BANGALORE UNIVERSITY
M.Sc. MICROBIOLOGY(CBCS)
(Effective from the academic year 2022-2023)
SCHEME FOR INSTRUCTION AND EXAMINATION
SEMESTER SCHEME

Paper No.	Title of the paper	Type of paper	Periods/ Week	Duration of Exam (Hours)	IA	EA	Max. Marks	Credits
First Semester		**Theory**						
MBH- 1.1	Microbial Diversity	Hard Core	4	3	30	70	100	4
MBH- 1.2	Prokaryotic and Acellular Microbiology	Hard Core	4	3	30	70	100	4
MBH- 1.3	Eukaryotic Microbiology	Hard Core	4	3	30	70	100	4
MBH- 1.4	Microbiological Techniques	Hard Core	4	3	30	70	100	4
MBS- 1.5	Biostatistics	Soft Core	2	2	15	35	50	2
Practical								
MBP- 1.6	Microbial Diversity, Prokaryotic and Acellular Microbiology	Practical	4	4	30	70	100	4
MBP- 1.7	Eukaryotic Microbiology and Microbiological Techniques	Practical	4	4	30	70	100	4
Total Marks and Credits							650	26

Second Semester		**Theory**						
MBH- 2.1	Microbial Genetics	Hard Core	4	3	30	70	100	4
MBH- 2.2	Molecular Biology	Hard Core	4	3	30	70	100	4
MBH- 2.3	Microbial Physiology and Biochemistry	Hard Core	4	3	30	70	100	4
MBH- 2.4	Food Microbiology	Hard Core	4	3	30	70	100	4
MBS- 2.5	Bioinformatics	Soft Core	2	2	15	35	50	2
Practical								
MBP- 2.6	Microbial Genetics, Molecular Biology and Bioinformatics	Practical	4	4	30	70	100	4
MBP- 2.7	Microbial Physiology and Food Microbiology	Practical	4	4	30	70	100	4
Total Marks and Credits							650	26

Paper No.	Title of the paper	Type of paper	Periods / Week	Duration of Exam (Hours)	IA	EA	Max. Marks	Credits
Third Semester		**Theory**						
MBH- 3.1	Medical Microbiology	Hard Core	4	3	30	70	100	4
MBH- 3.2	Recombinant DNA Technology	Hard Core	4	3	30	70	100	4
MBH- 3.3	Immunology	Hard Core	4	3	30	70	100	4
MBO-3.4	Open elective: Applied Microbiology	Open Elective (OE)	4	3	30	70	100	4
Practical								
MBP- 3.5	Medical Microbiology and Immunology	Practical	4	4	30	70	100	4
MBP- 3.6	Recombinant DNA Technology	Practical	4	4	30	70	100	4
MBP- 3.7	Industrial/ Institutional Visit	Report					50	2
Total Marks and Credits							650	26

Fourth Semester		**Theory**						
MBH- 4.1	Agricultural Microbiology	Hard Core	4	3	30	70	100	4
MBH- 4.2	Industrial Microbiology	Hard Core	4	3	30	70	100	4
MBH- 4.3	Microbial Biotechnology	Hard Core	4	3	30	70	100	4
Practical								
MBP- 4.4	Agricultural Microbiology, Fermentation Technology and Microbial Biotechnology	Practical	4	4	30	70	100	4
MBP- 4.5	Project work/ Dissertation						100	4
	Project viva-voce						50	2
Total Marks and Credits							550	22
Total Marks and Credits							**2500**	**100**

SCHEME OF THEORY EXAMINATION (Hard Core)

Time 3 Hours		Max. Marks 70
Section A Write brief notes on **any five** of the following	5 x 3 =15	1-7 questions
Section B Write short notes on **any five** of the following	5 x 5 = 25	8-14 questions
Section B Answer **any two** of the following	2 x 15 = 30	15-18 questions

SCHEME OF THEORY EXAMINATION (Soft Core)

Time 2 Hours		Max. Marks 35
Section A Write brief notes on **any five** of the following	5 x 2 =10	1-7 questions
Section B Write short notes on **any two** of the following	2 x 5 = 10	8-11 questions
Section B Answer **any one** of the following	1 x 15 = 15	12-14 questions

SCHEME OF PRACTICAL EXAMINATION

Question No.	Experiment	No. of Questions and marks	Marks
1	Major experiment	Experiment **1 (a)** = 20 marks	40
		Experiment **1 (b)** = 20 marks	
2	Minor experiment	Experiment **2 (a)** = 10 marks	20
		Experiment **2 (b)** = 10 marks	
3	Viva voce		10
		Maximum Marks	**70**

SCHEME OF INTERNAL ASSESSMENT

Assessments	Theory	Practical examinations
Test	10	15
Assignment	05	00
Seminar	10	00
Attendance	05	10
Record	00	05
Total	**30**	**30**

MBH-1.1: MICROBIAL DIVERSITY

Total hours: 52

Course Objectives: *The objective of this paper is to give a primary exposure on the history and development, basics of Microbiology, classification, diversity, and their ecological aspects.*

Learning outcome: *Students will have a comprehensive understanding of the basic features of microorganisms. This information will aid students in understanding the history, biology, and distribution of microorganisms.*

Unit 1

Microbial history and classification: History of microorganisms- Louis Pasteur, Robert Koch, Edward Jenner, Joseph Lister, Paul Ehrlich, Alexander Fleming, Martinus Beijerinck, Sergei Winogradsky and Carl Woese. Introduction to microorganisms- Acellular entities/microbes (Prions, Viroids and Viruses), Prokaryotic microbes (Archaea and Bacteria), Eukaryotic microbes (Protozoa, Algae and Fungi). Differences between prokaryotic and eukaryotic microbial cells; Microbial Taxonomy - Definition and systematics, Haeckel's three kingdoms, Whittaker's five kingdoms, Three-domain system ofclassification; Universal phylogenetic tree and evolutionary relationship.**10 hrs.**

Unit 2

Microbial distribution in ecosystem: Principles and concepts of microbial diversity; Microorganisms as components of ecosystem; Nutritional diversity of microorganisms; Culturable and unculturable microbes; Metagenomics approach for assessment of microbial diversity in ecosystem. Air microflora- Microbial diversity in indoor and outdoor, bioaerosols, and aeroallergens. Aquatic microflora- Microbial diversity in fresh water, marine water and estuaries. Soil microflora- Microbial diversity in surface, sub-surface, deep soil, humus and forest soil. **08 hrs.**

Unit 3

Extremophiles: Diversity of microorganisms in arctic, antarctic and hydrothermal vents; thermophiles, barophiles, acidophiles, alkaliphiles, Psychrophiles, osmophiles; Metal-tolerant microbes; Radiodurans (*Deinococcus radiodurans*), Xerophiles; Mechanism and adaptation. Microbial life in anoxic ecosystem; Microbial community in biogeochemical cycles.

Microbial interaction: Neutralism, commensalism, synergism/mutualism, parasitism, competition, syntrophy, antibiosis, predation, protocooperation, biotrophs and necrotrophs; Microbial flora of plant (rhizosphere and phyllosphere), animal (cow udder and intestine) and human (gut microflora) and their significance. **10 hrs.**

Unit- 4

Diversity and evolution of Bacteria: Phylogenetic lineages of bacteria; Morphological and physiological diversity; Nutritional diversity of bacteria - Phototroph, chemotroph, autotroph (lithotroph), heterotroph (organotroph), photoautotroph, photoheterotroph, chemoautotroph, Chemoheterotroph; Oxygenic and anoxygenic photosynthetic bacteria, Chemolithotrophic bacteria; Methanotrophic bacteria, nitrogen fixing bacteria, lactic acid producing bacteria; Endosymbiotic bacteria. **08 hrs.**

Unit 5

Diversity of fungi: Fungal diversity and phylogenetic lineages; Distribution of yeasts and fungi; Terrestrial and lignicolous fungi; Lichenized fungi; Endophytic fungi; Coprophilous fungi; Fungal communities in composts; Mycotoxigenic fungi; Fungal interaction withplants, animal and humans (symbiotic and antagonistic interactions); Marine fungi, ambrosia fungi. Predaceous fungi. **08 hrs.**

Unit 6

Microbial diversity and Biotechnological approach: Bioremediation and its types; Microbes in degradation of hydrocarbons (aliphatic and aromatic), Xenobiotic pollutants (pesticide, PAH, plastic); Microbes in metal extraction (bioleaching); Microbes in biosorption of heavy metals; biofilm; Microbes in waste management: solid (municipal, biomedical and electronic wastes) and liquid wastes (domestic and industrial).

08 hrs.

Content for student task and prospects: *Assignments, seminars, project, class room discussion, group discussion, class test, quiz competition, group activity, audio-video visualization, sample collection for isolation of microbes from different natural sources and creating research interest in Microbiology.*

REFERENCES:

1. Ananthanarayanan R., Jayaram Paniker C.K. (2017). Textbook of Microbiology, 10th ed. Orient Lomgman.
2. Bhatia, S.C. (2008). Hand Book of Environmental Microbiology, Atlantic Publishers Pvt. Ltd. New Delhi, India.
3. Jacquelyn G. Black, Laura J. Black. (2015). Microbiology: Principles and explorations, 9th ed. Wiley, Hoboken, New Jersey.
4. Joanne M. Willey, Linda Sherwood, Christopher J. Woolverton, Lansing M. Prescott(2017). Prescott's microbiology, 10th ed. Mcgraw-Hill Education, New York.
5. Madigan M. T., Martinko J. M., Bender K. S., Buckley D. H., Stahl D. A. (2015). Brock biology of microorganisms, Fourteenth edition. Pearson, Boston.

6. Marjorie Cowan, Kathleen Park Talaro (2009). Microbiology: A Systems Approach. 2nd Ed. The McGraw Hill. New York.
7. Pelczar, M.J., Chan, E.C.S., Krieg, N. R. (2008). Microbiology, 5th ed. McGraw Hillcompanies, New York.
8. Tortora Gerard J., Funke, Berdell R. Case, Christine L. (2016). Microbiology: An Introduction, 12th Ed. Pearson, Boston.

MBH-1.2: PROKARYOTIC AND ACELLULAR MICROBIOLOGY

Total hours: 52

Course Objectives: *The objective of this paper is to impart knowledge on the classification, ultra-structure, reproduction and significance of Prokaryotic (Bacteria and Archaea) and Acellular microbes/entities (Viruses).*

Learning outcome: *At the end of this semester students will gain complete knowledge on various groups of Bacteria, Archaea and Viruses, their morphological features, cell arrangement and structural components of bacteria and viruses, and the unique characteristics of archaea.*

Unit 1

Taxonomy of prokaryotic microorganisms: Phylogeny of prokaryotic microorganisms; Similarities and differences between Bacteria and Archaea; Criteria for classification of prokaryotes- Morphological, biochemical, physiological, serological, ecological and molecular methods; Chemotaxonomy and Numerical taxonomy; ICNB rules; Classification of prokaryotes according to Bergey's manual of systematic bacteriology (2nd edition); Dichotomous key; Cladograms and dendrograms. **10 hrs.**

Unit 2

Morphology and ultrastructure of prokaryotes: Morphological overview of Archaea and bacteria- size, shape and arrangement; Ultrastructure of Archaea, Gram-positive and Gram-negative bacteria: Flagella, pili, capsule, cell wall (including chemical composition), cell membrane, mesosomes, ribosomes, nucleoid, plasmids, gas vacuoles, Inclusion bodies, reserve food materials, magnetosomes, phycobilisomes, endospores and exospores

10 hrs.

