Revised Scheme of Examination and Syllabus

1st & 2nd Semester w.e.f. 2014-15
3rd and 4th Semester w.e.f. 2015-16

M.Sc. Microbiology

Department of Bio and Nano Technology
Guru Jambheshwar University of Science & Technology,
Hisar-125 001, Haryana

Revised Curriculum of M. Sc. Microbiology (w.e.f. 2014-15)

FIRST SEMESTER

Sr. No.	Course No.	Title	Type	L	P	Credit
1.	MML-511	General Microbiology	PC	5	0	5
2.	MML-512	Principles of Biochemistry	PC	5	0	5
3.	MML-513	Microbial Physiology and Metabolism	PC	4	0	4
4.	MML-514	Microbial Genetics	PC	4	0	4
5.	MML-515	Soil Microbiology	PC	4	0	4
6.	MMP-516	Lab I (Microbiology)	PC	0	6	3
7.	MMP-517	Lab II (Biochemistry)	PC	0	6	3
		TOTAL		**22**	**12**	**28**

SECOND SEMESTER

Sr. No.	Course No.	Title	Type	L	P	Credit
1	MML-521	Instrumentation Techniques	PC	4	0	4
2	MML-522	Food Microbiology	PC	4	0	4
3	MML-523	Industrial Microbiology	PC	4	0	4
4	MML-524	Principles of Immunology	PC	4	0	4
5	MML-525	Molecular Biology	PC	4	0	4
6	MMP-526	Lab III (Food Microbiology/ Industrial Microbiology)	PC	0	6	3
7	MMP-527	Lab IV (Instrumentation Techniques, Immunology)	PC	0	6	3
		TOTAL		**20**	**12**	**26**

THIRD SEMESTER

Sr. No.	Course No.	Title	Type	L	P	Credit
1.	MML-531	Recombinant DNA Technology	PC	4	0	4
2.	MML-532	Enzyme Technology	PC	4	0	4
3.	MML-533	Introduction to Bioinformatics	PC	4	0	4
4.	MML-534	Medical Microbiology	PC	4	0	4
5.	MML-535	Environmental Microbiology	PC	4	0	4
6.	MMP-536	Lab V (Recombination DNA technology and Bioinformatics)	PC	0	6	3
7.	MMP-537	Lab VI (Environmental & Medical Microbiology)	PC	0	6	3
8.	MMS-590	Credit Seminar	PC	1	0	1
9.	MMD-595	**Summer Training/Industrial Training**			**6**	**3**
		TOTAL		**21**	**18**	**30**

FOURTH SEMESTER

Sr. No.	Course No.	Title	Type	L	P	Credit
1.	MML-541	Bio- safety, Bio- business and IPR	PC	4	0	4
2	MMD-600	Investigation Problem	PC	0	16	16
		TOTAL		**4**	**16**	**20**

Semester	Credit
1st	**28**
2nd	**26**
3rd	**30**
4th	**20**
TOTAL	**104**

Note: **Program core (PC)**. **L=Lecture, P=Practical**

1. The minimum credit requirement for the M.Sc. degree in Microbiology is 104 credits.
2. For theory courses, one hour per week per semester is assigned as one credit. For practical courses six hours per week accounts for 3 credits. One hour per week per semester is assigned as half credit.
3. Each theory paper examination will be of 3 hours duration and practical examination will be of 4 hours duration.
4. After the completion of second semester the student are required to undertake a 4-6 weeks In-Plant Training/summer training MMD 595 in any industry /institute/research organization and shall be required to submit training certificate and report for which internal *viva–voce* examination will be conducted .
5. In the fourth semester the students are required to undertake Investigation Problem (MMD- 600) shall be required to submit an Investigation Report in the form of Thesis for which *viva-voce* examination will be conducted.
6. In the third semester, each student has to deliver one credit seminar of 1 credit and it will be evaluated internally by the seminar incharge.

MML- 511: GENERAL MICROBIOLOGY **MM: 70**
(Credits: 5+0) **Internal: 30**
Time: 3 Hours

The student shall attempt any five out of eight questions. Each question shall carry equal marks.

Introduction to Microbiology: Historical background and scope of Microbiology. Ubiquitous nature of microorganisms. Impact of microbes on human affairs. Structure of prokaryotic and eukaryotic cell. Differences between Eubacteria, Archaebacteria and Eukaryotes. Salient features of different groups of microorganisms such as bacteria, fungi, protozoa and algae including their morphological features, mode of reproduction and cell cycle.

Nutrition and Classification: Principles of microbial nutrition- Chemoautotrophs, chemoheterotrophs, photoautotrophs and photoheterotrophs. Basic principles and techniques used in bacterial classification. Phylogenetic and numerical taxonomy. New approaches of bacterial classification including DNA hybridization, ribosomal RNA sequencing and characteristics of primary domains. Major groups of bacteria based on latest edition of Bergey's manual.

Viruses: General characteristics, structure, and classification of plant, animal and bacterial viruses, Replication of viruses. Lytic and lysogenic cycle in bacteriophages. A Brief account of Retroviruses, Viroids, Prions and emerging viruses such as HIV, Avian and swine flu viruses.

Microbial Growth: The definition of microbial growth. Growth in batch culture. Mathematical representation of bacterial growth, Bacterial generation time. Specific growth rate. Monoauxic, Diauxic and synchronized growth curves. Measurement of microbial growth. Factors affecting microbial growth. Brief account of growth in fungi. Culture collection and maintenance of microbial cultures.

Control of Microorganism: Control of Microorganism by physical and chemical agents. Antiseptics and disinfectants. Narrow and broad spectrum antibiotics. Antifungal antibiotics, Mode of action of antimicrobial agents. Antibiotic resistance mechanisms.

Microbial Ecology: Microbial flora of soil, Interaction among microorganisms in environment. Symbiotic associations- types, functions and establishment of symbiosis. Brief account of biological nitrogen fixation.

