BHARATHIDASAN UNIVERSITY TIRUCHIRAPPALLI - 620 024.

M.Sc. MICROBIOLOGY: CHOICE BASED CREDIT SYSTEM – LEARNING OUTCOMES BASED CURRICULUM FRAMEWORK (CBCS - LOCF)

(Applicable to the candidates admitted from the academic year 2022-2023 onwards)

Sem.	Course		Ins. Hrs.	Credit	Exam Hrs.	Marks		Total
						Int.	Ext	
I	Core Course I (CC)	General Microbiology	6	5	3	25	75	100
	Core Course II (CC)	Biological Macromolecules	6	5	3	25	75	100
	Core Choice Course I(CCC)	1. Applied Biological Sciences 2. Molecular Taxonomy and Phylogeny	6	5	3	25	75	100
	Core Practical I (CP)	General Microbiology & Biological Macromolecules	6	3	3	40	60	100
	Elective Course I (EC)	1. Biological Techniques 2. Food & Dairy Microbiology	6	4	3	25	75	100
	Value Added Course I (VAC)	Medical Laboratory Technology	-	2*	3	25	75	100*
	Total		**30**	**22**	**-**	**-**	**-**	**500**
II	Core Course III (CC)	Microbial Physiology and Metabolism	6	5	3	25	75	100
	Core Course IV (CC)	Medical Microbiology	5	5	3	25	75	100
	Core Choice Course II(CCC)	1. Bioinformatics and Biostatistics 2. Pharmaceutical Microbiology	5	5	3	25	75	100
	Core Practical II (CP)	Microbial Physiology and Metabolisms & Medical Microbiology	6	3	3	40	60	100
	Elective Course II (EC)	1. Marine Microbiology 2. Microbial Biotechnology	5	4	3	25	75	100
	Non-major Elective I	Men and Microbes	3	2	3	25	75	100
	Total		**30**	**24**	**-**	**-**	**-**	**600**
III	Core Course V (CC)	Molecular Biology and Microbial Genetics	6	5	3	25	75	100
	Core Course VI (CC)	Environment and Agricultural Microbiology	5	5	3	25	75	100
	Core Choice Course III (CCC)	1. Bioprocess Technology 2. Bioethics and Intellectual Property Rights	5	5	3	25	75	100
	Core Practical III (CP)	Microbial Genetics and Molecular Biology & Environment and Agricultural Microbiology	6	3	3	40	60	100
	Elective Course III (EC)	1. Genetic Engineering 2. Microbial Nanotechnology	5	4	3	25	75	100
	Non-major Elective II	Public Health Microbiology	3	2	3	25	75	100
	Total		**30**	**24**	**-**	**-**	**-**	**600**
IV	Core Course VII (CC)	Advances in Virology	6	5	3	25	75	100
	Core Course VIII (CC)	Immunology and Immunotechnology	6	5	3	25	75	100
	Entrepreneurship / Industry Based Course	Entrepreneurship in Microbiology	6	5	3	25	75	100
	Project	Individual Project	12	5	-	20	80	100
	Value Added Course II (VAC)	Quality Control in Industries	-	2*	3	25	75	100*
	Total		**30**	**20**	**-**	**-**	**-**	**400**
Grand Total			**120**	**90**	**-**	**-**	**-**	**2100**

***The value-added courses credit will not be included in the total CGPA.**
These courses are extra-credit courses.
Instruction hours for these courses is 30 hours.

SUMMARY OF CURRICULUM STRUCTURE OF PG PROGRAMMES

Sl. No.	Types of the Course	No. of Courses	No. of Credits	Marks
1.	Core Course	8	40	800
2.	Core Choice Courses	3	15	300
3.	Core Practical	3	9	300
4.	Elective Courses	3	12	300
5.	Entrepreneurship/Industry Based Course	1	5	100
6.	Project	1	5	100
7.	Non-Major Elective Courses	2	4	200
	Total	**21**	**90**	**2100**
	Value Added Courses *	2*	4*	200*

PROGRAMME OBJECTIVES:

- Post graduates would gain basics & applied knowledge of biological sciences as well as microbiology oriented entrepreneur skills through the curriculum.
- Can demonstrate the desired sense of being seasoned and exhibit unequivocal spiritedness with excellent qualities of productive contribution to national science and technology and to the society.
- Graduates could choose to join industry for improving their financial stabilization and real- time experience.
- Microbiology is an emerging and dynamic subject and its practitioners can manage emerging and re-emerging problems.
- Post graduates would be mentored such that they exert leadership latitude in their chosen fields with commitment to novelty and distinction.