Unit 3

Type studies of major groups of prokaryotic species and their structure and significance: Euryarchaeota- *Methanococcus, Halobacterium*; Crenarchaeota- *Thermoproteus, Pyrodictium* and Sulfolobus; Proteobacteria (*Rickettsia, Rhizobium, Agrobacterium, Neisseria, Escherichia, Pseudomonas, Myxobacteria*), Actinobacteria (*Streptomyces* and *Mycobacterium*), Firmicutes (*Mycoplasma, Bacillus* and *Staphylococcus*), Cyanobacteria (*Microcystis, Spirulina, Nostoc* and *Scytonema*),Chlamydiae (*Chlamydia*) and Spirochaetes (*Treponema*) and Deinococcus-Thermus (*Deinococcus*) 1**0 hrs.**

Unit 4

Cultivation of prokaryotes: Media constituents- micro and macro nutrients; Culture media- Simple, complex and special media with example; Bacterial Growth- Growth kinetics, generation time, growth curve; binary fission; Aerobic, anaerobic, batch, continuous and synchronous cultures; Factors affecting bacterial growth. **06 hrs**

Unit 5

Acellular microbes (viruses): Fundamentals of viruses- Virus prehistory and discovery of viruses; Properties of viruses; Morphology and classification of viruses- ICTV system of classification; Ultrastructure of viruses: capsids, symmetry, envelops, enzymes and genome

(RNA/DNA). Oncogenic viruses; bacteriophage; cyanophage. Viral replication-Lytic (T-even phage) and lysogenic (Lambda phage);

Type studies of viruses- Structure and replication patterns of T2 Bacteriophage, TMV, Banana bunchy top virus, Rabies, Hepatitis B, HIV and COVID viruses; Cultivation of viruses: embryonated eggs, laboratory animals and cell cultures; Microbial viruses- General account on algal, fungal, protozoan viruses. Viral dissemination and control measures.

12 hrs.

Unit 6

Acellular entities: Discovery, structure, classification, replication and diseases caused by Satellite virus, Virusoids, Viroids and Prions. **04 hrs.**

***Content for student task and prospects**, Group discussion on identification of common bacteria and viruses with their distinct morphological characteristics, MCQ quiz, assignments, seminars, project, class test will be given.*

REFERENCES:

1. Atlas, R and Bartha, R. (2005). Microbial Ecology Fundamental and Applications, 4th edition, Pearson Education (P) Ltd. New Delhi, India
2. Black J.G. and Black L.J. (2017) Microbiology-Principles and Explorations, 10th Edition. John Wiley & Sons Inc. New York, USA.
3. Dimmock, N.J., Easton, A.J., and Leppard, K.N. (2016). Introduction to Modern Virology. 7th ed., Blackwell publishing, USA.
4. Flint S.J., Racaniello V.R., Enquist L.W., Rancaniello V.R., Skalka. A.M. (2015) Principlesof Virology, 4th Edition, 2 Vol. American Society for Microbiology, USA.
5. Marjorie Cowan, Kathleen Park Talaro (2009). Microbiology: A Systems Approach. 2nd Ed.The McGraw Hill. New York.
6. Michael T. Madigan, David P. Clark, David Stahl, John M. Martinko. (2012). Brock Biology of Microorganisms 13th ed., Benjamin Cummings
7. Pelczar, M.J., Chan, E.C.S., Krieg, N. R. (2008). Microbiology, 5th ed. McGraw Hill companies, New York.
8. Sherwood, and Woolverton Willey (2007). Prescott, Harley, and Klein's Microbiology 7thed., McGraw-Hill
9. Sullia, S.B. and Shantharam, S. (2000). General Microbiology (Revised) Oxford & IBHPublishing Co. Pvt. Ltd., India

Total hours: 52

Course Objectives: *The purpose of this paper is to provide a comprehensive information on the structure, reproduction and importance of eukaryotic microorganisms such as protozoa, algae and fungi.*
Learning outcome: *At the end of this semester, the students will gain in-depth knowledge on eukaryotic microorganisms. This study helps in understanding the distribution of algae and fungi, their significance in agriculture and industries.*

Unit 1

Protozoa: Introduction and Classification; Morphology, structure, locomotary organelles, reproduction and significance of *Giardia, Euglena, Leishmania, Trichomonas, Trypanosoma* (Flagellates); *Paramoecium* (Ciliates); *Entamoeba histolytica* (Sarcodina); *Plasmodium* (Sporozoa); Economic importance of protozoa. **08hrs.**

Unit 2

Algae: Introduction, classification (Smith), general structure, and reproduction - Vegetative (Fragmentation, binary fission, autocolony formation, propagules, bulbils and adventitious branches), Asexual (zoospores, aplanospores, hypnospores, autospores, monospores, endospores and exospores) and Sexual (isogamous, anisogamous and oogamous). Type study-thallus organization and life cycle of *Chlamydomonas, Chlorella, Diatoms, Dictyota, Laminaria, Sargassam, Spirogyra* and *Porphyra*. Media and methods used for culturing algae, strain selection and improvement, large scale cultivation. Symbiotic algae- Lichens (Ascholichens, Basidiolichens, Deuterolichens), Coral reef and Sea sponges. **12hrs.**

Unit 3

Algal biotechnology and their economic importance: Resource potential and commercial utility of algae- Algae as a source of food and feed, pigments, and bio-fertilizers. Biodiesel from algae- Advantages over other sources of biodiesel; Phyco-remediation; Role of algae in Nano-biotechnology; Immobilized and labeled algae; Algal blooms and toxins. **06 hrs**

Unit 4

Fungi: History of Mycology; Introduction and General characteristics; Structure and organization of fungi; Cell differentiation; General aspects of fungal nutrition and reproduction-Vegetative, asexual and sexual reproduction; Heterothallism, parasexuality, sex hormones in fungi, phylogeny of fungi. **08hrs.**

Unit 5

Classification of fungi (Ainsworth, 1973):

Criteria for classification; Salient features of division and subdivision of fungal kingdom.

Myxomycota:

Classes: Acrasiomycetes, Hydromyxomycetes, Myxomycetes, Plasmodiophoromycetes

Eumycota:

Mastigomycotina: Classes: Chytridiomycetes, Hyphochytridiomycetes, Oomycetes

Zygomycotina: Classes: Zygomycetes, Trichomycetes

Ascomycotina: Classes: Hemiascomycetes, Plectomycetes, Pyrenomycetes, Discomycetes, Laboulbeniomycetes, Loculoascomycetes

Basidiomycotina: Classes: Teliomycetes, Hymenomycetes, Gasteromycetes

Deuteromycotina: Classes: Hyphomycetes, Coelomycetes, Blastomycetes

Structure and reproduction of fungal species- *Dictyostelium, Pythium, Phytophthora Rhizopus, Neurospora, Puccinia, Polyporus, Aspergillus,* and *Trichoderma.*

12 hrs.

Unit 6:

Economic importance: Fungi in Agriculture, Environment, Industry, Food and Medicine- Production of drugs, food additives, alcohol, enzymes, biopesticides; Edible fungi and mushroom poisoning, Fungi as plants parasites, biocontrol agent and biofertilizers; Fungi as insect symbiont; Fungal bioremediation; Fungi as sources of secondary metabolites and mycotoxins. **06 hrs.**

Content for student task and prospects: *Group discussion about economic importance of algae and fungi, quiz competition for fungal identification based on morphological and microscopical analysis, group discussion, minor project and class test.*

REFERENCE:

1. Agrios, G. N. (2005). Plant Pathology, 5th Edition, Elsevier
2. Alexopoulos C. J. and Mims C. W. and Blackwell M. (2010). Introductory Mycology, John Wiley and Sons Inc.
3. Becker, E.W. (2008). Microalgae: Biotechnology and Microbiology. Cambridge University Press.
4. Bennett J. W. and Klich M. (2003). Mycotoxins. Clin. Microbiol. Rev. 16:497-516. Ainsworth, G.C. (2009). Introduction to the History of Mycology, 2nd Edition, Cambridge University Press
5. DinabandhuSahoo, Joseph Seckbach (2015). The Algae world. Springer.
6. Mehrotra, R.S. and Aneja, K.R. (2015). An Introduction to Mycology, New Age Publications.
7. Ruma Pal, Avik Kumar Choudhary (2014). An Introduction to Phytoplanktons: Diversityand Ecology. Springer.
8. SambamurtyA,V.S.S. (2005). A Textbook of Algae. I.K. International Publishing House Ltd. New Delhi.

MBH-1.4: MICROBIOLOGICAL TECHNIQUES

Total hours: 52

Course Objectives: *The objective of this paper is to expose students to the various instrumentation techniques and methodologies necessary for research in Microbiology.*

Learning outcome: *At the end of this semester students will acquire comprehensive knowledge on the techniques required for research. This course includes an introduction to microscopy, spectroscopy, chromatography, radioactivity, centrifugation and electrophoretic techniques.*

Unit 1

Isolation techniques: Types of inoculation techniques- dilution, spread, streak, pour plate, stamp, warcup, slide and single spore culture methods; Identification of bacteria and fungi - morphological, biochemical and molecular methods. Automated microbial identification system; Microbiological stains and staining techniques: Types of stains and principles of staining- simple staining, Differential staining, Structural staining; maintenance and preservation of pure cultures, National and International culture collection centers. **08 hrs.**

Unit 2

Microscopy: Working principle, magnification and resolving power of simple and compound microscopes (Bright field, Dark field, phase contrast, and Fluorescence microscopy) and stereomicroscopy. Electron microscopy: Principles, construction and modeof operation of scanning and Transmission electron microscopy (TEM and SEM), limitations; Atomic force microscope and confocal microscopy; Sample preparation, staining and image processing techniques for microscopy **10hrs.**

Unit 3

Growth measurement Techniques: Direct method-microscopic count, standard plate count, MPN, haemocytometry, micrometry. Indirect method-turbidimetry metabolic activity, dry weight

Sterilization techniques: Principles, types of Sterilization, and their mode of action. Physical methods: Heat-dry heat (Hot-Air oven), Incineration, Moist heat (Autoclave and Pressure cooker), Filtration-Types of filters, Laminar airflow. Radiation methods (UV radiation and x-rays). Biosafety cabinets – Level I – IV, Lab Containment.

Control of Microorganisms: Chemical methods: Definition of terms- Disinfectants, Antiseptics, Sanitizers, Microbistatic, Microbicides; Use and mode of action of Alcohols, Aldehydes, Halogens, Phenols, Heavy metals, and Detergents. **10 hrs.**

Unit 4

Spectroscopy: Electromagnetic spectrum and Beer Lambert's Law; Principle and applications of UV-visible and fluorescence Spectrophotometer; Infrared spectroscopy; FTIR, Atomic absorption spectroscopy, circular dichroism, ^{1}H and ^{13}C NMR spectroscopy; X-ray diffraction; Mass spectroscopy Fluorescent spectroscopy, Quenching, principle, instrumentation and application of MALDI-ToF. **10 hrs.**

Unit 5

Chromatography: Principles and applications of thin layer, gel filtration, ion-exchange, affinity, gas chromatography, GC-MS, HPLC and LC-MS.

Electrophoresis: Definition, principles and applications; different types of electrophoresis: PAGE, SDS-PAGE, 2D-PAGE, IEF and PFGE. **08 hrs.**

Unit 6

Centrifugation Techniques: Principles, Swedberg unit, sedimentation coefficient, factors affecting sedimentation rate, types of centrifuges- density gradient centrifugation, ultracentrifuges. **Flow cytometry and Next-generation sequencing methods.**

Isotope techniques: Stable and radioactive isotopes, radio isotopic labeling, autoradiography, scintillation counters, non-radioactive labeling, safety guidelines. **06 hrs.**

Content for student task and prospects: *Group discussions on various techniques employed to understand microbial diversity and their prospective, Assignments on methodology and working principles of different microbiological techniques, seminars, class test and creation of importance of modern techniques for characterization of microorganisms and their products.*

REFERENCES:

1. Becker, W. M., Kleinsmith, L.J. and Hardin, J. (2000). The world of the Cell. 1st ed. Benjamin/Cummings.
2. Madigan M.T., Martinko M. J. and Parker,J. (2003). Brock Biology of microorganisms.
3. Pearson education., NewJercy
4. Perry, J.J. and Staley, J.T. (1997). Microbiology. Dynamics and Diversity. 4th ed. Wesley Longman pub. NewYork.
5. Perry, J.J., Staley, J.T. and Lory, S. (2002). Microbial Life. Sinauer Associates, Publishers, Sunderland,Massachusetts.
6. Presscott, L. M. Harley, J. P. and Klein, D. A. (1999). Microbiology, 4th ed., WCBMcGraw-Hill.
7. Rouessac, F and Rouessac, A. (2007). Chemical Analysis: Modern instrumentation methodsand techniques. 2nd ed., John Wiley and Sons, U.S.A.