Recommended Books:

1.Madigan,M.T., Martinko, J.M., Bender, K., and Buckley, D. (2011) Brock Biology of Microorganisms, 13th Ed., Pearson Education, USA
2. Tauro, P., Kapoor, K.K. and Yadav, K.S. (1996). Introduction to Microbiology, New Age Pub., New Delhi
3. Pelczar, M.J. *et. al* (2001), Microbiology- Concepts and Applications, International Ed. McGraw Hill Publication, New York
4. Black, J.G. (2012), Microbiology: Principles and Explorations, 8th Edition, John Wiley and Sons, USA.
5. Willey, J.M., Sherwood, L., and Woolverton, C. (2013) Prescott's Microbiology 9th Revised edition, McGraw Hill Higher Education, New York
6. Pommerville, J.C. (2009) Alcamo's Fundamentals of Microbiology, Jones and Bartlett Publishers.
7. Tortora, G.J., Funke, B.R., Case, C.L. (2012) Microbiology -An Introduction, 11th Edition, Pearson education Pvt. Ltd. Singapore.

MML 512: PRINCIPLES OF BIOCHEMISTRY **MM: 70**
(Credits: 5+0) **Internal: 30**
Time: 3 Hours

The student shall attempt any five out of eight questions. Each question shall carry equal marks.

Biomolecules: General structure of biomolecules, Fundamental principles governing structure of biomolecules, Importance of covalent and non-covalent bonds.

Carbohydrates: Structure and function of biologically important mono-, di- and polysaccharides, glycoproteins and glycolipids. Metabolism of carbohydrates-Glycolysis, Feeder pathways, Citric acid cycle, Gluconeogenesis, Glyoxylate and Pentose phosphate pathways and their regulations.

Proteins: Structure of amino acids, non-protein and rare amino acids. A brief account of amino acid biosynthesis and degradation, Urea cycle. Structural organization of proteins, Reverse turns and Ramachandran plot, Supra-molecular complexes of proteins. Chemical synthesis of peptides and small proteins. Protein sequencing.

Lipids: Structure of fatty acids, Classification of lipids, Structure and functions of major lipid subclasses- Acylglycerols, Phospholipids, Glycolipids, Sphingholipids, Waxes, Terpenes and Sterols. Fatty acids biosynthesis, degradation and their regulations, Ketone bodies synthesis. Biosynthesis of TAG, Cholesterol, Phospholipids and Glycolipids.

Nucleic Acids: Structure and properties of nucleic acid bases, nucleosides and nucleotides. Biosynthesis and degradation of purines and pyrimidines, Salvage pathway.

Vitamins: Structure and biochemical roles of fat and water-soluble vitamins and their co-enzymes.

Recommended Books:

1. Nelson, D.L. and Cox, M.M. (2013), Lehninger Principles of Biochemistry, 6th Edition Freeman and Company, New York.
2. Conn E.E., Stumpf P.K., Bruening G. and Doi R.H. (1997,) Outlines of Biochemistry. John Willey and Sons Inc. New York and Toronto.
3. Voet D., Voet J.G. and Pratt C.W. (2013), Principles of Biochemistry, 4th Edition John Wiley and Sons Inc., New York.
4. Elliott W.H. and Elliott D.C. (1997), Biochemistry and Molecular Biology. Oxford University Press Inc. New York.
5. Metzler D.E. (2001), Biochemistry (Vol I and II) Academic Press, London and New York.
6. Berg J.M., Tymoczko J.L. and Stryer L (2012), Biochemistry, 7th Edition W.H. Freeman Publishers, New York.
7. Garret R.H. and Grisham C.M (2010) Biochemistry, 4th Edition. Brooks/Cole, Boston.

MML-513: MICROBIAL PHYSIOLOGY AND METABOLISM **MM: 70**
(Credits: 4+0) **Internal: 30**
Time: 3 Hours

The student shall attempt any five out of eight questions. Each question shall carry equal marks.

Cellular Organization of Microorganisms: Structure, function, biosynthesis and assembly of various cellular components of Prokaryotes-Capsule and slime layers, peptidoglycan, outer membrane, cytoplasmic membrane, flagella, axial filaments, pili and fimbriae, nuclear material, and storage molecules. Bacterial permeation-Transport of solutes across the membrane. Chemotaxis. Cell cycle of *E. coli*, and Yeast *S. cerevisiae.* Structure of fungal cell.

Differentiation in Bacteria: Endospore and cyst forming bacteria. Molecular architecture of spores, induction and stages of sporulation cycle. Influence of different factors on sporulation. Cytological and macromolecular changes during sporulation. Spore germination and out growth. Microcycle sporulation. Differentiation in *Caulobacter* and myxobacteria. Sporulation in fungi-biochemical and macromolecular changes.

Fermentation and Energy Generation: Metabolism of lactic acid bacteria, coliforms, yeast, clostridia, and propionic acid bacteria. Metabolism of methanogens.

Bacterial Photosynthesis: Photosynthetic bacteria, photosynthetic pigments, and generation of reducing power by cyclic and non-cyclic photophosphorylation, electron transport chain in photosynthetic bacteria, Carbon dioxide fixation pathways. Cyanobacterial photosynthesis.

Bacterial Respiration: Bacterial aerobic respiration, components of electron transport chain, free energy changes and electron transport, oxidative phosphorylation and theories of ATP formation, inhibition of electron transport chain. Electron transport chain in some chemolithotrophic bacteria such as nitrifiers and sulphur oxidizers. Oxidation of molecular hydrogen by *Hydrogenomonas* species. Bacterial anaerobic respiration- Nitrate and sulphate as electron acceptors.Electron transport chains in some anaerobic bacteria. Catalase, super oxide dismutase, mechanism of oxygen toxicity.

