNA,RNA; Nucleic acid modifying enzymes – Endonucleases, ligases, methylases, phosphatase, kinase – mode of action.

UNIT –II

Prokaryotic Vectors: Plasmid based - Natural (PSC101, PSF2124, PMB1), Artificial (pBR322, pUC); Phage based □ phage and its derivatives, M13; Hybrid - Phagemid, Phasmid, Cosmid, BAC, YAC, Eukaryotic vectors: Ti plasmid, retrovirus.

UNIT –III

Gene Transfer Technique: Physical – Biolistic, DNA microinjection: Chemical- Calcium chloride, DEAE Method; Biological – Transfection, transformation; Selection – direct and indirect.

Techniques in rDNA: PCR, Blotting, RFLP, RAPD, Microarray, DNA finger printing, cDNA library, genomic library – methodology

UNIT IV

Tansgenesis: Plants – insect, virus, fungus, herbicide resistant: Animals – embryonic stem cell method of transfer – pig, cattle, fish, bird.

UNIT -V

Pharmaceutical products : Interferons, Human growth hormone; Vaccines – sub unit vaccines; monoclonal antibody. Human genome project; gene therapy; Bioethics in recombinant DNA technology.

References

1. Brown T.A 1995 An Introduction to gene cloning. 3rd edition. Chapman and hall
2. Bernard. R Glick and Jack J Pasternak. 1994 Molecular biotechnology, Panima Publishing Corporation.
3. U.Sathyanarayana., Biotechnology Books and Allied(P) Ltd., (2005) First Edition.

ELECTIVE II – B : VIROLOGY

UNIT -I

Early development of virology – general properties of viruses- cultivation of Viruses- virus purification and assays. The structure of viruses- virion size- General structure properties- helical capsids, icosohedral capsid- nucleic acids- Viral envelopes and enzymes- virus classification.

UNIT- II

Reproduction of DNA phages- ds DNA lytic phages- lytic cycle of T4 phage The one step growth- adsorption to the host cell and penetration- synthesis of Phage nucleic acids and protein assembly of phage particles- release of phage particles. Example of ss DNA phage- OX 174- circle replication.

UNIT-III

Lysogeny- temperate bacteriophages- lambda phage- induction of lysogens- Generation of defective phages and their uses. Reproduction of RNA phages.

UNIT -IV

Viruses of Eukaryotes- Reproduction of animal and plant viruses- Viruses of Algae, fungi and viruses- viruses and cancer.

UNIT- V

Human viral infections- pathogenicity and diagnosis of Hepatitis (A,B). Mumps, AIDS, Rabies, Influenza, Measles, Rubella, Herpes simplex I&II..

References

1. Luria S.E. Darnel, J.E Jr. Baltimore. D and Campbell A. 1978. General Virology 3rd edition, Wiley and sons.
2. Prescott L.M, Harley, J.P Klein D.A. 1990. Microbiology Wm C Publishers.

ELECTIVE II – C : BIOINSTRUMENTATION – PRINCIPLES AND APPLICATIONS

UNIT – I

Autoclave , Hot air oven , Incubator , Water Bath , Laminar air flow, BOD incubator, Centrifuges – Bench top , High sped , Ultra centrifuge.

UNIT – II

pH meter , Conductivity meter, Lyophilizer , McIntosh anaerobic jar , Biosensor, Metabolic shaker.

UNIT -III

Chromatography – Paper , Thinlayer, Column, Ion-exchange, Gas and HPLC – Electrophoresis – SDS – PAGE and Agarose gel electrophoresis.

UNIT –IV

Colorimetry, Turbidometry, Spectrometry – UV & Visible spectrophotometer . Flame photometry- Micronutrient analysis.

UNIT-V

Biochemical calculations-preparations of Molar solutions - Buffers- Phosphate, Acetate, TE, TAE- calculation of Normality ,PPM- Ammonium sulphate precipitation.

References

1. Gedder , A. and L. E. Balsler, John Wiley and Sons , Principles of applied Biomedical instrumentation.
2. Dean, Willard and Merrit , Instrumental Methods of analysis Asian Ed.
3. Fritschen, L. J and L. W . Gay, Springer, Verlag, Environmental Instrumentation, 1979, New York.
4. Boyer, Rodney, F. Benjamin and Cummins, Modern Experimental Biochemistry 2nd Edition.
5. E.Padmini., Biochemical Calculations and Biostatistics (2007) Books and Allied (P) Ltd., First Edtn.