8. Sharma. R.K. (2009). Basic Techniques in Biochemistry and Molecular Biology. I.K. International Publishing House Ltd. New Delhi.
9. Simpson, R.J., Adams, P. D. and Golemis, E.A. (2009). Basic methods in Protein purification and analysis; Laboratory Manual. Cold Spring Harbor Laboratory Press, U.S.
10. Wahid, P.A. (2001). An Introduction to Isotopes and Radiations: Allied Publishers Ltd., India
11. Wilson K. & Walker. J. (2010). Principles and Techniques in Practical Biochemistry. 7th ed. Cambridge Univ. Press, UK

BTS-1.5: Biostatistics (Soft core)

Total hours: 26

Course Objectives: *Objective of this paper is to provide a basic knowledge on various statistical tools required for biology.*

Learning outcome: *At the end of this semester students will get basic knowledge on statistical analysis of biological data. In this paper, students will study data processing and validation methodologies for scientific publications.*

Unit 1:

Introduction to Bio-statistics: basic concepts, data types. Need for statistical techniques for biological applications, replicable data, Tabulation of data, construction of graph and graphical representations of data. Different models of data presentations.

Frequency distribution, Properties of the data-Central tendency and their measures: Arithmetic mean, mode, median, and percentiles. Dispersion and their measures: Range, mean deviation. standard deviation and co-efficient of variation. Skewness and Kurtosis and their various measures.

Probability: Types of event, sample space, definition, conditional probability, addition and multiplication rules of probability and some simple problems. Probability distributions- Binomial, Poisson and Normal distributions and a few simple problems. **14 hrs.**

Unit 2:

Statistical Inference Population and sample: Random sample, use of table of random numbers, parameter and statistics, sampling distribution of sample means, Standard error; confidence intervals Estimation-confidence interval for means and proportion. Testing of hypothesis: basic concepts and definitions, types of errors. Tests based on Normal, student's, chi-square and F-distributions (Analysis of variance), interpretation of "p" value.

Correlation and regression analysis: Simple linear regression and correlation-test of significance.

Statistical package- Features of statistical software, SPSS and Bluesky packages for various applications in Bio-statistical programme. **2 hrs.**

Content for student task and prospects: *Group discussions on research data interpretation using statistical software, Assignments, seminars, class test and creation of importance of biostatistics in modern scientific research.*

REFERENCES:

1. Bliss, C.I.K. (1967). Statistics in Biology, Vol.1 Mc Graw Hill, New York.
2. Campbell, R.C. (1974). Statistics for Biologists, Cambridge Univ. Press, Cambridge
3. Chernick, M. R., & Friis, R. H. (2003). Introductory biostatistics for the health sciences: modern applications including bootstrap. John Wiley & Sons.
4. Daniel (1999). Biostatistics (3rd edition) Panima Publishing Corporation. New Delhi.
5. Green, R.H. (1979). Sampling design & Statistical methods for environmental Biologists, Wiley Int. New York.

6. Islam, M.A., & Al-Shiha, A. (2018). Foundations of biostatistics. Singapore: Springer.
7. Khan (1999).Fundamentals of Biostatistics,Panima Publishing Corporation. New Delhi.
8. Le, C. T., & Eberly, L. E. (2016). Introductory biostatistics. John Wiley & Sons.
9. Snedecor, G. W., & Cochran, W. G. (1989). Statistical Methods, eight edition. Iowa state University press, Ames, Iowa, 1191.
10. Swardlaw, A.C. (1985). Practical Statistics for Experimental Biologists, John Wiley & Sons, Chichester – New York.

MBP 1.6: MICROBIAL DIVERSITY, PROKARYOTIC AND ACELLULAR MICROBIOLOGY

Total Units: 15

Course Objectives: *The main objective of this paper is to provide hands-on training in different fundamental microbiological techniques.*

Learning outcome: *At the end of the course, the students will be trained in basic microbiological laboratory techniques and also culturing and identification of different species of bacteria. Students will become familiar with sterilization techniques when handling microbes.*

1. Safety measures in Microbiology laboratory and study of Microscopes
2. Preparation of culture media (plate and slant)- Nutrient agar (NA), PDA, SDA, BG11, Maconkey, EMB
3. Isolation and enumeration of microorganisms from natural soil, water and air
4. Culturing of microorganisms and study of cultural characteristics of microorganisms (bacteria, fungi, and microalgae) - Shape, elevation, margin, size, texture, appearance, pigmentation and optical property.
5. Study of bacterial shape (cocci, rods, spiral, vibrio, chains), and motility (hanging drop method)
6. Staining techniques – simple (positive and negative), differential (Grams and acid fast), structural (endospore and capsule)
7. Measurement of microbial cell number/Spore number using hemocytometer and cell size by micrometry
8. Biochemical tests for the identification of bacteria – catalase, oxidase, IMViC, Urease, TSIA, Nitrate reduction, hydrolysis of gelatine, starch and casein, Citrate utilization,
9. Determination of growth curve in *E.coli*.
10. Isolation of coliphages from sewage
11. Effect of physical and chemical factors on microalgal growth (pH, temperature, light, carbon and nitrogen)
12. Lipid estimation in microalgae (for biofuel production)
13. Estimation of protein (single cell protein) in *Spirulina* sp.
14. Microbial growth measurement- Cell count, turbidometry, colony count, biomass weight.
15. Microbial preservation techniques (lyophilization, with glycerol, soil)

Content for student task and prospects: *Isolation and identification of microorganisms from environmental samples, group discussion for different techniques and their working principles, hands-on training of individual techniques, assignments and, class test.*

REFERENCES

1. Benson, Harold J. Brown, Alfred E. (2010). Benson's microbiological applications: laboratory manual in general microbiology, complete version New York: McGraw- Hill Higher Education
2. Aneja, K R (2001). Experiments in Microbiology, Plant Pathology, Tissue Culture and Mushroom Cultivation, New Age International Ltd.
3. Florence G. Burleson, Thomas, M. Chambers, and Danny L. Wiedbrauk, (1992). Virology: A Laboratory Manual. The Academic Press, USA.

TECHNIQUES

Total Units: 15

Course Objectives: *The main aim of this paper is to study the diversity of fungi, algae and protozoa, provide hands-on training for identification of these microorganisms.*

Learning outcome: *At the end of the semester, the students will be familiar with identification of different fungi isolated from natural sources. Student will also learn methods for extraction of biomolecules from fungi and algae.*

1. Isolation of fungi from soil, air, water and food grains/cereals
2. Isolation of endophytic fungi from plant samples.
3. Isolation and identification of fungi from wood, leaf litter, humus and animal(s) dung.
4. Spore germination assay (fungal spore)
5. Collection and preservation of different types of lichens and mushrooms.
6. Isolation and identification of micro algae from soil and water
7. Isolation and identification of protozoa from soil and water
8. Effect of environmental (pH, temperature) and nutritional factors (carbon, nitrogen sources) on growth of fungi and algae.
9. Fungal growth assessment by colony diameter measurement
10. Extraction and separation of secondary metabolites (pigments/mycotoxins) by thin layer chromatography.
11. Protein precipitation by ammonium sulphate method and purification by dialysis.
12. Purification of biomolecule(s) (proteins/lipids) by column chromatography.
13. Identification of fresh water algae, *chlamydomonas, diatoms, chlorella, scenedesmus, volvox, microcystis* (any four).
14. Molecular weight determination of a protein by SDS-PAGE.
15. Types studys and submission of permanent slides of the following genera *Aspergillus, Penicillium, Fusarium, Alternaria, Drechslera, Curvularia,Trichoderma, Rhizopus, Candiada Neurospora, Saccharomyces, Xylaria, Polyporus, Agaricus, Puccinia, Sclerotium, Saprolegnia* (any ten).

Content for student task and prospects: *Creating interest to know the diversity of fungi and their importance in nature, Group discussion and preparation of minimum five different fungal cultures for each student will be encouraged.*

REFERENCES

1. Benson, Harold J. Brown, Alfred E. (2010) Benson's microbiological applications: laboratory manual in general microbiology, complete version New York: McGraw- Hill Higher Education
2. Aneja K R (2001), Experiments in Microbiology, Plant Pathology, Tissue Culture and Mushroom Cultivation, New Age International Ltd.

MBH- 2.1: MICROBIAL GENETICS

Total hours: 52

Course Objectives: *In this paper students will be exposed to the fundamentals of microbial genetics, gene expression, genetic mapping, the link between phenotype, genotype and the use of microbes in genetic research.*

Learning outcome: *At the end of this semester, students will obtain a clear understanding of microbial genes, their structures, functions and their vital importance. Students also obtain knowledge on molecular basis of mutation, gene regulation and expression.*

Unit 1

Historical development: Definition and scope of Genetics; Basic principles of heredity, Genotype and Phenotype; Premendelian genetic concepts-Inheritance of acquired characters, and Germplasm theory; concepts and theories of Mendelian genetics; Non- Mendelian inheritance; Hereditary and Environment; Experimental proof of genetic material; chromosome theory of inheritance; Microbes as tools for genetic studies. **06 hrs.**

Unit 2

Genome organization: Prokaryotic genome- General characteristics of the bacterial genome; metagenomics; *E. coli* chromatin- coiled, supercoiled (plectonemic, solenoid), folded fiber model; Genome organization in *Mycoplasma genitalium*.

Eukaryotic Genome: Structure of chromatin, chromosome, centromere, telomere, nucleosome, and genome organization, split gene, overlapping genes, and cot curves; Chromatin remodeling; types of histones, histone modifications- methylation, acetylation, phosphorylation and their effects on structure and function of chromatin; DNA methylation, repetitive and non-repetitive DNA sequence. Law of DNA constancy, C value paradox, genome size, karyotype and idiogram, chromosome banding pattern; types of chromosomes; Organelle genome (Mitochondria and plastid). 1**0 hrs.**

Unit 3

Gene and Mutation: Definition, types of mutations, Gene as a unit of mutation, molecular basis of spontaneous and induced mutations- physical and chemical mutagenic agents; types of mutation: point, frameshift, lethal, conditional lethal, inversion and deletion, null mutation, reversion of mutations, intra and intergenic suppression mutations. Mutagens, transposon mutagenesis, site-directed mutagenesis; environmental mutagenesis; Ame's test. Importance and uses of mutation analysis. Mutation in *Saccharomyces cerevisiae* and *Neurospora crassa* and other toxicity testing. **10 hrs.**

Unit- 4

Recombination in Viruses: General characteristics of the viral genome, General principle; Phage phenotypes, phenotype mixing, mechanisms of replication in DNA and RNA viruses; recombination and mapping, circular map, lytic phages and lysogenic phages –T7 and T4; P1, P2, P4, ᵠx174, *E. coli* ʎ phage and their application. Genetic mapping of viruses, Recombination in viruses; Genetics of bacteriophage. **10 hrs.**

Unit- 5

Recombination in Bacteria: General principle; bacterial plasmids and type, fertility factors, resistance factors, plasmidsand types, other types of plasmids; transposable elements. Bacterial conjugation– F^+ x F^- mating, Hfr conjugation, F' conjugation, conjugation mapping, and recombination mapping. Bacterial transformation– mechanisms; natural and artificial transformations; Transduction: generalized and specialized transduction; host restriction and modifications; mapping the genome. **10 hrs.**

Unit- 6

Fungal recombination: Structural organization of fungal genome; Tetrad analysis and linkage detection - 2 point and 3 point crosses. Chromosomal genes, mitochondrial genes, plasmids and transposable elements, genetic variations in fungi – haploidy, heterokaryosis, parasexuality, homothallism, heterothallism. genome mapping in fungi. **06 hrs.**

Content for student task and prospects: *Group discussion on mutation and mutagens, assignments, quiz and class test on genetic issues, and establishment on awareness of microbial recombination.*

REFERENCES:

1. Benjamin A Pierce (2012) Genetics: A conceptual approach, 4thedition. H. Freeman and Company.
2. Dale. J.W. (2007). Molecular Genetics of bacteria, 4th edition, John Wiley & Sons. New York
3. Daniel L. Hartl - Essential Genetics: A Genomics Perspective- 6th Edition; publisher: Jones & Bartlett Learning 2012.
4. Jeremy W Dale and Simon F Park. (2013). Molecular Genetics of Bacteria. Fifth Edition.
5. Wiley-blackwell. New York
6. Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton (2009), Prescott's Principles of Microbiology, McGraw Hill Higher Education.
7. Larry Snyder & Joseph E. Peters & Tina M. Henkin& Wendy Champness (2013) Molecular Genetics of Bacteria, 4th Edition
8. Lewin, B. (2017). Genes VIII. Oxford University Press, Oxford.
9. Robert J. Brooker. (2020). Genetics: Analysis and Principles, 7thEdition. McGraw Hill Company. New York.