Recommended Books:

1. Caldwell, D.R. (1995), Microbial Physiology and Metabolism, Brown Publishers.
2. Moat, A.G. and Foster, J. W. (1999), Microbial Physiology. Wiley., NY
3. Brun, Y.V. and Shimkets L.J. (2000), Prokaryotic Development. ASM Press, Wisconsin
4. Doelle, H.W. (1969). Bacterial Metabolism. Academic Press, NY
5. Gottschalk, G. (1979). Bacterial Metabolism.Springer Verlag, Berlin
6.Sokatch, J.R. (1969). Bacterial Physiology and Metabolism. Academic Press, *NY*
7. Srivastava, B. (2011) Microbial Physiology and Metabolism, LAP Lambert Academic Publishing, USA

MML -514: MICROBIAL GENETICS **MM: 70**
(Credits: 4+0) **Internal: 30**
Time: 3 Hours

The student shall attempt any five out of eight questions. Each question shall carry equal marks.

Inheritance: Historical background, Extra-chromosomal inheritance, Inheritance of quantitative traits, Sex linked, Sex influenced and sex limited traits.

Molecular Organizations of Chromosomes: Viral and bacterial chromosomes, Nucleosome and chromatin structure, Structure of centromere and telomere, Euchromatin and heterochromatin, Polytene and lamp brush chromosomes, Genome complexity.

Linkage, Crossing over and Gene mapping in Eukaryotes: Linkage and recombination of gene, Gene mapping by three point test cross, Tetrad analysis, Positive and negative interference, Molecular mechanism of recombination, Post-meiotic segregation, Mapping through somatic cell hybridization.

Mutation: Molecular mechanism of spontaneous mutations, Molecular mechanism of mutations induced by known chemical mutagens, DNA repair mechanisms - excision, mismatch, SOS, photo-reactivation, recombination repair and glycocylase system., Molecular mechanism of suppression, Somatic mutations.

Gene Concept: Classical concept, Fine structure of the gene, Molecular concept of the gene, Pseudogenes, Overlapping genes, Oncogenes, Repeated genes, Gene amplification.

Bacterial and Viral Genetics: Transformation, Conjugation and Transduction, Molecular mechanism of recombination in bacteria, IS and Tn elements in bacteria, *E.coli* recombination system, Bacterial plasmids, Lytic cascade and lysogenic repression.

Recommended Books:

1. Gardener *et.al*. (2001), Principles of Genetics, 8th Edition, John Wiley, New York
2. Brooker R.J. (1999), Genetics – Analysis and Principles. Addison Wesley Longman Inc. California.
3. Maloy S.R., Cronan Jr. J.R. and Freifelder D. (1994), Microbial Genetics 2nd Edition, Jones and Barlett Publishers, London.
4. Hartl, D.L. (2012), Essential of Genetics, 8th Edition, Jones and Bartlett Publishers, London.
5. Klug, W.S., Cummings, M.R, Spencer C.A and Palladino, M.A. (2012), Concept of Genetics, 10th Edition, Pearson Education, Singapore.
6. Miglani, G.S. (2002), Advanced Genetics, Narosa Publishing House, New Delhi.
7. Snustad, Peter. D and M.J. Summons. (2012) Genetics, 6th Edition, Wiley John & Sons.

MML-515: SOIL MICROBIOLOGY **MM: 70**
(Credits: 4+0) **Internal: 30**
Time: 3 Hours

The student shall attempt any five out of eight questions. Each question shall carry equal marks.

Soil as a Habitat for Microorganisms: Nature and properties of soil. Distribution of various groups of microorganisms in soil, such as bacteria, fungi, protozoa, algae and viruses. Impact of environmental factors and global climate change on distribution of soil biota .Measurement of soil microbial biomass and microbial activities. Soil metagenomics- Unculturable soil biota and its diversity.

Microbial Transformations: Carbon cycle. Biodegradation of soil organic constituents- Degradation of cellulose, hemicelluloses and lignin. Humic substances in soil-Genesis, structure, composition and role in agriculture and environment. Role of microorganisms in cycling of nitrogen, phosphorus, sulphur, iron and manganese in soil-plant system. Environmental impact of biogeochemical cycles.

Microbial Interactions in Soil: Positive and negative interactions. Microbiology of rhizosphere. Biological nitrogen fixation. Symbiotic associations- Legume-rhizobial symbiosis, actinorhizal symbiosis, and associative symbiosis. Mycorrhizal associations and P nutrition. Soil enzyme activities: Origin and their significance.

Microbial Control and Bioinoculants: Microorganisms involved in biological control of plant diseases. Biocontrol agents and mechanisms of disease suppression. Plant growth promoting rhizobacteria. Biological control of insects and nematodes. Production and use of microbial inoculants.

Soil Biological Health: Biological indicators of soil health. Biodegradation of pesticides. Role of microorganisms in sustainable agriculture and organic farming.

Recommended Books:

1. Alexander, M. (1977). Introduction to Soil Microbiology. John Wiley, New York
2. Paul, E.A. (2007). Soil Microbiology, Ecology and Biochemistry. 3rd Ed. Academic Press, New York
3. Sylvia, D.M. *et al. (*2005). Principles and Applications of Soil Microbiology. 2nd Ed. Pearson Edu.
4. Van Elsas, J. D., Trevors, J.T. and Wellington, E.M.H. (1997). Modern Soil Microbiology. Marcel Dekker., NY.
5. Tate, R.L. (2012).Soil Microbiology, Wiley-Blackwell., NY
6. Dixon; G.R. and Tilston, E.L. (2010) Production. Springer, Heidelberg.
7. Coyne, M. (1999). Introduction to Soil Microbiology, Delmar Cengage Learning, NY.
8. Bloem; J., Hopkins; D.W. and Benedetti, A. (2008) Microbiological Methods for Assessing Soil Quality, CABI, Wallingfard.
9. Stevenson; F.J. and Cole, M.A. (1999) Cycles of Soils. John Wiley, NY.

MML- 521: INSTRUMENTATION TECHNIQUES **MM: 70**
(Credits: 4+0) **Internal: 30**
Time: 3 Hours

The student shall attempt any five out of eight questions. Each question shall carry equal marks.