ELECTIVE II – A : FERMENTATION TECHNOLOGY

UNIT -I

Industrially important strains- Screening methods- Strain development for Improved yield- Mutation, Recombination and protoplasmic fusion.

UNIT -II

Fermentation- submerged and solid state- component parts of a CSTR- types of Fermentors (Tower, cyllindroconical & airlift) – batch fermentation – continuous Fermentation.

UNIT -III

Production of beverages – beer and wine- vitamin B12 and Riboflavin – Antibiotics- penicillin and streptomycin- production of enzymes- Amylases and Proteases- methods of immobilization.

UNIT- IV

Single cell protein- Bakers yeast, spirulina- Details of mushroom development- Oyster (Pleurotus) and Button (Agaricus) mushroom.

UNIT -V

Downstream process- Intercellular and extracellular- Centrifugation, filtration, Floatation- solvent extraction, precipitation- Breakage of cells- physical and Chemical methods.

References

1. Stanbury P T and Whitaker 1984, Principles of Fermentation Technology, Pergamon Press. NY
2. Casida, L E JR 1968 Industrial Microbiology. New Age International Publishers.
Prescott and Rehm 1979. Industrial Microbiology. Wiley and Sons.

ELECTIVE II – B : DAIRY MICROBIOLOGY

Unit I

Milk-Introduction, composition,. Microorganisms in Milk – Bacteria, Yeasts, Moulds. Starter Cultures – Starter cultures their biochemical activities. (Strptococcus thermophilus, Lactobacillus bulgaricus) starter culture preparation, mesophilic and thermophilic organisms. Dairy processing unit operations: Clarification, separation, standardization, toning of milk, Pasteurization, UHT treatment, homogenization, Membrane processing, storage, transportation and distribution of milk. Judging and grading of milk and its products.

Unit II

Milk and milk products – Definitions, composition, food and nutritive value of milk, properties of milk and its constituents. Dairy Products Production : Overview and Fluid Milk Products, Concentrated and Dried Milk Products, condensed milk, evaporated milk, whole and skimmed milk powder, cultured Dairy Products: Cheese, yogurt, fermented beverages, Whipped Cream, Ice Cream, Butter, Whey Products, fermented milks,

Unit-III

Microbiology of fermented milk products - Acid fermented milks (acidophilus milk, yoghurt). Slightly acid fermented milks (Cultured butter milk), Acid-alcoholic fermented milk (Kefir). Fermented milk production with extended self life (labneh). Milk borne diseases, antimicrobial systems in milk, sources for contamination of milk - bacterial with examples of infective and toxic types –, Clostridium, Salmonella, Shigella, Staphylococcus, Campylobacter, Listeria. Mycotoxins in food with reference to Aspergillus species.

Unit – IV

Hygiene in Manufacturing Milk Products: Microorganisms of concern – HACCP - Pasteurization - Cleaning of Dairy Equipment - Instantization of milk and milk products. In-plant cleaning system. Dairy Processing Plant Sanitation . Probiotic role of lactic acid bacteria and fermented milk products. Utilization and disposal of dairy by product – whey.

Unit V

Quality assurance: Microbiological quality standards of food. Government regulatory practices and policies. FDA, EPA, HACCP, ISI. HACCP – Food safety, safety of dairy products, control of hazards

References

1. Fundamentals of Dairy Microbiology by Prajapati.
2. Dairy Microbiology by Robinson R.K.1990 Volume II and I. Elsevier Applied Science, London.
3. Applied dairy microbiology edited by Elmer Marth and James Steele.
4. Milk & Milk Products - Fourth edition - clarence henry eckles, Tata McGraw Hill publishing company Limited, New Delhi, 1957

5. Dey, S. 1994. *Outlines of Dairy Technology*. Oxford Univ. Press, New Delhi. MaCrae
6. Robinson, R.K. (2 vol. set). 1986. *Modern Dairy Technology* Elsevier Applied Science, UK.
7. Rosenthal, I. 1991. *Milk and Milk Products*. VCH, New York.
8. Warner, J.M. 1976. *Principles of Dairy Processing*. Wiley Eastern Ltd. New Delhi.
9. Yarpar, WJ. and Hall, C.W. 1975. *Dairy Technology and Engineering* AVI, Westport.