MBP- 2.2: MOLECULAR BIOLOGY

Total hours: 52

Course Objectives: *The purpose of this paper is to provide knowledge about the basic units of life, including their types, structures, modes of action, and importance.*

Learning outcome*: At the conclusion of the course, students would acquire an in-depth understanding of genetic materials, their precise actions, and their crucial role in biological function. This paper expands our understanding on the structure and functions of genetic material, genome organization, transcription, and translation in prokaryotic and eukaryotic microorganisms.*

Unit 1

Basic concepts of Molecular Biology: Central Dogma of Molecular Biology. DNA as genetic material, Structure of DNA-Watson and Crick model, DNA polymorphisms (A, B, Z, C and D). Properties of DNA- UV absorption, denaturation, renaturation. Structure and functions of different types of RNA. **06 hrs.**

Unit 2

DNA topology and replication: Models for DNA replication (semiconservative, conservative and dispersive mode of replication), Enzymes and accessory proteins involved in DNA replication. Topology of DNA: Supercoiling of DNA, topological stress- twists, wriths, writhing number, linking number, catenation and decatenation. Mechanism of replication in prokaryotes and viruses (Rolling circle and M13 Bacteriophage replication)- Origin of replication, leading and lagging strands, fidelity of replication, extrachromosomal replicons. Eukaryotic DNA polymerases and mechanism of replication in eukaryotes, end replication problem, Telomere synthesis-telomerases. Inhibitors of replication. **10 hrs.**

Unit 3

DNA damage: Types, Ionizing radiation, Pyrimidine dimers, Deamination, Oxidative damage, Alkylation, Depurination.

DNA repair mechanism: Photoreactivation, excision repair, Post replication repair, methyl directed mismatch repair, very short patch repair, SOS repair, recombination and heat shock response, DNA damage response. **06 hrs.**

Unit 4

Transcription: Transcription in prokaryotes- Characteristics and functions of bacterial RNA polymerases, mechanism of transcription and regulation. Eukaryotic RNA polymerases-transcription factors, mechanism of transcription and regulation. Heat shock response, Stringent response. Post transcriptional modifications of mRNA (capping, polyadenylation, editing, splicing), Modifications of tRNA and rRNA. Inhibitors of transcription.

Gene Silencing- Definition, types –transcriptional and post transcriptional gene silencing, RNAi mechanism (siRNA and miRNA). **12 hrs.**

Unit 5

Translation: Genetic code- Features and characteristics, Wobble hypothesis, ribosome assembly, mechanism of activation of amino acids. Mechanism of translation in prokaryotes and eukaryotes. Differences between prokaryotic and eukaryotic translation, inhibitors of translation and their mechanism of action, post-translational modifications of proteins.

08 hrs.

Unit 6

Regulation of gene expression: Gene regulation, Operon concept, catabolite repression, Inducible and repressible systems. Negative regulation- *E.coli lac* operon; Positive regulation- *E.coli ara* operon; Regulation by attenuation- his and trp operons, anti- termination- N protein and nut sites, DNA binding protein, transcriptional control, cis control elements, promoters, enhancers, transacting factors, post-transcriptional control.

Control of gene expression at transcription and translation level: Regulation of phages, viruses, prokaryotic and eukaryotic gene expression, role of chromatin in regulating gene expression. **10 hrs.**

Content for student task and prospects: *Group discussion on post-translational protein modification, multiple-choice questions to evaluate knowledge on DNA and RNA structure, assignment on DNA repair mechanisms, and presentation on the structure and function of polymerases.*

REFERENCES:

1. Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, and Peter Walter (2015). Molecular Biology of the Cell. Garland Publishing, Inc., New York and London.
2. Darnell, J. Lodish, H., Baltimore, D. (2003). Molecular Cell Biology. Scientific American Books Inc. NY.
3. Garrett, R.H. and Gresham, C.M. (2010). Molecular aspects of Cell Biology, International 4thedition, Saunders College Pub.
4. Karp, G. (2016). Cell and Molecular Biology concepts and experiments, 8th edition, John Wiley and Sons Inc. NY.
5. Lodish, H., Baltimore, D., Berk, A., Zipursky, B.L., Mastsydaira, P., Darnell, J. (2004).
6. Molecular Cell Biology, Scientific American Books Inc. NY.
7. Nelson, D.L., Cox, M.M. Lehninger. Principles of Biochemistry (2012). 6th edition Pub WH Freeman Co. NY,
8. Old R.W., Primrose S.B., (2005) Principles of gene manipulation - An introduction togenetic engineering, Blackwell Scientific Publications. NY.

MBH-2.3: MICROBIAL PHYSIOLOGY AND BIOCHEMISTRY

Total hours: 52

Course Objectives: *The objective of this paper is to study the various physiological processes in microorganisms.*

Learning outcome*: This course will teach students how microorganisms metabolize various organic and inorganic nutrients and their response to environmental changes.*

Unit 1

Photosynthesis: Photosynthetic pigments and apparatus in bacteria. Oxygenic and anoxygenic photosynthesis. CO_2 fixation. Utilization of light energy by Halobacteria. Chemolithotrophy, Hydrogen bacteria, Nitrifying bacteria, Sulfur bacteria, Iron bacteria, Methylotrophs.

Microbial stress responses: Oxidative stress, Thermal stress, Starvation stress, Aerobic to anaerobic transitions.

Bioenergetics: Principles and laws of thermodynamics. Coupling of chemical reactions

10 hrs.

Unit 2

Enzymes: Properties and Classification; Different structural conformation of enzymes. Enzymes as biocatalysts, catalytic power, activation energy, substrate specificity and active site. Theory and mechanism of enzyme action-lysozyme, chymotrypsin and ribonuclease. Monomeric, Oligomeric and multienzyme complex, isozymes and allosteric enzymes. Ribozymes and abzymes

Enzyme kinetics- Importance of enzyme kinetics, factors affecting rate of enzyme mediated reactions (pH, temperature, substrate, enzyme concentration and reaction time). Derivation of Michaelis-Menton equation and its significance. Lineweaver-Burk plot, Haldane-Briggs relationship, sigmoidal kinetics, steady state kinetics and transient phases of enzyme reaction. **12 hrs.**

Unit 3

Carbohydrate metabolism: Classification and properties of carbohydrates Mono-,di-, oligo and poly-saccharides, with examples,(asymmetric centre in sugars, Dextro, Levo- rotatory, reducing and non-reducing sugars, anomers, epimers, derivatives of sugars- alcohols, amino, acids and deoxy sugars). EMP, HMP, ED and Phosphoketolase pathway, TCA cycle, Anaplerotic pathway, glyoxylate cycle, gluconeogenesis, glycerol metabolism, regulation of carbohydrate metabolism, Pasteur effect. Substrate level phosphorylation. Biosynthesis of peptidoglycan.

Bacterial respiration, energy production in cell, oxidation-reduction reactions, Redox potential; Electron transport chain; Oxidative phosphorylation, ATP generation.

Homo- and hetero-lactic fermentation: Alcohol, lactate, mixed acid, butyric acid, acetone-butanol, propionic acid, succinate, methane, and acetate fermentations.

14 hrs.

Unit 4

Lipids metabolism: Classification, structure and properties of lipids according to chemical structure; (fatty acids- saturated, unsaturated, branched, triglycerides, phospholipids, glycolipids, sterols, sphingolipids and terpenes). Oxidation of fatty acids (α, β and ω); Biosynthesis of fatty acids (saturated and unsaturated) and ergosterol. **06 hrs.**

Unit 5

Nucleotide metabolism: Structure of bases; nucleosides and nucleotides. Biosynthesis of purines (*de novo* and salvage), pyrimidines and deoxyribonucleotides. Nucleotide degradation- an overview. **04 hrs.**

Unit 6

` **Proteins:** Amino acids and metabolism (an overview). Classification, structure and properties of proteins (primary, secondary, tertiary and quaternary) conformation and properties of proteins, metabolism of amino acids; biosynthesis and degradation- an overview. Urea cycle. **06 hrs.**

Content for student task and prospects: *Group discussion on metabolism of biomolecules, multiple-choice questions to evaluate the knowledge on enzymes.*

REFERENCES:

1. Byung Hong Kim and Geoffrey Michael Gadd. (2008). Bacterial Physiology. Cambridge. Charles Gerday and Nicolas Glansdorff. (2007). Physiology and Biochemistry of Extremophiles. ASM Press.
2. El-Sharoud, Walid (Ed.). (2007). Bacterial Physiology a molecular approach. Springer. Brun, Y.V. and Shimkets, L.J. (2000). Prokaryotic Development, ASM Press.
3. Moat, A.G. & Foster, J.W. (1999). Microbial physiology, Wiley-Liss. NY
4. Arora, D.K. and Seema G (1996). Bacterial Physiology. Anmol Publications. New Delhi. Caldwell. D.R. (1995). Microbial Physiology and metabolism, Brown Publishers.UK
5. Roger, L.P., Adams, Johm T., Knowler and David P., Leader. (1992). The Biochemistry of the Nucleic Acids. 11th edition. Chapman and Hall. Florida
6. Smith and Wood (1991). Energy in Biological Systems. Chapman and Hall.
7. FloridaGerhard Gottschalk. (1985). Bacterial Metabolism. Springer Series in Microbiology

Total Hours: 52

Course Objectives: *The purpose of this paper is to provide a comprehensive understanding on the beneficial and harmful effects of microorganisms in food, risks connected with consuming food contaminated with microorganisms, as well as their preventative methods.*
Learning outcome*: At the end of the semester, students should be able to understand the microbial flora of various food sources. In addition, they would be able to study the various detection techniques to identify food spoilage microbes.*

Unit 1

Microbiology of food: History and scope of Food microbiology; Food as a substrate for microorganisms; Intrinsic and Extrinsic parameters affecting the growth of microorganisms in food; Microflora of food- Cereal grains, fruits and vegetables, meat and meat products, Fish and sea foods and poultry. **Dairy Microbiology:** Microbiology of raw and processed milk, Milk as a vehicle of pathogens, Microbiological standards for milk and milk products **10 hrs.**

Unit 2

Contamination and food spoilage: Sources of food spoilage; Microbial spoilage of cereal and cereal products, fruits and vegetables, meat and meat products, fish and sea foods, poultry, packed and canned foods and milk and milk products **08 hrs.**