Microscopic Techniques: Principles and applications of light, Phase contrast, Fluorescence microscopy, Scanning and Transmission Electron Microscopy, Confocal Microscopy. Flow Cytometry.

Centrifugation: Preparative and analytical Centrifuges, Sedimentation analysis, RCF, Density Gradient Centrifugation.

Chromatography Techniques: Theory and Application of Paper Chromatography, TLC, Gel Filtration, Ion Exchange Chromatography, Affinity Chromatography, GLC and HPLC.

Electrophoresis Techniques: Theory and Application of PAGE, Agarose Gel Electrophoresis, Iso-electric Focusing.

Spectroscopic Techniques: Theory and Application of UV and Visible Spectroscopy, FTIR Spectroscopy, MS, NMR, Atomic Absorption Spectroscopy, X- ray diffraction, Raman Spectroscopy.

Radio-isotopic Techniques: Introduction to Radioisotopes and their biological applications, Radioactive Decay – Types and Measurement. Principles and Applications of GM Counter, Solid and Liquid Scintillation Counter, Autoradiography, Radiation Dosimetry.

Other Techniques: Particle Size Analyzer, Circular Dichroism.

Recommended Books:

1. Freifelder D. (1982), Physical Biochemistry- Application to Biochemistry and Molecular Biology, 2nd Edition, W.H. Freemen and Company, San Fransisco.
2. Rietdorf, J. (2010) Microscopy Techniques, Springer, Berlin
3. Walker J. and Wilson K (2010), Principles and Techniques-Practical Biochemistry, 7th Edition, Cambridge University Press, London.
4. Robyt, J.F. and White, B.J. (1987) Biochemical Techniques: Theory and Practice,
Waveland Press
5. Skoog, D.A.; Crouch, S.R. and Holler, F.J. (2006) Principles of Instrumental Analysis, 6thEdn. Brooks/Cole, USA
6. Slater R.J. (1990), Radioisotopes in Biology-A Practical Approach, Oxford University Press, New York.
7. Boyer, R.F. (2006) Modern Experimental Biochemistry, Pearson, New Delhi.

MML- 522: FOOD MICROBIOLOGY **MM: 70**
(Credits: 4+0) **Internal: 30**
Time: 3 Hours

The student shall attempt any five out of eight questions. Each question shall carry equal marks.

An Overview of Microbes in Food: Brief historical aspects of microorganism in foods; source, types and role of microorganisms in foods; intrinsic and extrinsic factors affecting microbial growth.
Microbial spoilage of foods: Fruits and vegetables, Meat and meat products, Milk and milk products, canned foods.

Food Preservation: Use of High and low temperature, Control of water activity, Use of Radiations in preservation, Modified atmosphere packaging, High pressure processing, chemical preservatives and naturally occurring antimicrobials. Hurdle technology in food preservation, Bacteriocins and their applications; Probiotic bacteria in foods.

Fermented Food Products: Microorganisms involved in food fermentations. Fermented meats and sausages; Fermented milk products- Acidophilus and Bulgarian milk, yoghurt, cheese, Kefir, Koumiss; Fermented grains and vegetable products - Sauerkraut, Soy sauce, Tempeh, Miso, Olive, and Kimchi; Single cell protein, Baker's yeast production; Microbial polysaccharides and pigments in foods. Role of enzymes in food technology.

Protein engineering: Protein engineering in food technology-objectives, methods, targets, potential applications in food industry and limitations.

Food Borne Infections and Intoxications: Types of Food Poisonings, Role of microorganisms and their toxins in food poisoning. Common food borne pathogens: *Bacillus cereus*, *Staphylococcus aureus*, *Vibrio*, *Campylobacter jejuni*, *Clostridium botulinum*, *Clostridium perfringens*, *Escherichia coli*, *Listeria monocytogenes*, *Salmonellosis*, *Shigellosis*, *Yersinia enterocolitica*. Mycotoxins and algal toxins.

Food Safety and Quality Assurance in Foods: Microbial testing of foods-traditional methodology and new approaches: Microbiological, Physical , Chemical methods, Use of gene probes and PCR, bioluminescence, Immunological methods, BAX system, Riboprinter and Real Time PCR based approaches Microbiological quality standards for food industry. Biosensors in food. Concept of HACCP for quality assurance and food safety in food industry.

Recommended Books:

1. Ray, B. and Bhunia, A. (2013). Fundamental Food Microbiology, 5th Revised edition. CRC Press Inc
2.Frazier, W.C. andWesthoff, D.C.(1991). Food Microbiology. 3rd Ed. Tata McGraw Hill.
3. Banwart, G. J, (1989.) Basic Food Microbiology. AVI. Pp.462
4. Jay, J.M., Loessner, M.J. and Golden , D.A. (2005) Modern Food Microbiology, 7th edn. Springer-Verlag New York
5. Lee, B.H. (1996), Fundamental of Food Biotechnology, VCH Publishers.
6. Doyle, M.P.and Buchanan, R.L. (2012), Food Microbiology, ASM Press, Washington.
7. Joshi, V.K. and Pandey, A. (1999), Biotechnology: Food Fermentation Vol. 1 & 2, Education Publisher and Distributor, New Delhi.
8. Marwaha, S.S. and Arora, J.K. (2000), Food Processing: Biotechnological applications, Asia Tech Publishers Inc., New Delhi.

MML-523: INDUSTRIAL MICROBIOLOGY **MM: 70**
(Credits: 4+0) **Internal: 30**
Time: 3 Hours

The student shall attempt any five out of eight questions. Each question shall carry equal marks.

Introduction to Fermentation Technology: Fermentation overview, Introduction to fermentation processes, industrially important microorganisms-Isolation, screening, and preservation of industrially important microorganisms.

Strain Improvement: Natural selection, mutation and screening of improved cultures, random and strategic screening methods, Use of recombinant DNA technology, protoplast fusion etc. **Principles of overproduction of primary and secondary metabolites with relevant examples.**

Fermentation Systems: Batch and Continuous system, Fed batch culture, multistage systems, Feedback systems, Solid substrate fermentation. Instrumentation and control of fermentation processes.