ELECTIVE II – C : PLANT BIOTECHNOLOGY

UNIT – I

Plant Tissue culture – History, Plant tissue culture media, types, constituents and preparation of media, selection of suitable medium.

UNIT – II

Protoplast culture and somatic hybridization, production of Haploid plants, Somaclonal variations, Clonal propagation (micro propagation) germplasm conservation and cryopreservation.

UNIT – III

Genetic Engineering of plants – Gene transfer methods – vector mediated gene transfer, virus – mediated gene transfer, Direct or Vectorless DNA transfer.

UNIT –IV

Application of Transgenic plants – Resistance to biotic stresses – Insect resistance plant virus, bacteria and fungi resistance, abotic stress – herbicide resistance plants.

UNIT – V

Molecular Marker Aided plant Breeding – Molecular markers, Molecular marker assisted selection, Arid & semi-arid plant Biotech, Green house & Green home technology.

References:

Dr. U. Sathyanarayana – Biotechnology. Books and Allied Publications

Winnacker, E.L. 1989: *From genes to clones. Introduction to Gene Technology*. VCH Weinheim.

Old, R.M. and S.B. Primrose. 1995. *Principles of Gene Manipulation*. Blackwell Scientific Publication. London.

Glick, B.K. and Pasternak, J.J. 1994. *Molecular Biotechnology. Principles and applications of recombinant DNA*. ASM Press, Washington.

ELECTIVE III – A : MEDICAL MICROBIOLOGY

UNIT- I

Infections- sources of infections- types of infections - methods of infections- definitions- epidemic, pandemic, endemic diseases - Epidemiology of infectious diseases, infectious diseases cycle- investigation of epidemics - control of epidemics.

UNIT- II

Morphology, pathogenicity and laboratory diagnosis - Gram positive organisms - *Staphylococcus aureus*, *Streptococcus pyogenes*, *Bacillus anthracis*, *Clostridium tetani*, Gram negative organisms – *Escherichia coli*, *Klebsiella*, *Shigella*, *Pseudomonas*, *Vibrio cholerae*.

UNIT- III

Morphology, pathogenicity and laboratory diagnosis - *Mycobacterium tuberculosis*, *Mycobacterium leprae*, *Leptospira*. Superficial infections – *Dermatophytes*, *Trichophyton*, Epidermophyton. Opportunistic fungal infections- *Candida albicans*, *Aspergillus*, Parasitic diseases - *Plasmodium vivax*, *Ascaris*, *Wuchereria bancrofti*.

UNIT -IV

Etiology and laboratory diagnosis of urinary tract infections. Pyogenic infections - *Staphylococcus* and *Pseudomonas*: sexually transmitted diseases. Fever of unknown origin, meningitis, diarrhea, respiratory tract infections.

UNIT -V

Antibiotics and chemotherapeutic agents - Mechanism of actions – Drug resistance – Antimicrobial susceptibility testing - Disc diffusion - Kirby Bauer.

References

1. Mackie and McCartney, 1994, Medical Microbiology, Voll and II Churchill Livingstone, 14th edition.
2. Ananthanarayanan, R and C K Jayaram Panicker, 1994. Textbook of Microbiology, Orient Longman.
3. Chakraborty P 1995, A Text book of microbiology, New Central Book Agency Pvt Ltd. Calcutta.
4. Bailey and Scotts, 1994 Diagnostic Microbiology 9th edition, Baron and Finegold, C V Moshby Publications.
5. Jawetz E Melnic JL and Adelberg EA 1998, review of Medical Microbiology Lange Medical Publications, USA.
6. Jayaram Panicker, C K 1993, 3rd edition, Text book for Medical Parasitology, Jaypee Brothers Medical Publishers (P) Ltd.