Unit 3

Food borne diseases: Bacterial food borne diseases- Staphylococcal intoxification, Botulism, Salmonellosis, Listeriosis, Shigellosis, Brucellosis, Enteropathogenic *Escherichia coli* (EPEC) Diarrhoea, *Clostridium perfringens* gastroenteritis, *Bacillus cereus* gastroenteritis, Food borne Gastroenteritis by *Vibrio, Campylobacter* and *Yersinia*; Food-borne fungi: Mycotoxins- Aflatoxicosis, Fumonisins, Deoxynivalenol, Ergotism. Food Borne Viral Pathogens- Rotavirus, Adenovirus, Hepatitis A Virus; Food Borne Protozoa – Giardiasis, Ameobiasis, Crypotosporidiosis. Detection of food-borne microorganisms: Culture and Microscopic analysis, molecular (PCR) and Immunological methods (Radioimmuno assay and ELISA). **12 hrs.**

Unit 4

Methods for food preservation: Physical method (High temperature, Low temperature, radiation, drying, asepsis, canning); Chemical preservative (Organic acids and food additives); various types food packaging- Types of packaging materials, properties and their merits and demerits, Modified atmosphere packaging (MAP). **06 hrs.**

Unit 5

Food produced by microbes: Microbial cells as food- single cell proteins, and mushroom production; Fermented foods- Nutritional & therapeutic importance of fermented foods, Fermented dairy Products (cheese, kefir, yogurt and acidophilus milk), plant products- bread, idli, Sauerkraut, fermented and olives; Beverages; Meat and fishery products, poultry and fish product; Probiotics, prebiotics and synbiotics; Nutraceuticals and functional foods; Genetically modified food; Application of fungal pigments in food industry **08 hrs.**

Unit 6

Food safety and quality management systems: General principles of food safety risk management; Recent concerns on food safety; Genomics and proteomics of food borne microorganisms; predictive microbiology; Microbial risk assessment- hazard analysis and critical control point system (HACCP), ISO systems for food safety; Food and sanitation: Good Hygiene Practices, Sanitation in manufacture and retail trade; Organic food; food quarantine. **08 hrs.**

Content for student task and prospects: *Assignment on the role of microbes for production of fermented foods. Group discussion on food safety, presentation on current novel techniques for the detection of food borne microbes. Seminars and discussion on positive and negative role of microbes in food industry*

REFERENCES

1. Adams M. R. and Moss M. O. (2007). Food Microbiology 3rd Edition. Royal Society of Chemistry.UK.
2. Ahmed E.Y. and Carlstrom C. (2003). Food Microbiology: A Laboratory Manual, John Wiley and Sons, Inc. New Jeresy
3. Bhunia A. K. (2008). Food-borne Microbial Pathogens- Mechanisms and Pathogenesis,Food Science text Series, Springer International, New York, USA
4. Deak T. and Beuchat L. R. (1996). Hand Book of Food Spoilage Yeasts, CRC Press, New York.
5. Doyle M. P. and Beuchat L. R. (2007). Food Microbiology- Fundamentals. Frontiers, ASM Press.
6. Frazier W.C. and Westhoff C.D. 2008 Food Microbiology. Tata McGraw Hill Publishing Company Limited, New Delhi, India.
7. Garbutt J. (1997). Essentials of Food Microbiology, Armold- International Students edition, London.
8. Marriott N. G. and Gravani R. B. (2006). Principles of Food Sanitation, Food Science text Series, Springer International, New York, USA.
9. ThomasJ., Matthews,Karl; Kniel, Kalmia E (2017), Food Microbiology: An Introduction, American Society for (ASM).

MBS-2.5: BIOINFORMATICS
(Soft core)

Total hours: 26

Course Objectives: *Objective of this paper is to provide knowledge on various bioinformatic tools used for analysis of biological macromolecules.*

Learning outcome: *At the end of the semester, students should be able to understand the Computer Network and Programming Languages, different types of biological database, protein structure and molecular interactions.*

Unit 1

Introduction to computer: Binary, Octal and Hexadecimal number systems– Binary arithmetic, Binary code. Computer Architecture- internal and external Devices. Computer softwares- operating system- Windows, UNIX, Linux, Application software- word processor, spread sheet. Introduction to statistical software (SPSS). **03 hrs.**

Unit 2

Computer network and programming languages: Structure, architecture, advantages, types (LAN, MAN & WAN), Network protocols- Internal protocol (TCP/IP), File transfer protocols (FTP), WWW, HTTP, HTML, URL. Network Security- Group polices, Fire- walls. C Programming and PERL- Algorithm and flowchart, Structure of C program, Header file, global declaration, main function, variable declarations, Control statement- conditional and unconditional - sub functions. Introduction to PERL, Applications of Bioperl. **04 hrs.**

Unit 3

Databases: Introduction- Relational Databases Management (RDMS)- Oracle, SQL, Database generation. **03 hrs.**

Unit 4

Biological databases: Data mining and applications, accessing bibliographic databases- Pubmed, Nucleic acid sequence databank – NCBI and EMBL. Protein sequence databank- NBRF- PIR, SWISSPROT. Structural databases - protein data Bank (PDB). Metabolic pathway data bank (Pub gene), Microbial genomic database (MBGD), Cell line database (ATCC), Virus data bank (UICTVdb). Sequence alignment - Global and Local alignment, scoring matrices. Restriction mapping - NEB CUTTER, Similarity searching (FASTA and BLAST), Pairwise comparison of sequences, Multiple Sequence alignment of sequences, Identification of genes in genomes and Phylogenetic analysis with reference to nucleic acids and protein sequences, Identification of ORFs, Identification of motifs. **08hrs.**

Unit 5

Protein structure and molecular interaction: Chemical bonding and non-bonding interactions, stability of electrovalent bond. Covalent bond – partial ionic character of co-valent bonds and Vander Waals forces. Introduction to protein structure - secondary structure prediction, tertiary structure prediction, protein modelling- principles of homology and comparative modelling. Threading, structure evaluation and validation and *ab intio* modelling, Applications - Molecular docking - Autodoc. **08 hrs.**

Content for student task and prospects: *Group discussion on computer network and program language, Written assignment on molecular interaction, student presentation on biological database, class test and to develop interest on usage of bioinformatic tools for identification of compounds.*

REFERENCES

1. Baxevanis, A.D., Petsko, G.A., Stein, L.D., and Stormo, G.D., eds., (2007) CurrentProtocols in Bioinformatics. Wiley, New York.
2. Sharrma T. R. (2009) *Genome Analysis and Bioinformatics* I. K. International publishing House Pvt. Ltd. New Delhi.
3. David M, (2004), "Bioinformatics: Sequence and Genome Analysis"; Cold Spring harbor laboratory Press, US Revised Edition.
4. David Edward, (2007) Plant Bioinformatics: Methods and Protocol, Humana Press.Higgins & Taylor (2000). Bioinformatics, Oxford University Press, Oxford.
5. Arthur Lesk, (2013) Introduction to Bioinformatics 4 Edition; OUP, Oxford

MBP-2.6: MICROBIAL GENETICS, MOLECULAR BIOLOGY AND BIOINFORMATICS

Total Units: 20

Course Objectives: *The objective of this study is to provide practical information on the use of microorganisms in research at genetical level.*

Learning outcome*: At the end of the semester, students will have hands-on experiences with the isolation of DNA and RNA from microbes, their purification.*

1. Isolation and identification of mutant fungi (*Neurospora*) and bacteria (*E.coli*) - physical (UV) and chemical (EMS) methods.
2. Study of replica plating techniques.
3. Selection of auxotrophs by ampicillin enrichment.
4. Ames test for detecting chemical carcinogens.
5. Study of Karyotype and idiogram.
6. Problems on (a) law of segregation (b) independent assortment (c) sex linked inheritance (d) population genetics.
7. Study of conjugation in *E.coli.*
8. Study of transduction in *E.coli.*
9. Estimation of DNA by diphenylamine method.
10. Estimation of RNA by Orcinol method.
11. Isolation and electrophoretic analysis of genomic DNA (bacteria/fungi).
12. Isolation and electrophoretic analysis of plasmid DNA from bacteria.
13. Isolation and electrophoretic analysis of RNA.
14. Elution of DNA from agarose gels.
15. Determination of Melting temperature (Tm) of DNA.
16. Preparation of competent cells, transformation by calcium chloride method and calculation of transformation efficiency.
17. Restriction mapping, sequence (FASTA and BLAST) searches.
18. Pairwise comparison of sequences, multiple alignments of sequences and phylogenetic analysis.
19. Protein databank retrieval and visualization on ROSMOL.
20. Calculation of SD, analysis of variance and plotting the graph using

Content for student task and prospects: *Assignment on methodology used for isolation of DNA and RNA, regular seminars, class tests and discussions on the techniques learnt to develop interest in the field of Molecular biology*

MBP-2.7: MICROBIAL PHYSIOLOGY, FOOD MICROBIOLOGY

Total Units: 12

Course Objectives: *The purpose of this paper is to provide practical information on estimation of biological macromolecule, enzymatic activity, detection of food-borne diseases.*
Learning outcome: *By the end of the semester, students should comprehend quantitative and qualitative estimation of carbohydrate, protein, and lipids, enzymatic activities of amylase and protease, identification of food-borne pathogens.*

1. Estimation of total protein by Lowry's /Bradford method.
2. Estimation of reducing sugar by DNS method.
3. Isolation of lipolytic microbes from soil-plate method and estimation of total lipid by Folch method (gravimetry).
4. Fractionation of total lipid (glycolipid, neutral lipid and phospholipid) by column chromatography and Separation of fatty acids from phospholipids by thin layer chromatography.
5. Assay of amylase/protease/cellulase/invertase activity and Study of enzyme kinetics: calculation of Km and Vmax; determination of optimum pH, temperature of amylase/invertase.
6. Isolation and identification of Bacteriocin producing lactic acid bacteria (LAB).
7. Study of antimicrobial activity of food preservatives.
8. Isolation and identification of common food borne pathogens (Enterobacteriaceae, *Staphylococcus, Listeria, Vibrio, Aspergillus, Penicillium and Fusarium*).
9. Detection of Aflatoxin from fungi-Qualitative and quantitative analysis.
10. Study of fermented foods- Isolation and identification of microbes from yogurt, sauerkraut, idli batter and sausages.
11. Production, antimicrobial effect and nutritional value of probiotics-yoghurt, kefir and acidophilus milk.
12. Quality testing of milk and its products (DMC, MBRT, Alcohol, Clot-on-boiling, Titratable acidity tests).

Content for student task and prospects: *Assignment on characteristic features of pathogenic food borne microbes, student presentation on aflatoxin and its quantification. Seminars, class test on positive and negative role of microbes in food industry.*

MBH- 3.1: MEDICAL MICROBIOLOGY

Total Hours: 52

Course Objectives: *This course focuses on the relationship between microbes and human health. Students will study important diseases emphasizing on etiology, pathogenesis, diagnosis, treatment, and prevention.*

Learning outcome*: Students will have a clear understanding of microbial diseases, host pathogen interactions, and the issues associated with drug-resistant microorganisms. Students also comprehend the significance of normal flora associated with human health.*

Unit 1

Introduction to Medical Microbiology: History, development and scope of medical microbiology. **Human pathogens**: Normal microbial flora of human body and its significance, tissue tropism. Emerging and reemerging pathogens: Viral, bacterial,protozoan and fungal pathogens. **04 hrs.**

Unit 2

Infection and transmission: **Infestation, infection and disease process**. Types of infection, Mode of transmission, Virulence factors and their role in breaching host defense, Mechanism of microbial adhesion and portal of entry: Urinary Tract Infection, Sexually Transmissible Disease, Central Nervous System, Circulatory System, Oral Cavity, Respiratory and Gastrointestinal Infections.