Production and Recovery of Primary and Secondary Metabolites: Industrial Alcohol, Beer, Wine, Citric Acid, Acetic acid, lactic acid, Acetone- Butanol fermentation, Amino acids- Lysine & Glutamic acid production, Industrial enzymes, Antibiotics- Penicillin and Tetracycline, Bioinsecticides, Biopolymers, vitamins and steroids.

Fermentation raw materials: Media for industrial fermentation, Criteria used in media formulation, sterilization, raw materials and process control. Downstream processing- Separation processes and recovery methods for fermentation products.

Fermenter Design: Bioreactor configuration, design features, Criteria in Fermenter design, Requirement for aeration and mixing, Energy Transfer .Other fermenter designs- Tube reactors, packed bed reactors, fluidized bed reactors, cyclone reactors, trickle flow reactors.

Waste Treatment: Waste Treatment systems, Aerobic and anaerobic waste treatment systems for waste treatment in fermentation industry.

Recommended Books:

1. Stanbury, P.F., Hall, S., Whitaker, A. (1998), Principles of Fermentation Technology, 2nd edn. Butterworth-Heinemann Ltd
2. Ward O.P., (1999), Fermentation Biotechnology – Principles, Process and Products. Prentice Hall Publishing, New Jersey.
3. Rehm, H.J., Reed, G.B., Puehler, A. and Stadler (1993), Biotechnology, Vol. 1-8, VCH Publication.
4. Prescott, S.C.and Dunn, G.C (1992), Industrial Microbiology, 4th Edition CBS Publication, New Delhi.
5. Domain, A. I. and Davies, J. E. (1999), Manual of Industrial Microbiology and Biotechnology, 2nd Edition, ASM Press, Washington D.C.
6. Glazer and Nikaido (1998) Microbial Biotechnology By WH Freeman & Company, New York.
7. Cruger,W. and Kruger. (2002), Biotechnology –A Textbook of Industrial Microbiology, 2nd Edition, Panima Publishing Corporation, New Delhi.

MML 524: PRINCIPLES OF IMMUNOLOGY **MM: 70**
(Credits: 4+0) **Internal: 30**
Time: 3 Hours

The student shall attempt any five out of eight questions. Each question shall carry equal marks.

Immunology- fundamental concepts and anatomy of the immune system
Components of innate and acquired immunity; Phagocytosis; Complement and Inflammatory responses; Haematopoesis; Organs and cells of the immune system- primary and secondary lymphoid organs; Lymphatic system; Lymphocyte circulation; Lymphocyte homing; Mucosal and Cutaneous associated Lymphoid tissue. (MALT & CALT); Mucosal Immunity; Antigens - immunogens, haptens; Complement system.

Immune responses generated by B and T lymphocytes
Immunoglobulins-basic structure, classes & subclasses of immunoglobulins, Hybridoma technology and its application, antigenic determinants; Multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; Principles of cell signaling; Basis of self, non-self-discrimination; Kinetics of immune response, memory; Generation of antibody diversity.

Processing and presentation of antigen: Antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens, Major Histocompatibility Complex - MHC genes, MHC and immune responsiveness and disease susceptibility, HLA typing.

Antigen-antibody interactions
Precipitation, agglutination and complement mediated immune reactions; Advanced immunological techniques- RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence, flow cytometry and immune electron microscopy; Surface plasmon resonance, Biosensor assays for assessing ligand –receptor interaction, CMI techniques- lymphoproliferation assay, Mixed lymphocyte reaction, Cell Cytotoxicity assays, Apoptosis.

Clinical Immunology
Immunity to Infection: Bacteria, viral, fungal and parasitic infections (with examples from each group); Hypersensitivity – Type I-IV; Autoimmunity; Types of autoimmune diseases; Mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; Treatment of autoimmune diseases; Cytokines-properties, receptors and therapeutic uses; Vaccines

Tumor immunology –Tumor antigens; Immune response to tumors and tumor evasion of the immune system, Cancer immunotherapy; Immunodeficiency Primary immune deficiencies, Acquired or secondary immune deficiencies.

Texts/References

1. Kuby, RA Goldsby, Thomas J. Kindt, Barbara, A. Osborne Immunology, 8th Edition, Freeman, 2012.
2. Brostoff J, Seaddin JK, Male D, Roitt IM., Clinical Immunology, 6th Edition, Gower Medical Publishing, 2002.
3. Janeway et al., Immunobiology, 8th Edition, Current Biology publications, 2012.
4. Paul, Fundamental of Immunology, 4th edition, Lippincott Raven, 1999.
5. Goding, Monoclonal antibodies, Academic Press. 1985.

MML 525: MOLECULAR BIOLOGY **MM: 70**
(Credits: 4+0) **Internal: 30**
Time: 3 Hours

The student shall attempt any five out of eight questions. Each question shall carry equal marks.

DNA Structure: DNA as genetic material, Chemical structure and base composition of nucleic acids, Double helical structures, Different forms of DNA, Forces stabilizing nucleic acid structure, Super coiled DNA, Properties of DNA, Renaturation and denaturation of DNA. Tm and Cot curves, Structure of RNA.

DNA Replication: General features of DNA replication, Enzymes and proteins of DNA replication, Models of replication, Prokaryotic and eukaryotic replication mechanism. Replication in phages, Reverse transcription

Transcription: Mechanism of transcription in prokaryotes and eukaryotes, RNA polymerases and promoters, Post-transcriptional processing of tRNA, rRNA and mRNA (5' capping, 3' polyadenylation and splicing), RNA as an enzyme- Ribozyme.

Translation: Genetic code, General features, Deciphering of genetic code, Code in mitochondria. Translational mechanism in prokaryotes and eukaryotes. Post transnational modification and transport, Protein targeting (signalling), Non ribosomal polypeptide synthesis, Antibiotic inhibitors and translation.