PROGRAMME OUTCOME:

- Gain advanced knowledge of applied biological sciences and microbial biochemical nature as to enable them find solutions for complex molecular functions and physiology.
- Graduates and their microbial natural recycling knowledge would contribute towards the improvement of soil quality and agricultural output through sustainable microbiological applications.
- Shine as an entrepreneur by using microbes as biofertilizers and biocontrol agents, microbial by-products as pharmaceutically potent molecules and microbes as nutritionally rich sources of food.
- Create self-confidence to develop an entrepreneurship avenue by providing technical and entrepreneurship skills. Skill focused lab courses would highly assist in disease diagnosis, treatment and prevention.
- Understanding of human ethical principles and responsibilities, moral and social values in personal life would bring out a culturally rich and civilized personality.

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First Year **CORE COURSE I** **Semester I**

GENERAL MICROBIOLOGY

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To introduce the beginners to the microbial arena as well as to orient them on the fundamental equipments, tools and techniques required for a primary but, a strong understanding of microbes.
- To impart the knowledge of different methods of classification of bacteria, viruses, fungi & others.
- To provide unique characteristic features of microbes.
- To describe the different types of microscopy and their working principles.
- To explain about microbial media, preservation and control techniques.

UNIT - I INTRODUCTION:

Spontaneous generation, conflict - contributions of early microbiologists: Leeuwenhoek, Louis Pasteur, Robert Koch, Edward Jenner & Winogradsky. Bacteria: Cell walls of Gram negative, Gram positive, and L-forms. Cell wall synthesis. Structure and mechanism of movement of flagella - Pili and fimbriae: types, structure and their role. External cell surface structures: capsule, glycocalyx, slime layer and S-layer. Brief account on gas vesicles, chlorosomes, carboxyomes, magnetosomes, phycoblisomes & PHB.

UNIT – II MICROSCOPY AND MICROBIAL TAXONOMY:

Principle, working & applications of Bright field, Dark field, Phase Contrast, Fluorescence, Confocal scanning microscope and Electron (TEM, SEM) microscopes. Microbial Taxonomy - Definition and systematics, Nomenclature and identification. Classification of microorganisms & its basis - Haeckel's three kingdom concept, Whittaker's five kingdom concept and Three domain concept of Carl Woese. Major characteristics used in taxonomy – morphological, physiological, metabolic, serological and molecular. Classification and salient features of bacteria according to Bergey's Manual of Determinative Bacteriology - Ninth edition. Numerical taxonomy - 16S rRNA based classification

UNIT – III CLASSIFICATION AND BASICS OF FUNGI AND VIRUSES:

Alexopoulos & Mims Classification of fungi - characteristics of fungi – Filamentous, non- filamentous and dimorphic fungi -Morphology, structure and life cycle of *Aspergillus niger* and *Saccharomyces cerevisiae.* Parasitism, mutualism and symbiosis with plants and animals. Viruses: ICTV system of classification, General properties, Morphology, viral capsids and their arrangements, viral envelopes and their composition, viral genome (RNA, DNA); Viroids, Prions - structure and importance.

UNIT – IV CLASSIFICATION AND BASICS OF ALGAE AND PROTOZOA:

Fritsch system of algal classification – General characters of Blue-green Algae (Cyanobacteria) - Structure and reproduction of *Chalmydomonas* sp. - Macroalgae - Biological and Economic importance of algae. Protozoa – modified form of Levine classification & characteristics - Structure and reproduction of *Paramecium* sp.

UNIT - V METHODS OF MICROBIAL CULTURE, PRESERVATION AND CONTROL:

Isolation of different types of bacteria - Fungi – Actinomycetes - Cyanobacteria - Protozoa. Physical and Chemical requirements for growth; Pure culture methods. Anaerobic culture techniques. Preservation methods of microbes. Type culture collections. Physical and chemical methods of controlling microorganisms.

UNIT – VI CURRENT CONTOUR (For Continuous Internal Assessment Only):

Cultivable and uncultivable microbe importance for evolutionary studies. Preparation of power point presentations (ppts) or charts representing a topic of the course and their seminar presentations – chart preparations and presentations covering equipments/ tools of the course & their display - Quiz classes – discussion of previous semester question papers.