Establishment, spreading, tissue damage and anti-phagocytic factors; Evasion of host defense, non-specific host defense, toxigenesis-bacterial toxins and its types, Quorum sensing in microorganisms. *Streptococcus pyogenes*. Modes of transmission and factors influencing. **12 hrs.**

Unit3

Disease, diagnosis and treatment: symptomology, pathogenicity, epidemiology, diagnosis and treatments

Bacterial diseases -*Streptococcus, Staphylococcus, Shigella, Salmonella, Vibrio, Haemophilus, Mycobacterium*. **Fungal diseases**: Aetiology, clinical symptoms of superficial infections (dermatomycoses): Epidermophyton, Microsporum and Trichophyton; *Subcutaneous mycoses:* Sporotrichosis, Blastomycosis, Candidiasis. **Protozoan diseases**-*Entamoeba histolytica, Trichomonas vaginalis, Plasmodium vivax,* Leishmaniasis and filariasis. **Viral diseases**: Corona virus (COVID-19), Herpes virus, Hepatitis viruses (Hepatitis A, B, C, D), HIV, Oncogenic viruses (HPV, CMV), Arboviruses (Dengue, chickungunya), Rhabdoviruses. **16 hrs.**

Unit 4

Nosocomial infection: Epidemiology of nosocomal infections, types of nosocomal infections, hospital infection control programmes, preventing nosocomial infections and surveillance. General concepts of collection and handling of specimens, specimen processing and biosafety. **06 hrs.**

Unit 5

Antimicrobial agents and resistance: Classification of antimicrobial agents, Mechanism of drug action-antibacterial, antifungal, antiviral and antiprotozoans. Recent advances in the discovery of antimicrobial agents. **04 hrs.**

Unit 6

Chemotherapeutic agents: Antibiotics (Classification based on chemical structure, mode of action and range of effectiveness). Recent trends in drug resistance and its consequences, antibiotic policy, NCCLS (CLSI) guidelines and standards, WHO guidelines, Methods of testing drug sensitivity (*in vitro* and *in vivo*), antibiotic assay in body fluids. Factors contributing to the emergence of antibiotic resistance. Impact of antibiotic resistance, therapeutic use of antibiotics, multidrug-resistant (MDR) strains, Mechanism of drug resistance. **10 hrs.**

Content for student task and prospects: *Group discussion on the concept of drug resistance, Assignment on diseases caused by pathogenic microorganisms, student presentation on various diseases. Discussion on positive and negative role of microbes in human health.*

REFERENCES

1. Connie R Mahon. (2010). Textbook of Diagnostic Microbiology. 3rd edition. Pearson.
   Credric, A. Mims. (2004) Medical microbiology. (3rd Ed.). Moshy Inc.
2. Frank, Steven A. (2002). Immunology and Evolution of Infectious Disease. Princeton University Press.
3. Fritz H. Kayser. (2005). Medical microbiology. Thieme Verlag.
   Kufe, et al., (2003). Cancer Medicine. BC Decker Inc.
4. Leslic Collier, John Oxford. (2000) Human virology: a text book for students of medicine, dentistry & microbiology (2nd Ed.) Oxford University Press.
5. Wadher, and Bhoos reddy. (2005). Manual of Diagnostic Microbiology. Himalaya Publisher.
6. Warren Levinson Ernest Jawetz (2002), Medical Microbiology and Immunology: Examination and Board Review, 7th Edition. McGraw-Hill/Appleton and Laye.
7. Warren Levinson. (2000) Medical microbiology and immunology: examination and board review. (8th Ed.) McGraw Hill.

Total Hours: 52

Course Objectives: *This study aims to educate students to understand the concept of DNA recombinant technology, the function of vectors, DNA sequencing, and antisense RNA.*
Learning outcome*: At the end of the semester, students will be able to acquire knowledge on genetic engineering and would be acquainted with various prokaryotic cloning strategies. This course also explores the legal and ethical issues associated with rDNA technology.*

Unit 1

Tools of recombinant DNA technology: Restriction endonucleases: Restriction modification; restriction endonucleases- types, nomenclature, recognition sequences and mechanism of action. Methylation, RNA modification. Role of Kinases, phosphatases, polynucleotide phosphorylase, polynucleotide kinases. Ligases - types and mechanism of action.

Vectors: General characteristics of vectors, Brief account of naturally occurring Plasmids: Promoter, MCS, Ori, and marker genes-lac Z. Construction of pBR 322, pBR325, pUC 18 and 19. Cloning and expression vectors. *E.coli* promoters, lac promoter, trp promoter, lambda pL promoter and hybrid tac promoters. Ribosome binding site, codon selection. M 13 derived vectors, Lambda based vectors, cosmids, phagemids, mini chromosomes, BAC‟s, YAC‟s, Shuttle vectors, Ti plasmids, vectors for animals-SV40 and Bovine papilloma virus.

10 hrs.

Unit 2

Gene cloning strategies and construction of gene libraries: Cloning in Prokaryotes (*E.coli*) and Eukaryotes (*Saccharomyces cerevisiae* and *Pichia pastoris*). Construction of cDNA and Genomic DNA library. Cloning from mRNA: Isolation and purification of RNA, synthesis of cDNA. Isolation of plasmids (plasmid vectors, bacteriophage vectors).

Cloning of genomic DNA: Isolation and purification of DNA, preparation of DNA fragments and cloning. Construction of genomic libraries using λ vector. *In vitro* packaging of λ phage. Amplification of libraries.

Advanced cloning strategies-synthesis and cloning of cDNA, PCR amplified DNA, use of adaptors and linkers, homopolymer tailing in cDNA. Cloning and expression of cloned DNA.

10 hrs.

Unit 3

Selection, screening and analysis of recombinants: Genetic selection, insertional inactivation, chromogenic substrates, complementation of defined mutations, nucleic acid hybridization, screening methods for cloned libraries, PCR screening protocols, immunological screening, restriction mapping of cloned gene, blotting techniques, sequencing methods. Purification strategies of expressed His- tagged proteins. **08 hrs.**

Unit 4

Transformation techniques: Purification of vector DNA, restriction digestion, end modification, cloning of foreign genes, (from mRNA, genomic DNA, synthetic DNA) transformation screening, selection, expression and preservation.
Transformation and transfection techniques, Preparation of competent cells of bacteria. Chemical methods: calcium phosphate precipitation method, liposome mediated method. Physical methods: Electroporation, gene gun method. Method of DNA transfer to yeast, mammalian and plant cells, transformation and transfection efficiency. **10 hrs.**

Unit 5

DNA sequencing: Dideoxy and chemical methods, sequence assembly, automated sequencing, genome sequencing, mapping of genes and fine structure analysis of genes
Human genome project: global patterns of gene expression. Analysis of single nucleotide polymorphisms (SNP) using DNA chips.
Chemical synthesis of genes: Phosphodiester, phosphotriester, phosphate triester approaches: Enzymatic synthesis of DNA; application of synthetic oligonucleotides, synthesis of complete gene. **10 hrs.**

Unit 6

Application of rDNA technology: genetically modified organisms (Bt cotton). Overview of Transgenic plants, GM foods (golden rice, tomato, corn, brinjal), transgenic animals (cow, sheep, poultry, fish). Gene therapy. DNA/genome editing, Microarray, Applications ofNGS. **04 hrs.**

Content for student task and prospects: *Group discussion on types of vectors; assignment on the significance of recombinant DNA technology; student presentation on screening and analysis of recombinants; and a class discussion on recent development in recombinant DNA technology.*

REFERENCES:

1. Benjamin Lewis, Gene VIII 10th Edition (2018) Oxford University & cell press, NY.
2. Bernard, R.G. and Jack, J.P. (2003). Molecular Biotechnology: principles and application of recombinant DNA. ASM Press.
3. Brown T.A. (2018). Genome 4. Tylar and Francis. 4th Edition.
4. Glick B.R and Pasternak J.J. (2010), Molecular Biotechnology: Principles and Applicationsof Recombinant DNA. ASM Press.
5. Howe C. (2007). Gene Cloning and Manipulation. 2nd edition Cambridge University Press.

6. Pierre Baldi G, Wesley Hatfield, (2009). DNA Microarrays and Gene Expression: From Experiments to Data Analysis and Modelling. Cambridge University Press.
7. Primrose, S. B. Twyman, P.M. and Old, R. W. (2006) Principles of gene manipulation 7th
8. Ed.). Black well publishers.

MBH-3.3: IMMUNOLOGY

Total Hours: 52

Course Objectives: The objective of this paper is to expose foundational and up-to-date understanding of immunology and immunological techniques.

Learning outcome*:* The student will acquire fundamental and advanced knowledge on the immune system, diseases, and contemporary technologies.

Unit 1

Immune system and Immunity: Origin and development of immune system, Types of immunity, Structure and functions of immune cells- T cells, B cells, Macrophages, NK cells, Dendritic cells, Neutrophils, Eosinophils, Basophils and Mast cells. Organs of the immune system- Structural organization and functions of the Primary and secondary lymphoid organs. Nutritional status and immunity - Role of micro and macro nutrients in the outcome of immune response. **08 hrs.**

Unit 2

Antigens, Antibodies and T Cell Receptor (TCR): Antigens and immunogens. Iso and alloantigens. Structure and properties of antigens- Antigen specificity, haptens and adjuvants. Immunoglobulins- Structure, properties, types, subtypes and functions. Affinity and avidity, class switching, Structure and functions of TCR, Generation of diversity of antibody and TCR. Complement system- component, properties and functions. Complement pathways and biological significance of activation. **06 hrs.**

Unit 3

Antigen recognition and response- Role of Immunoglobulins and TCR. Kinetics of primary and secondary immune response, immunological memory. Functions of antigen presenting cells (APC). Co-stimulatory molecules – role of CD 28, B7, CTLA-4 and PD-1. Interactions between T cells, antigen presenting cells and co-stimulatory molecules. Immune check points, Positive and negative immune regulation, Clonal selection, lymphocyte activation, proliferation and differentiation. Lymphocyte homing and trafficking

10 hrs.

Unit 4

Major Histocompatibility Complex (MHC) and Transplantation: Major and minor histocompatibility antigens. Structure, genomic organization and functions of HLA system. MHC restriction. Processing and presentation of antigens by MHC class I and class II molecules-cytosolic and endocytic pathway. Role of Ir genes in the control of immune response.

Tissue transplantation- Types of grafts, graft rejection- acute, chronic and hyperacute rejections. Stages and clinical manifestations of graft rejection. Graft Vs Host response. Prevention of graft rejection: Tissue typing- Cell and DNA base methods. Immunosuppressive therapy. Future of Xeno transplantation-prospects and challenges.

08 hrs.

Unit 5

Hypersensitivity reactions and autoimmunity: Types (I, II, III, and IV), symptoms, diagnosis and treatment. Autoimmunity and Autoimmune diseases: Organ specific and systemic autoimmune diseases- Hashimoto's disease, Systemic lupus erythematosus, Multiple sclerosis, Myasthenia gravis, Rheumatoid arthritis–symptoms, diagnosis and treatment. Immunological tolerance and its significance. Cytokines: Interleukins and Interferons- Production and biological functions**.** **08 hrs.**

Unit 6

Immunological Techniques, Immunization and Immunotherapy: Agglutination, precipitation, immunofluorescence, immune electrophoresis, immunoblotting, ELISA, RIA, Flow cytometry. Production and purification of antibodies (monoclonal and polyclonal), T cell cloning and applications in vaccine development.

Vaccines- conventional, peptide vaccines, subunit, DNA vaccines, Toxoids, antisera, edible vaccines, ISCOMs, Recombinant antibodies, Common immunization programmes5- BCG, SmallPox, DPT, Polio, Rubella, Measles, Hepatitis-B.