Regulation of Gene Expression in Prokaryotes and Eukaryotes: Operon concept, Positive and negative control, lac, trp and arb operon, Regulation of gene expression in eukaryotes (a brief account), Anti-sense RNA, RNAi.

Recommended Books:

1. Adams R.L.P. *et al.* (1992), The Biochemistry of Nucleic Acids, 11th Edition, Chapman and Hall, New York.
2. Lewin B. (2004), Gene VIII, Pearson Prentice and Hall, New Delhi.
3. Karp G. (2010), Cell and Molecular Biology-Concept and Experiments, 5th Edition, John Wiley, New York.
4. Lodish *et al* (2013), Molecular Cell Biology, 7th Edition, W.H. Freeman Publisher.
5. Malacinski, G.M. and Freifelder D. (1998), Essentials of Molecular Biology, 3rd Edition, John and Bartlett Publishers.
6. Buchanan B.B. *et.al* (2000), Biochemistry and Molecular Biology of Plants, American Society of Plant Physiologist, Rockville, Maryland, USA.
7. Watson *et.al* (2009), Molecular Biology of gene, 5th Edition, Pearson Education, New Delhi.
8. Klug, W.S., Cummings, M.R, Spencer C.A and Palladino, M.A. (2012), Concept of Genetics, 10th Edition, Pearson Education, Singapore.

MML -531: RECOMBINANT DNA TECHNOLOGY **MM: 70**
(Credits: 4+0) **Internal: 30**
Time: 3 Hours

The student shall attempt any five out of eight questions. Each question shall carry equal marks.

Introduction: Historical background, Restriction enzymes and modifying enzymes, Restriction mapping, Construction of chimeric DNA- staggered cleavage, Addition of poly dA and dT tails, Blunt end ligation, Gene cloning.

Cloning and Expression Vectors: Vehicles for gene cloning, Plasmids, Bacteriophages, Cosmids and Phagemids as vectors, P1 vectors, F- factor based vectors, Plant and animal viruses as vector, Artificial chromosomes as vectors (YAC, BAC, PAC and MAC vectors), Expression vectors- use of promoters and expression cassettes, Bacculoviruses as expression vectors, Virus expression vectors, Binary and shuttle vectors.

Isolation Sequencing and Synthesis of Genes: Methods of gene isolation, Construction and screening of genomic and cDNA libraries, Chromosome walking, Chromosome jumping, Transposone tagging, Map based cloning, DNA sequencing Techniques (Maxam Gilbert's chemical degradation methods and Sanger's dideoxy chain termination method), Automated DNA sequencing, Organochemical gene synthesis, Blotting techniques- Southern, Northern and Western Blotting.

Molecular Probes and PCR: Molecular probes**,** Labeling of probes, Radioactive vs Non radioactive labeling, Uses of molecular probes. Polymerase Chain Reaction- basic principle, Modified PCR (Inverse PCR, Anchored PCR, PCR for mutagenesis, asymmetric PCR, RT PCR, PCR walking), Gene cloning Vs. Polymerase chain reaction, Applications of PCR in biotechnology, Ligase chain reaction.

Molecular Markers and DNA Chip Technology: Molecular Markers- types and applications, Construction of molecular maps (genetic and physical maps), DNA chip Technology & Microarrays (a brief account).

Genomics and Proteomics: Whole genome sequencing and functional genomics (a brief account), Applications of genomics and Proteomics with special reference to Arabidopsis and Rice.

Recommended Books

1. Brown T.A. (2010), Gene Cloning & DNA Analysis, 6nd Edition, Wiley-Blackwell, New York.
2. Watson J.D. (2009), A Passion for DNA: Genes, Genomes & Society, Cold Spring Harbor Laboratory press (CSHL)
3. Glover D.M. and B.D. Hames (1995), DNA cloning: A Practical Approach, IRL Press, Oxford.
4. Primrose (2009), Principles of Gene Manipulation & Genomics, Blackwell's Publishers, 7th Edition.
5. S.M. Kingsman and A.J. Kingsman (1998), Genetic Engineering : An Introduction to Gene Analysis and Exploitation in Eucaryotes, Blackwell Scientific Publications, Oxford,.
6. Sambrook J. E.F. Fritech and T. Maniatis (2000), Molecular cloning: A laboratory Manual, Cold Spring Harbor Laboratory Press, New York
7. Hill W.E. (2000), Genetic Engineering: A Primer, Taylor and Francis.

MML-532: ENZYME TECHNOLOGY **MM: 70**
(Credits: 4+0) **Internal: 30**
Time: 3 Hours

The student shall attempt any five out of eight questions. Each question shall carry equal marks.

Introduction: Historical background, Enzymes vs Chemical catalyst, Enzyme nomenclature and classification, Units of activity, Methods for enzyme assays, Extraction and purification of enzymes, Cofactors and coenzymes.

Enzyme Specificity: Substrate and reaction specificity, Lock & key hypothesis, Induced Fit hypothesis, Wrong way binding hypothesis, Three point attachment hypothesis, Mechanism of action of selected enzymes i.e. chymotrypsin, trypsin, papain, Lysozyme, ribonuclease.

Enzyme Kinetics: Factors affecting velocity of enzyme catalyzed reactions, Michaelis-Menten hypothesis, Transformation of Michaelis- Menten equation and determination of Km and Vmax, Haldane relationship, Multi-reactant enzymes, Enzymes inhibition i.e., reversible and irreversible inhibition, Competitive, Non-competitive and uncompetitive inhibition.

Regulatory Enzymes: Allosteric enzymes, Sequential and symmetry models, covalently regulated enzymes.

Enzyme Technology: Large scale production of enzymes, Uses of isolated enzymes in food and chemical industries, Therapeutic & medicinal use of enzymes.

Protein Engineering: Concept and Methods, Site directed mutagenesis, Active site mapping, Nature of the active site, Identification of functional groups at the active site, Immobilized enzymes–methods and applications.