REFERENCES:

1. Jacquelyn G. Black., Laura J. Black (2015).Microbiology: Principles and Explorations 9th Ed.., John Wiley & Sons.
2. Atlas, R.M., (2015). Principles of Microbiology 2nd Ed. WCB McGraw Hill Publications, New Delhi
3. Rajan S and Selvi Christy R. (2018). Essentials of Microbiology, CBS Publishers, New Delhi, 2018.
4. Dubey RC and Maheswari DK (2022). A Text of Microbiology. Revised edition, S. Chand and Company Ltd., New Delhi
5. Alexopoulos CJ, Mims CW and Blackwell M. (2007) Introductory Mycology. Fifth edition John Wiley and Sons. Chichester.
6. Prescott LM, Harley JP and Klein DA (2013). Microbiology. 7th edition, McGraw Hill, Newyork
7. DM Knipe, PM Howley. 2007. Fields Virology. 5th Edition. ippincott Williams & Wilkins Health
8. Johri RM, Snehlatha, Sandhya Shrama. A Textbook of Algae. Wisdom Press, New Delhi. 2010.
9. Pelczar TR, Chan ECS and Kreig NR (2006) Microbiology. 5th Edition, Tata McGraw – Hill, New Delhi.
10. Schlegel HG. (2008) General Microbiology, Cambridge University Press, UK.
11. http://ecoursesonline.iasri.res.in/course/view.php?id=108
12. http://www.microbiologyonline.org.uk/links.html
13. http://www.bact.wisc.edi/Microtextbook/index.php
14. http://www.bris.ac.uk/vetpath/cpl/tut.html
15. http://www.bmb.leeds.ac.uk/mbiology/ug/ugteach/elect/elect.htm

COURSE OUTCOMES:

Students who undergo the course, will be able to:

- Strongly understand the basic features of microbes such as bacteria, fungi, algae, protozoa & viruses
- Master the classifications the microbes.
- Learn the working principles of important equipments like microscopes.
- Clearly recognize the contributions of early microbiologists.
- Understand molecular tools required for accurate microbial identifications.

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First Year **CORE COURSE II** **Semester I**

BIOLOGICAL MACROMOLECULES

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To educate the structure and functions biological molecules.
- To know the interrelationship between various biomolecules and consequences of any deviation from normal.
- To understand the structure and functions of blood, hormones and phytohormones.
- To study the basic metabolic regulators' characteristic features.
- To understand the interrelationships among biological energy, functions and health.

UNIT - I CARBOHYDRATE, PROTEINS AND AMINO ACIDS:

Carbohydrate: Definition, sources, classification, structure of glucose, biological significance, digestion and absorption. Proteins: Definition, sources, classification and structure of proteins (Primary, secondary, tertiary), Amino acids–structure- classification - essential and non-essential, protein and non-protein amino acids.

UNIT - II LIPIDS, FATTY ACIDS AND NUCLEIC ACIDS:

Lipids: Definition, sources, classification, structure, properties and functions, Fatty acids-saturated, unsaturated and essential fatty acids. Nucleic acids: Definition, structure, forms and functions of DNA. Types, structure and functions of RNA (mRNA, tRNA, rRNA).

UNIT – III HORMONES:

Hormones: Definition, classification of hormones, Human- Endocrine glands – Pituitary, thyroids, Para thyroid, pancreas, adrenal, testis and ovary. Phytohormones: Structure and functions of auxin, gibberellins, cytokinins and abscissic acid.

UNIT – IV VITAMINS AND MINERALS:

Vitamins – Definition, sources, deficiency syndromes and functions of Fat-soluble vitamins (A, D, E and K) and Water-soluble vitamins (B complex and C). Minerals Zn, Ca, Iodine, Fe, and Mg.

UNIT – V BLOOD AND PIGMENTS:

Blood: Introduction, origin, composition, characterization, functions and coagulation of blood. General account and secondary metabolites. Major and accessory microbial pigments – chlorophylls, carotenoids, phycobilins and anthocyanins.

UNIT – VI CURRENT CONTOUR (For Continuous Internal Assessment Only):

Diseases associated with deficiency of endocrine hormones- hypo and hyper secretions. Life style diseases and metabolic diseases. Diet-biochemical-health. Food as drug.

REFERENCES:

1. Albert L Lehninger, David L Nelson and Michael M Cox. Lehninger Principles of Biochemistry, 2nd edition, Wiley publisher. 2010.
2. Ambika Shanmugam. Fundamentals of Biochemistry for Medical students. Nagaraj and Company Pvt ltd, India. 1998.
3. Charlotte W Pratt and Kathleen Comely. Essential Biochemistry, 3rd edition Wiley publisher. 2013.
4. Deb AC. Edition. Fundamentals of Biochemistry, 10th edition, New Central Book Agency (p) ltd, London. 2011.
5. Denise R Ferrier. Biochemistry, 6th edition, LWW publishers. 2013.
6. Rafi MD. Textbook of Biochemistry for medical students, 2nd edition, Universities Press, (India) Pvt. Ltd, Hyderabad, India. 2014.
7. Rajagopal G. Concise textbook of biochemistry, 2nd edition. Ahuja Publishing House.2010.
8. Reginald H Garrett and Charles M Grisham, 5th edition. Biochemistry, Brooks Cole publishers. 2012.
9. Sathyanarayana U and Chakrapani U. Biochemistry, 4th edition, Elsevier publishers. 2013.
10. Thomas M Devlin. Textbook of Biochemistry with Clinical Correlations, 7th edition, Wiley publisher. 2010.