ELECTIVE III – B : MEDICAL BIOCHEMISTRY

Unit I

Disorders of carbohydrate metabolism – Diabetes mellitus, Glucose tolerance tests, sugar levels in blood, renal threshold for glucose, factors influencing blood glucose level, glycogen storage diseases, pentosuria, galactosemia

Unit II

Disorders of lipids- Plasma lipo proteins, cholesterol, triglycerides and phospholipids in health and disease, hyperlipidemia, hyperlipoproteinemia, Gaucher's disease, Tay-Sach's, ketone bodies, β -lipoproteinemia

Unit III

Disorders of liver and kidney- Jaundice, fatty liver, normal and abnormal functions of liver and kidney, inulin and urea clearance

Unit IV

Abnormalities in nitrogen metabolism- Uremia, hyperurecemia, porphyria and factors affecting nitrogen balance

Unit V

Blood –composition and functions, properties and functions of haemoglobin. Blood clotting- disturbances in blood clotting mechanisms- haemorrhagic disorders, haemophilia, purpura, thrombocytopenic purpura, disseminated intravascular coagulation, acquired prothrombin complex disorders, circulating anticoagulants.

References

1. Fundamentals of biochemistry. A. C. Deb. 8th edition. New central book agency (p)ltd. India
2. Textbook of biochemistry with clinical correlations. Thomas M Deblin. 4th edition. A John Wiley and sons, Inc., publications., New York.
3. Biochemistry. U. Sathyanarayana. 2nd edition. Books and allied pvt ltd.
4. Fundamental of Biochemistry for medical students. Ambika Shanmugam. Revised edition(2003). Published by the Author, 17. III Cross street, west CIT nagar, Chennai-35

ELECTIVE III – C : ENTREPRENEURIAL MICROBIOLOGY

UNIT I:

Entrepreneur development, activity, Institutes involved, Government contributions to entrepreneurs, risk assessment. Industrial Microbiology, Definition, scope and historical development.

UNIT II:

Microbial cells as fermentation products- Bakers yeast, food and feed yeasts, Bacterial Insecticides, Legume Inoculants, Mushrooms, Algae. Enzymes as fermentation products- Bacterial and Fungal Amylases, Proteolytic Enzymes, Pectinases, Invertases, and other enzymes.

UNIT III:

Mushroom cultivation and Composting- Cultivation of *Agaricus campestris*, *Agaricus bisporus*, and *Volvariella volvaciae*; Preparation of compost, filling tray beds, spawning, maintaining optimal temperature, casing, watering, harvesting, storage. Biofertilizers- Historical background, Chemical fertilizers versus biofertilizers, organic farming. *Rhizobium* sp, *Azospirillum* sp, *Azotobacter* sp, as Biofertilizers.

UNIT IV:

Patents and secret processes, History of patenting, composition, subject matter and characteristics of a patent, Inventor, Infringement, cost of patent. Patents in India and other countries. Fermentation Economics.

UNIT V:

Brewing- Media components, preparation of medium, Microorganisms involved, maturation, carbonation, packaging, keeping quality, contamination, by products. Production of Industrial alcohol.

References:

Industrial Microbiology- L.E.Casida, jr, New age International publication.
Entrepreneurial Development in India- By Arora
Experiments in Microbiology, Plant pathology, Tissue culture and Mushroom production technology- K.R.Aneja, New age International publication.

Diagnostic microbiology involves the study of specimens taken from patients suspected of having infections. The end result is a report that should assist the clinician in reaching a definitive diagnosis and a decision on antimicrobial therapy. Hence, clinicians should be acquainted with the techniques of taking specimens, and understand the principles and techniques behind laboratory analysis. 6.1 The cycle of important events in diagnostic microbiology, depicting the interaction between the clinician and the microbiology laboratory.

1. clinical request and provision of clinical information.
2. collection and transport of appropriate specimen(s).
3. laboratory analysis.
4. interpretation of the microbiology report and use of the information.

Clinical request. Contact experts in Diagnostic Microbiology to get answers | Solutions to scientific and research problems, and discussions about Diagnostic Microbiology. Yes of course it need to be diluated which is a normal procedure for PCR. e.g we are using specific PCR primers and probes where we are diluting our material up to 10 ng/ul. And sometimes after isolation we get 500-800 ng/ul. We use this for total reaction in 10 ul of (buffers, primers etc). Of course I don not think they are saing that they have milion colonies and this 1 mln account for results from PCR. They are just comparing profiles to have idea that this number of colonies is similar to such result from PCR. So they are not saying that Ct that they get from PCR is equal to 1 mln colonie