Recommended Books:

1. Palmer T. (2001) Enzymes Biochemistry, Biotechnology and Clinical Chemistry, 5th Edition, Howood Publishing Chishester, England.
2. Marangoni A.G. (2003), Enzyme Kinetics-A Modern Approach,
3. Price N.C. and Stevens L. (1999), Fundamentals of Enzymology 3rd Edition Oxford University Press, New York.
4. Dixon M. and Webb E.C. (1979), Enzyme, 3rd Edition, Academic Press, New York.
5. Uhlig H (1998), Industrial Enzymes and Their Applications, Jone Wiley, New York.

MML -533: INTRODUCTION TO BIOINFORMATICS **MM: 70**
(Credits: 4+0) **Internal: 30**
Time: 3 Hours

The student shall attempt any five out of eight questions. Each question shall carry equal marks.

Introduction to Bioinformatics: Definition, role, scope and limitation of bioinformatics. Different branches of bioinformatics. Terminologies: Internet browser, software, hardware, database, Network, NicNet, Inflibnet, EMBnet, Operating System, algorithm.

Biological Data Banks: (A brief account) introduction to data mining and data security, Data warehousing, Data capture, Data Analysis, Introduction to nucleic acid and protein sequence, Data Banks, Gene banks, EMBL nucleotide sequence data bank, Sequence data bank, rRNA data Bank, Peptide data bank., Data Bank similarity searches (BLAST, FASTA, PSI-BLAST algorithms multiple), Structural Data Bank (Cambridge small molecules crystal structure data Bank), Calculation of conformational energy of Bio-molecules.

Biodiversity Data Bases: Organizing Biological SPP information, Data sets in Biodiversity informatics (Spp 2000, Tree of life, ATCC, NCBI Spp analyst collaboration. (ICTV, Animal virus information system) a brief account.

Sequence Analysis: Computational methods and significance, homology algorithms (BLAST) for proteins and nucleic acids, open reading frames, annotations of genes, conserved protein motifs related structure / function. Phylogenetic analysis: Introduction and importance, phylogenetic tree, methods of phylogenetic analysis.

Application of Bioinformatics and Scientific Documentation: Virtual library searching-Medline, Science citation indexes, Electronic Journals, Grants and finding information. Research documentation- preparation of research report, settling up of a laboratory, seminar, paper preparation and presentation. How to write dissertation? Guidelines for writing of literature, materials and method, result, discussion, Presentation and references

Recommended Books:

1. Brown S.M. (2000), A Biologist Guide to Bio-computing and the Internet, A Bio-Techniques Books Publication, Eaton Publishing, USA.
2. Krane, D.E. (2005), Fundamental Concept of Bioinformatics, Dorling Kindersley Pvt. Ltd.
3. Przytycka, T.M. and Sagot, M.F. (2011) Algorithms in Bioinformatics, Springer My Copy, UK
4. Mount, D.W (2002), Bioinformatics: Sequence & Genome Analysis, Cold Spring Harbor Laboratory Press.
5. Lesk, A.M. (2013), Introduction to Bioinformatics, 4thEdn. Oxford University Press, Oxford.
6. Day, R.A. (1996), How to Write and Publish a Scientific Paper, 4th Edition, Cambridge University Press, Cambridge

MML-534: MEDICAL MICROBIOLOGY **MM: 70**
(Credits: 4+0) **Internal: 30**
Time: 3 Hours

The student shall attempt any five out of eight questions. Each question shall carry equal marks.

Infection Process: Process of infection-Types, stages of infection, Establishment of pathogenic microorganisms: Entry, spread and tissue damage. Mechanism of bacterial adhesion, colonization and invasion of mucous membranes of respiratory, enteric and urogenital tracts. Aggresssins and toxins.

Pathogenic Bacteria: Morphological characteristics, pathogenesis and laboratory diagnosis including rapid methods of following pathogenic bacteria; *Staphylococcus, Streptococcus, Neisseria, Klebsiella, Proteus, Salmonella, Shigella, Virbrio, Campylobacter, Pseudomonas, Acinetobacter, Yersinia, Francisella, Pasteurella, Haemophilus, Bordetella, Bacillus, Clostridium, Mycobacterium, Actinomyces, Nocardia, Bacteroides, Fusobacterium, Listeria, Legionella. Mycoplasma, Rickettsiae, Chlamydiae,* Spirochetes.

Pathogenic Fungi: Morphological characteristics, pathogenesis and laboratory diagnosis of following pathogenic fungi;- *Microsporum; Trichophyton; Histoplasma capsulatum; Blastomyces dermatitidis; Candida albicans; Cryptococcus neoformans; Pneumocystis carinii.*

Protozoal Pathogens: General description, biological properties and diseases caused by Protozoa- *Plasmodium* spp, *Giardia intestinalis, Entamoeba histolytica, Pneumocystis jiroveci, Leishmania tropica.*

Viral Pathogens: Brief account of viral diseases-Hepatitis, Herpes, Measles, Rabies, Polio, Rubella, HIV, SARS, Rotaviruses.

Vaccinology: Active and passive immunization; Live, killed, attenuated, sub unit vaccines. Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines. Antibody genes and antibody engineering- chimeric and hybrid monoclonal antibodies. Catalytic antibodies and generation of immunoglobulin gene libraries.

Recommended Books:

1. Atlas, R.M. (1994); Principles of Microbiology, McMillan, New York
2. Tortora, G.J., Funke, B.R., Case, C.L. (2004), Microbiology -An Introduction, 8th Edition, Pearson education Pvt. Ltd. Singapore.
3. Walsh, G. (1998) Biopharmaceuticals: Biochemistry and Biotechnology, John Wiley & Sons, New York.
4. Benjamin, E. (1996), Immunology-A short course 3rd Edition, John Wiley, New York.
5. Kuby J. (1997), Immunology, 3rd Edition, W.H. Freeman & Co., New York.

MML- 535: ENVIRONMENTAL MICROBIOLOGY **MM: 70**
(Credits: 4+0) **Internal: 30**
Time: 3 Hours

The student shall attempt any five out of eight questions. Each question shall carry equal marks.