COURSE OUTCOMES:

Upon successful completion of this course, the students would be able to:

- Gain the knowledge of structure and function of biological molecules.
- Discuss the interrelationship between various biomolecules and consequences of deviation from normal.
- Understand the structure and functions of blood, hormones and phytohormones.
- Provide the information about basic metabolic regulators' characteristic features.
- Able to explain the interrelationships among biological energy, functions and health.

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First Year **CORE CHOICE COURSE I** **Semester I**

1) APPLEID BIOLOGICAL SCIENCES

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVE:

- To enable the students to understand the basics components of biology.
- To understand the biological diversity, uniqueness and their characteristic features.
- To study the importance of biological sciences in human welfare.
- To educate about the farm animals developmental principles and essential qualities.
- To create an awareness as to ensure nature based activities and minimize usage of experimental animals.

UNIT - I ALGAE AND FUNGI:

Thallophytes: Algae-General characteristics- Economic importance- Types of life cycle- Outline of various classifications. Fungi: General characteristics- Classifications and Economic importance

UNIT - II CRYPTOGAMIC PLANTS:

General characteristics- Economic importance and outline of reproduction methods in Lichens, Bryophytes, Pteridophytes and Gymnosperms. Stelar evolution

UNIT - III PHANEROGAMIC PLANTS:

Salient features of monocot and dicot. Taxonomy: Systems of classification, (Artificial, Phylogenetic and Natural). Morphometric diversity: Morphology; types of inflorescences. Technical description of flower and floral diagram and types of fruits. Economic importance.

UNIT - IV INVERTEBRATES:

General characteristics and outline classification up to classes in Protozoa, Porifera, Coelenterata, Platyhelminthes, Aschelminthes, Annelida, Arthropoda and Echinodermata; Economic importance of invertebrates. General characters - a brief study on Star fish.

UNIT - V VERTEBRATES:

Classification of Chordata – General characteristic features and Classification (up to the orders) – Prochordata, Pisces, Amphibia Reptilia, Aves and Mammalia- Economic importance of Vertebrates. Farm animals – Controlling of breeding animals.

UNIT – VI CURRENT CONTOUR (For Continuous Internal Assessment Only):

Bioluminescence. Principles of insect control: physical, mechanical, chemical, biological and integrated methods of pest control. Cell cultures and line lines.

REFERENCES:

1. Arumugam N. Invertebrate Zoology, Saras publication, Nagercoil. 2002.
2. Ekambaranatha Iyar M and Ananthakrishnan TN. Manual of Zoology. Vol. I. part I and II, S. Visvanathan publication, Chennai.1994.
3. Ayyar EK and Ananthakrishnan A Manual of Zoology, Vol. II (Chordata).1992.
4. Ekambaranatha Iyar M and Ananthakrishnan TN. Manual of Zoology Vol. II. S. Visvanathan publication, Chennai.1994.
5. Ranganathan TN. Chordata Zoology, Rainbow printers, Palayamkottai.1996.
6. Ekambaranatha Ayyar. Outlines of Zoology. Vols. I and II S. Viswanathan (Printers and Publishers) Pvt. Ltd., Chennai.1993.
7. Kotpal RL. Invertebrata, Rastogi Publication, Meerut.2000.
8. Jordan EL and Verma PS. Invertebrate Zoology, 12th Edition, S. Chand and Co.1995.
9. Mani MS. General Entomology, Oxford and IBH publishing Co., New Delhi. 1982.
10. Nayar KK, Ananthankrishnan TN and David M. General and applied Entomology, Tata McGraw Hill Pub. Co., Ltd., New York. 1995.
11. David BV. Pest Management and pesticides Indian Scenario, Namrutha Publications.1992.
12. Krishnan NT. Economic Entomology, J.J. Publications, Madurai. 1993.
13. https://oer.galileo.usg.edu/biology-textbooks/
14. https://DAMS-CSIR-Companion-Handbook-Applied-Biology-CCH-12/dp/B07J5YTZV9#detailBullets_feature_div

COURSE OUTCOMES:

Upon successful completion of this course, the students would be able to:

- Understand the important components of biological sciences.
- Understand the biological diversity, uniqueness and their characteristic features.
- Know the importance of biological sciences in human welfare
- Appreciate the farm animals' developmental principles and essential qualities.
- Create an awareness to ensure the nature based activities and minimize usage of the experimental animals.