Immunotherapeutic strategies: Cancer vaccines, intravesical BCG therapy, engineered fusion proteins, monoclonal antibodies, cytokine therapy, immune check point blockade therapy. **12 hrs.**

Content for student task and prospects: *Group interaction on immune system and immunity, Seminar and discussion on recent advances in immuno-therapy, hypersensitivity reaction, antigen recognition response.*

REFERENCES:

1. Abul K. Abbas, Andrew K. Lightman, Jordan S. Pober. (1998). Cellular and Molecular Immunology. Saunders College Pub.
2. Jacquelyn G. Black, Larry M. Lewis. (2005). Microbiology: Principles & Explorations. Edition 6th,Wiley, John & Sons.
3. Kuby, J. (2018). Immunology 8th Edition. WH. Freeman and Company, New York. Madigan, Martinko, Dunlap, Clark. (2010). *Brock Biology of Microorganisms*, 13thEdition. Benjamin Cummings.
4. Marjorie Cowan, Kathleen Park Talaro. (2009). Microbiology: A Systems Approach. 2nd Edition. The McGraw/Hill.
5. Richard, A., Goldsby, Thomas J., Kindt, Barbara A. & Osborne (2000). Kuby Immunology. 4th edition. W. H. Freeman and Company, New York.
6. Topley&Wilson‟s (1995). Textbook on Principles of Bacteriology, Virology and Immunology, IX Edition (5 volumes) Edward Arnold, London.
7. Warren Levinson (2000) Medical Microbiology and Immunology: Examination and Board Review. 8th Edition McGraw Hill.

OPEN ELECTIVE
MBO- 3.4: APPLIED MICROBIOLOGY

Total Hours: 52

Unit -1

Microbiology of Air: Airspora of indoor and outdoor environment, factors affecting airspora, Techniques of trapping air borne microorganisms. **2 hrs**

Unit -2

Soil Microbiology: Historical accounts and the "Golden Age" of soil microbiology and significant contributions of pioneer soil microbiologists. Diversity and abundance of dominant soil microorganisms, Methods of isolation of soil microflora, soil organic matter decomposition. **8 hrs**

Unit -3

Food microbiology: Definition, concepts and scope. Food as substrate for microbes. Factors influencing microbial growth in food-Extrinsic and intrinsic factors.

Principles of food preservation- Chemical preservatives and Food additives, Asepsis-Removal of microorganisms, (anaerobic conditions, high temperatures, low temperatures, drying). Canning, processing for Heat treatment. Contamination and food spoilage: Cereals, sugar products, vegetables, fruits, meat and meat products, Fish and sea foods- poultry- spoilage of canned foods. **12 hrs**

Unit -4

Dairy Microbiology: Microbiology of raw milk, Milk as a vehicle of pathogens, Prevention of contamination of raw milk, Microbiology of processed milk, Spoilage and defects fermented milk and milk products, Microbiological standards for milk and milk products. Ceram and butter bacteriology **12 hrs**

Unit -5

Clinical Microbiology: Role of Microbiologist in Diagnostic laboratory, General concepts for specimen collection, handling, transportation, processing, specimen workup, Laboratory safety and infection control. Scientific and Laboratory basis for Clinical/Diagnostic Microbiology: Microscopic examination of infectious diseases, Growth and biochemicalcharacteristics, Rapid methods of identification **12 hrs**

Unit -6

Agricultural Microbiology: Introduction to agricultural microbiology, concepts and scope of agricultural microbiology, Agronomy and production of important crop plants, Green revolution. **6 hrs**

References:

1. Microbiology by MJ Pelczar Jr, ECS Chan, NR Krieg 5th Edition, Pub: Tata Mcgra-Hill Publishing Co Ltd.
2. Introductory Microbiology by Heritage Pub Heritage
3. General Microbiology by Stainer Pub; Ingraham and Wheeler (McMillan)
4. Alexander M (1977) Introduction to soil microbiology, John Wiley and Sons Inc.N.Y.
5. Atlas R.M. (1998) Microbiology, Fundamentals and applications 2nd Edition, Milan Publishing Co.

6. Brock T.D. and Madigan M.T (1992) Biology of Microorganisms 6th Edn. Prentice Hall, Eagle wood cliffs N.j.
7. Prescott L.M, Harley T.P and Klein D.A. (1996) Microbiology WMC. Brown publishers Connie R Mahon. (2010). Textbook of Diagnostic Microbiology. 3rd edition. Pearson.
8. Fritz H. Kayser. (2005). Medical microbiology. Thieme Verlag.
9. Wadher, and Bhoosreddy. (2005). Manual of Diagnostic Microbiology. Himalaya Publisher.
10. Credric, A. Mims. (2004) Medical microbiology. (3rd Ed.). Moshy Inc.

MBP- 3.5: MEDICAL MICROBIOLOGY AND IMMUNOLOGY

Total Units: 14

Course Objectives: *The purpose of this paper is to provide hands-on training on medical and immunological techniques.*

Learning outcome*: At the end of the semester, students would acquire knowledge on the isolation and identification of pathogenic microbes from clinical samples in general.*

1. Isolation and identification of clinically important microbes from clinical specimens (throat swab, sputum, nasal swab, urine, blood, stool)
2. Isolation and identification of mycosis (Dermatomycosis)
3. Identification of pathogens on selective, differential and enrichment media
4. Different staining techniques a) Ziehl-Neelsen method of AFB b) Fluorochrome staining c) Leishman's staining d) Giemsa's staining
5. Special staining methods to demonstrate granules, capsules and spores
6. Testing of drug susceptibility according to NCCLS
7. Determination of MIC by Kirby-Bauer method, T test, checker board method
8. Purification of antigens (bacteria, fungi)
9. Induction and purification of antibodies
10. Demonstration of precipitation reaction (ODD and SRID)
11. Demonstration of agglutination reaction (latex and slide)
12. Blood grouping and Rh typing
13. Determination of bactericidal activity of normal serum
14. ELISA and tests for allergens

Content for student task and prospects: *Group discussions and quiz on the experiments carried*

MBP- 3.6: RECOMBINANT DNA TECHNOLOGY

Total Units: 11

Course Objectives: *The purpose of this paper is to a comprehensive understanding of different types of recombinant technology and bioinformatic tools.*

Learning outcome*: At the end of the semester, students will understand PCR based amplification of DNA, Restriction digestion, elucidation using SDS PAGE and different types of bioinformatic tools.*

1. Agarose gel electrophoresis
2. Restriction digestion of DNA and molecular weight determination.
2. Ligation.
3. Selection of recombinants by scorable and selectable markers.
4. Polymerase chain reaction (PCR)
6. SDS-PAGE
7. RAPD.
8. Isolation of RNA and analysis by formaldehyde gel electrophoresis
9. Blotting techniques (southern and western)
10. UV mutation to achieve 90% killing rate (visual observation of changes in morphology growth and pigment production)
11. Cloning and expression of gene (GFP)

Content for student task and prospects: *Group discussion on DNA amplification techniques, Quiz on the above experiments.*

- Visit to industries/ research institutes-report to be submitted along with the record.

MBH-4.1: AGRICULTURAL MICROBIOLOGY

Total hours: 52

Course Objectives: *This study aims to provide a complete overview of the role of microbes in agriculture, plant-microbe interactions, plant diseases caused by pathogenic microorganisms, and also the potential of microbes as biofertilizers and biopesticides for ecofriendly crop improvement.*

Learning outcome*: After completing the course, students will be able to develop novel strategies for controlling plant diseases, as well as a better understanding of pathogen interactions and plant defense systems. Students are also familiar with the application of microbial biocontrol agents and their ability to prevent drug resistance and environmental contamination.*

Unit- 1

Introduction to Agricultural Microbiology: Introduction, concepts and scope of agricultural Microbiology, Green revolution; Microbial diversity in Soil- structure, profile, physico- chemical nature, and microbial distribution; importance of microorganisms in agriculture; role of microorganisms in organic matter decomposition (cellulose, Hemicellulose, Lignins and pectin); effect of agricultural practices on soil microflora - Effect of pesticides on soil microflora; Plant Pathology: History, concept, disease triangle and significance of plant diseases . **08 hrs.**

Unit-2

Plant-microbe interactions: Mutualism, synergism, amensalism, commensalism, parasitism; Microbial distribution in rhizosphere, rhizoplane, phyllosphere, spermosphere; rhizosphere effect; factors influencing microbial distribution in rhizosphere and methods of enumeration; phosphate solubilizer- Arbuscular Mycorrhiza (AM) and their types.

06 hrs.

Unit-3

Microbes in nitrogen fixation (BNF): Role of microbes in nitrification, denitrification; symbiotic nitrogen fixation (*Rhizobium* spp., *Frankia* spp.) and non-symbiotic nitrogen fixation (*Azotobacter* spp., *Azospirillum* spp.); Molecular mechanism of nitrogen fixation- role of nitrogenase enzyme and *nif* genes in nitrogen fixation; Genetic engineering of biological nitrogen fixation (BNF). **06 hrs.**

Unit-4

Phytopathology: Introduction and historical milestones; types and significance of plant diseases; pathogenicity and plant disease development; disease cycle; plant disease triangle Levels of disease establishment: Pre-penetration, host recognition, the role of host exudates, entry by plant pathogens through natural openings and wounds, direct penetration, the process of pathogenesis, infection and establishment of pathogens in the host tissues;

Molecular mechanisms of disease establishment- Involvement of elicitors; the role of R and r genes in disease development, Resistance mechanisms in plants- Resistance genes, phytoalexins, PR proteins, and signaling mechanisms; Transgenic approaches for crop

protection; plant disease diagnosis- conventional and molecular methods **10 hrs.**

Unit-5

Microbial bioinoculants: Definition, types and status of biofertilizers; Cultivation and mass production of microbial bioinoculants- Species of *Azotobacter, Rhizobium, Azospirillum*, Cyanobacteria (*Anabaena*) phosphate solubilizing microorganisms (VAM) and PGPR; Carrier-based inoculants- Production, methods of applications and quality control; Mechanisms of plant growth promotion.

Microbial biopesticides: Definition, types of biopesticides- Bacterial (Bacillus *thuringiensis, B. sphaericus, B. popilliae,* and *Pseudomonas syringae*), fungal (*Beauveria, Cephalosporium,* and *Trichoderma*) and viral (Nuclear Polyhedrosis Virus and Baculovirus)and target pests; mode of action of toxins production by *Bacillus thuringiensis*, and *Pseudomonas*; Advantages and limitations of biopesticides. **10 hrs.**

Unit-6

Study of some plant diseases: Introduction to Plant pathogenic microorganisms- Fungal, bacterial, viral, mycoplasma and Nematode; Symptoms, etiology, epidemiology and control measures of **Fungal diseases**- Wilt diseases, Downy mildews, Powdery mildews, Rusts, Smuts; **Bacterial diseases**- Bacterial wilt of tomato, Bacterial blight of rice, Angular leaf spot of cotton, Citrus canker; Mycoplasmal diseases- Sandal spike, Grassy shoot of sugar cane; **Viral diseases**- Tobacco mosaic, Banana bunchy top, Cucumber mosaic, Leaf curl of Papaya; **Protozoal diseases**- Hartrot of coconut, Phloem necrosis of coffee; **Viroid diseases** - Potato spindle tuber; **Parasitic plant diseases**-Dodder, Mistletoes; **Post-harvest diseases**; Integrated pest management. **12 hrs.**

Content for student task and prospects: *Group discussion on the role of microbes for improvement of crop production, Assignments on biofertilizers and biopesticides, student presentation on plant diseases caused by pathogenic microorganisms, seminars, class test and creating awareness on positive and negative role of microbes in agriculture.*

REFERENCES

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2. Bagyaraj D.G. and Rangaswami. G. (2005). Agricultural Microbiology, Prentice- Hall ofIndia, 2nd edition, NewDelhi.
3. George. N. Agrios (2005), Plant pathology, Elsevier academic press, 5th edition,U.K. Hermann H. Prell, Peter R. Day. (2001). Plant-Fungal Pathogen Interaction: A Classical and
4. Molecular View, 1st edition, Springer-Verlag Berlin Heidelberg,Germany
5. Kannaiyan. S. (2002), Biotechnology of Biofertilizers, Alpha science international, 1stedition.
6. Mehrotra. R.S. and Ashok Aggarwal (2002), Plant pathology, Tata MC Graw-Hillpublishers, 2nd edition, Delhi.
7. Purohit, S.S. 2003. Agricultural Biotechnology, 2nd edition, Agrobios Publisher, Jodhpur, India.
8. Roger Hull (2013). Plant virology, Elsevier academic press, 1th edition, U.K.