Scope of Environmental Microbiology: An overview of microbial niches in global environment. Microbes in terrestrial, aquatic and aerial environments. Microbes in the extreme environments and their adaptations-Thermophiles, psychrophiles, acidophiles, alkalophiles, halophiles and barophiles .Dispersal of microorganism-role of physical and biological factors. Methods to study microbes in natural environments.

Microbial Degradation of Organic Pollutants: Degradation of Xenobiotic compounds-pesticides, hydrocarbons, polychlorinated biphenyls Bioremediation strategies for soils and waters polluted with heavy metals and organic pollutants. Phytoremediation of pollutants.

Microbiology of Wastewater and Solid Waste Treatment: Waste types-solid and liquid waste their characterization, physical, chemical, biological. Aerobic, anaerobic, primary, secondary and tertiary treatments. Anaerobic processes: Anaerobic digestion, anaerobic filters, and upflow anaerobic sludge blanket reactor. Treatment schemes for effluents of dairy, distillery, tannery, sugar, paper and pharmaceutical industries including microbes used, and types of effluent treatment plants. Management of solid wastes. Sanitary landfills. Bioconversion of solid waste and utilization as fertilizer-Composting and vermicomposting.

Microbial Interaction in Rumen and Gastrointestinal Tract: Microbiology of silage making. Microbiology of termite and earthworm gut. Interaction of soil fauna and microflora in cycling of plant litter in forest ecosystem.

Bio-fuels and Bio-mining: Bioethanol and future fuels-hydrogen, biodiesel. Biomining-Microbial leaching of low grade ores. Containment of acid mine drainage. Genetically modified organisms released and its environmental impact assessment and ethical issues.

Recommended Books:

1. Campbell, R. (1983). Microbial Ecology. Blackwell.
2. Maier, R.M., Pepper, I.L. & Gerba, C.P. (2009.) Environmental Microbiology. 2nd Ed. Academic Press.
3. Mitchell, R. *(*1992).Environmental Microbiology. John Wiley & Sons.
4. Richards, B.N. (1987). Microbes of Terrestrial Ecosystem. Longman.
5. Baker K.H. and Herson D.S. (1994). Bioremediation. McGraw Hill Inc. N.Y.
6. Connell, D.W. and Miller, G.J. (Eds.) (1984). Chemistry and Ecotoxicology of pollution. WileyInterscience Publications.
7. Forster, C. F. and Wase, D.A.J. (Eds.) (2001). Environmental Biotechnology. Ellis Harwood Ltd. Publication.
8. Trivedy, R. K. (1998). Advances in Waste Water Treatment Technologies. Volumes I and II, Global Science Publication.
9. Wicket, L. P. and Hershberger, C. D. (2000) Biocatalysis and Biodegradation: Microbial transformation of organic compounds. ASM Publications.
10Agate, A. D. (1982) Basic Principles of Geomicrobiology, MACS, Pune.

MML-541: BIO- SAFETY, BIO-BUSINESS AND IPR **MM: 70**
(Credits: 4+0) **Internal: 30**
Time: 3 Hours

The student shall attempt any five out of eight questions. Each question shall carry equal marks.

Intellectual Property Rights and Protection: The GATT & TRIPs, Concept of Patents, Copyrights, Trademarks; Patenting – need for patents. Patenting of biological materials, Patenting of life forms−plant, animals, microbes, gene, process and products, Regulatory issues and challenges to food products. Patent process, protection of knowledge, knowledge consortia and databases. Procedure for patent application, International harmonization of patent laws. Implications of intellectual property rights on the commercialization of biotechnology products.

Plant Variety Protection Act: TRIPS and WTO. Plant breeders' rights, and farmers' rights. International conventions on biological diversity.

Agricultural Biotechnology and the Society. Transgenic plants, commercial status and public acceptance. Bio-safety guidelines for research involving GMO's, Benefits and risks, Socio-economic impact and ecological considerations of GMO's. Gene flow. ; National biosafety policies and law, WTO and other international agreements related to biosafety, cross border movement of germplasm; risk management issues - containment.

Regulatory Practices: Financing R&D capital and market outlook, IP, BP, SP.Government regulatory practices and policies, FDA perspective. Reimbursement of drugs and biologicals, legislative perspective.

General Principles for the Laboratory and Environmental Biosafety: Health aspects; toxicology, allergenicity, Sources of gene escape, creation of superbugs etc. Quality Assurance and validation**.** Good Manufacturing Practices (GMP) and Good laboratory practices (GLP) in pharmaceutical industry. Regulatory aspects of quality control. Quality assurance and quality management in pharmaceuticals ISO, WHO and US certification. Sterilization control and sterility testing (heat sterilization, D value, z value, survival curve, Radiation, gaseous and filter sterilization). Design and layout of sterile product manufacturing unit, (Designing of Microbiology laboratory), Safety in microbiology laboratory.

Recommended Books:

1. Gupta P.K. (2003), Biotechnology and Genomics, Rastogi Publications Meerut
2. Stewart-Tull, D.E.S. & Sussman, M. (Eds.) (1994). The release of Genetically Modified Microorganisms, REGEM 2, Plenum Press, New York. Bills, D. and Kind, Shain-Daw (Ed) 1990, Biotechnology and Food safety Butterworth-Heinemann Boston, London.
3. Gasser, C.C. and Eraley, R.T. (1989). Genetically engineering plants for crops improvements Science 1293-1296.
4. Singh, B.D. (2007). Biotechnology: Expanding Horizon. Kalyani, New Delhi
5. Karmach, C.L. (Eds) (1991). Biotechnology Regulations Handbook, Centre for energy and environmental management, FanifacStn. Virginia.
6. Monney, H.A. and Bernandi, G (Ed) (1993) Introduction of genetically modified organisms into the environment, Wiley, New York.
7. Sussman, M., Collmi, C.H., Shimnen, A.A. and Stewart-tull D.E. (1994). The release of genetically engineered microorganisms. Academic Press, London