9. Subbarao, N.S. and Dommergues, Y.R. 2000. Microbial interactions in agriculture and forestry. Volume 2, Science publishers.

MBH- 4.2: INDUSTRIAL MICROBIOLOGY

Total Hours: 52

Course Objectives: *The curriculum focuses on methodologies for strain improvement of industrially important microorganisms, bioreactor design, techniques involved in upstream and downstream fermentation process.*

Learning outcome: *Students will acquire knowledge on industrially important microorganisms and strain improvement techniques, basic characteristics and design of various types of bioreactors, techniques used for purification of industrial products, and IPR rules and regulations.*

Unit1

Introduction to Industrial microbiology: Scope and concepts of Industrial Microbiology; History and Scope of industrial Microbiology; Industrially important micro-organisms; Criteria for selection of industrially important microbes; isolation and screening of industrially useful microbial strains; Strategies for strain improvement; Recombinant organisms; Preservation of industrially important microbes. **08hrs.**

Unit 2

Fermentation media and methods of bioprocess: Natural and synthetic media; Strategies for media formulation; Sources of carbon, nitrogen, vitamins and minerals; Role of buffers, precursors, inhibitors, inducers and antifoam agents; Types of fermentation process- submerged fermentation, surface or solid state fermentation, batch fermentation, continuous fermentation; kinetics of fermentation process; monitoring of bioprocess variables- temperature, agitation, pH, pressure and microbial growth; Concepts of Newtonian, Non-Newtonian and plastic fluids. **10 hrs.**

Unit 3

Fermentor: Basic features, design and components of advanced bioreactor (Stirred tank bioreactor). Specialized bioreactors- design and their functions of airlift bioreactor, tubular bioreactors, fluidized bed reactor, packed bed reactors, membrane bioreactors, tower bioreactors and Photo-bioreactors; Sterilization of fermentor, medium and air supply; Aseptic inoculation and sampling methods; Scale up of fermentation process- Merits and demerits; **10 hrs.**

Unit 4

Solid state fermentation (SSF): Introduction, characteristics and application of SSF; advantages of SSF compared with submerged fermentation; Solid Matrix in SSF; Inert support materials; Factors influencing SSF, design of Koji fermentor; Production of commercially important products by SSF- cellulases, penicillin, gibberillic acid and clavulanic acid. **10 hrs.**

Unit 5

Downstream processing: Objectives and criteria; Steps in extraction and purification of product; Methods of Biomass separation- Filtration and centrifugation; Methods for cell disruption- Physical, chemical and biological methods; Methods for product extraction-precipitation, liquid-liquid extraction, distillation; Methods for product purification and polishing- Chromatography, crystallization, drying devices (Lyophilization and spray dry technology); Effluent treatment; process economy; Quality control. **12 hrs.**

Unit 6

Intellectual Property Rights (IPR) and Entrepreneurship: Introduction and implications, WTO, WIPO, GATT, TRIPS; Patenting procedures and granting, compulsory licenses, patent search, Patent Cooperation Treaty (PCT); Patents in microbiology-National and international status; Legal implications; Traditional knowledge in commercial exploitation and protection; GI tags and significance; Entrepreneurship– Potential activities in microbial biotechnology, product development, marketing, research and training units. Industrial licensing and venture capital. Microbial Biotechnology industries in India and potential job opportunities. **10 hrs.**

Content for student task and prospects: *Students are taken to a bioreactor facility and assigned with describing the various components and their functions, Group discussion on the role of microbes in the industry, Written assignment on techniques used for purification of industrial products, student presentation on varieties types of bioreactors, seminars, tests, and promotion of interest in the role of microorganisms in industrial product production.*

REFERENCES:

1. Arindam Kuila and Vinay Sharma (2018) Principles and Applications of Fermentation Technology, Wiley.
2. Casida L.E.J.R. (2016) Industrial Microbiology, 2nd edition, New Age, internationalpublisher.
3. Crueger, W & A. Crueger (2017). Cruegers Biotechnology: A Text Book of Industrial Microbiology. Edited by K.R. Aneja. Panima Publishing Corporation.
4. Deborah E. Bouchoux (2012) Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets, 4th edition, Delmersangage.
5. Michael, J. W., Neil L. Morgan (2013) Industrial microbiology: an introduction. Blackwell science.
6. Nduka Okafor, Benedict C. Okeke (2017). Modern Industrial Microbiology and Biotechnology. 2nd Edition: CRC Press Publishers
7. Robert W. Hutkins (2019) Microbiology and technology of fermented foods, Blackwell publishing
8. Stanbury P.F., W. Whitaker & S.J. Hall (2016). Principles of Fermentation Technology. 3rd edition. Elsevier publication
9. Waites, M.J., Morgan, N.L., Rockey, J.S. and Higton, G. (2002). Industrial Microbiology:An Introduction. Blackwell Science Publishers.

MBH- 4.3: MICROBIAL BIOTECHNOLOGY

Total hours: 52

Course Objectives: *The objective of this paper is to create knowledge and awareness on the types of commercial products obtained from potential microbes. Also on conventional and modern production strategies.*

Learning outcome: *At the end of the semester, students will have an in-depth understanding of how efficiently microorganisms can be utilized for commercial and pharmaceutically important for production of various products.*

Unit 1

Introduction: Principle, applications, economics and milestones in Microbial Biotechnology. **02 hrs.**

Unit 2

Microbial products for commercial use: Industrial production of organic acids (acetic acid). Amino acids (glutamic acid), Solvents (ethanol), Antibiotics (Cephalosporin,), Microbial polysaccharides and polyesters, Vitamin (B12), Hormones (insulin), anticholesterol compound (Lovastatin). Microbial insecticides. Secondary metabolites in bacteria and fungi (anti-cancer) and anti-diabetic compounds). Microbial surfactants, biosimilars; bioflavours. **10 hrs.**

Unit 3

Microbial enzymes: History; Use of enzymes in starch processing, food (baking, oil, breweries and textile, detergent, leather, paper, therapeutics); Immobilized enzymes and cells: Techniques and types of immobilization, industrial applications of immobilization: merits and demerits. **10 hrs.**

Unit 4

Microbial transformation and organic synthesis: Transformation of steroids and sterols, over production of glutathione by genetically engineered cells. Metabolic engineering for vitamin C production, Synthesis of acrylamide by nitrile hydratase.

Clinical trial of microbial products: preclinical and clinical trials; basic principle of toxicology; oral toxicity, sub-acute, acute and chronic toxicity. Toxic dose: LD_{50}, dose response relationship; local verses systemic toxicity; antagonism and synergism. **10 hrs.**

Unit 5

Nanotechnology: Introduction, types, properties and synthesis of nanoparticles (Physical, Chemical and Biological), Nanoparticles synthesized using microorganisms- advantages and disadvantages; Biopolymeric nanoparticles; Bionanosensors; Applications of bionanoparticles. **10 hrs.**

Unit 6

Microbial metabolites and drug discovery: The search for microbial products with bioactive prj9oroperties-Cell based assay, Receptor binding Assay, Enzyme Assay;

Modern methods of Drug Discovery: Computer aided drug design. Quantitative Structure-Activity Relationship (QSAR) in drug design. Search for drugs among unculturable microorganisms.

Approval of new antibiotics and other drugs: Pre-submission work by the pharmaceutical firm, submission of the new drug to the FDA, approval, post marketing surveillance.

10 hrs.

Content for student task and prospects: *Students are required to submit a report on several microbial products with commercial applications. Group discussion on challenges in drug discovery, frequent written test, seminars, and promotion of interest on microbial products and human welfare.*

REFERENCES:

1. Alexander N. Glazer, Hiroshi Nikaido (2007), Microbial Biotechnology: Fundamental of applied Microbiology, 2nd Edition, Cambridge University Press.
2. El-Mansi, E.M.T. and Bryce, C.F.A. 2004. Fermentation Microbiology and Biotechnology.
3. Taylor and FrancisGroup.
4. Elnashar MMM. (2010). Immobilized Molecules Using Biomaterials and Nanobiotechnology. J Biomaterials Nanobiotechnology. 01:61-77. 43
5. Goutam Brahmachari, Arnold Demain, Jose L Adrio (2016) Biotechnology of microbial enzymes: production, biocatalysis and industrial application. Acadmic press.
6. Harzevili F.D. & Chen H. (2016) Microbial biotechnology: progress and trends, CRC Press. Honda K, Ishige T, Kataoka M and Shimizu S. (2007) Microbial and Enzymatic Process for production of chiral compounds. Biocatalysis in the Pharmaceutical and Biotechnology Industries. Book chapter 20.
7. Hui YH, Meuiner-Goddick, Hansen AS, Josephsen J, Nip W, Stanfield PS and ToldrihF. (2011) Handbook of food & beverage fermentation technology. CRC Press.
8. Moo-Young M, Butler MM, Colin Webb C, Moreira A, Grodzinski B, Cui ZF &A gathos S. (2011) Comprehensive Biotechnology, 2nd Edition. Elsevier.
9. Nduka Okafor, Benedict C. Okeke (2017). Modern Industrial Microbiology and Biotechnology. 2nd Edition: CRC Press Publishers.
10. Stanbury P.F., W. Whitaker & S.J. Hall (2016). Principles of Fermentation Technology. 3rd edition. Elsevier publication.
11. Zheng R, Zheng Y, and Shen Y. (2010). Acrylamide, Microbial Production by Nitrile Hydratase, Wiley.

Total Units: 20

Course Objectives: *The main objective of this paper is to provide hands-on training on role of microbes for crop improvement, and production of different industrial products from microorganisms.*

Learning outcome: *At the end of the course, the students will be trained on the production of laboratory scale biofertilizer, biopesticides, wine, antibiotics, enzymes and polysaccharides. Student will become familiar with the significance of microbially derived nanoparticles.*

1. Isolation of cellulose, hemicelluloses, lignin, xylan and pectin degrading microbes.
2. Isolation of symbiotic and non-symbiotic nitrogen fixing microorganisms
3. Isolation of phosphate solubilising bacteria and fungi-plate method.
4. Isolation of bioinoculants: *Bacillus thuringiensis, Bauveria bassiana, Trichoderma, Pseudomonas.*
5. Assay of bio fertilizers (seed treatment, seedling, inoculation and measurement of rootand shoot length) and formulations.
6. Mushroom cultivation using locally available substrates and evaluation of total protein content.
7. Extraction and estimation of phytoalexins and phenolics from diseased plants
8. Production of organic acids (lactic acid and citric acid) by microbes
9. Immobilization technique: whole cell or enzyme- sodium alginate gel method and demonstration of its significance.
10. Production of antibiotic (penicillin) by submerged and solid substrate fermentation.
11. Laboratory scale production of ethanol from industrial wastes and estimation of totaland volatile acidity.
12. Laboratory scale production of wine/beer.
13. Detection and quantification of pigment from microbes: Melanin.
14. Detection and quantification siderophore produced by *Pseudomonas* spp.
15. Microbial assay of vitamin B_{12} and Glutamic acid
16. Sterility tests for pharmaceutical products
17. Production of amylase by solid substrate fermentation (at least 4 substrates)
18. Demonstration of a basic fermentor
19. Synthesis of nanoparticles from microbes (Bacteria/ Yeast/ Fungi/ Microalgae/plant)
20. Determination of antimicrobial activity of nanoparticles.

Content for student task and prospects: *Group discussion on the methodology used for the production of industrially important products.*

REFERENCES

1. Bull, Alan T. and Junker, Beth and Katz, Leonard and Lynd, Lee R. and Masurekar, Prakash and Reeves, Christopher D. and Zhao, Huimin, eds. (2010). Manual of Industrial Microbiology and Biotechnology, 3rd Edition. ASM Press.
2. Aneja, K.R. 1993. Experiments in Microbiology, Plant Pathology. Rastogi and Company, Meerut.