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First Year **CORE CHOICE COURSE I** **Semester I**

2) MOLECULAR TAXONOMY AND PHYLOGENY

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To gain the knowledge of microbial taxonomy and molecular phylogeny
- To explore the sources of information for phylogenetic analysis
- To know about recent techniques of sequencing, sequence analyses and fingerprinting
- To grasp the speed of technological change in molecular biology and their impact on phylogenetic research
- To study about evolutionary origin and their importance.

UNIT - I MICROBIAL TAXONOMY:

Introduction to microbial taxonomy – morphological, Biological Classification, Three Domain concept, biochemical and molecular taxonomy. Basic concepts of numerical taxonomy. Positive and negative aspects of each taxonomical methods. Morphological phylogeny.

UNIT - II BIOCHEMICAL AND MOLECULAR TAXONOMY:

Chemotaxonomy - fatty acid, protein finger printing, Isozyme typing, pigments and polyamines. Biochemical phylogeny. Molecular taxonomy - G +C content, DNA –DNA hybridization, DNA – RNA hybridization, Plasmid profiles, RFLP, RAPD, AFLP, STRR and LTRR, REP –PCR, rRNA based DNA finger printing methods.

UNIT – III 16S rRNA BASED FINGER PRINTING:

Types of rRNA - 23s rRNA, 16S rRNA and 5S rRNA. Isolation of DNA, amplification of 16S rDNA using PCR technique, Cloning, transformation, Blue-white screening, Dot Blot/Southern blot hybridization using specific Probes. Sequencing of 23s rRNA, 16S rRNA and 5S rRNA. Importance of 16S rRNA in identification of prokaryotes. Methods of 16S rRNA / rDNA fingerprinting.

UNIT – IV SEQUENCE SUBMISSION AND ANALYSIS:

Submission of rDNA sequences in GenBank – BankIt and Sequin guidelines. NCBI, EMBL, PDB and DDBJ – retrieving sequences. RNA structure prediction, Restriction enzyme patterns. Ribosomal Database Project - Designing primers and probes. Sequence comparison, alignment and data base searching – ClustalW, FASTA and BLAST. DNA barcoding.

UNIT – V MOLECULAR PHYLOGENY:

Introduction to Molecular phylogeny – tree terminology, software programs for making phylogenetic trees – MEGA, Phylib, RAPDistance. Cladogram, additive trees and ultrametric trees, rooted, unrooted trees and tree shapes.

UNIT – VI CURRENT CONTOUR (For Continuous Internal Assessment Only):

Field trip and Hands on training on Sample collection – algae, lichen, etc. – monitoring algae diversity. Hands on about microalgae identification using manuals – program content free hand drawing of algae, cyanobacteria, lichen, bacteria's – phylogeny tree making using Clustal W and/or MEGA softwares.

REFERENCES:

1. Anna Tromontano. Introduction to Bioinformatics, CRC Press, Florida, USA. 2002.
2. Baxavanis and Oullette. Bioinformatics. A practical Guide to the Analysis of gene and proteins, 3rd edition. John Wiley and Sons, New York.2005.
3. Brendan Wren and Nick Dorrell. Functional Microbial Genomics (Volume 33) (Methods in Microbiology), Academic Press, UK. 2002.
4. Higgins. Bioinformatics: Sequence structure and data banks: A practical approach, Blackwell Publishers, UK. 2005.
5. Perry JJ, Staley JT and Lory S. Microbial Life. Sinauer Associates, Publishers, Sunderland, Massachusetts. 2002.
6. Primrose SB. Principles of Genome Analysis: A guide to mapping and sequencing DNA from different organisms, 2nd edition, Oxford England; Cambridge, Mass., USA: Blackwell Science. 1998.
7. Roderic DM Page and Edward C Holmes. Molecular Evolution: A Phylogenetic Approach. Blackwell publishing, USA. 1998.
8. Sandy B Primrose and Richard M Twyman. Principles of Genome Analysis and Genomics, Blackwell Publishing, USA. 2005.
9. Huson DH and Scornavacca C. (2012). Dendroscope: An Interactive Tool for Rooted Phylogenetic Trees and Networks. Syst. Biol: 1–7.
10. Aharon O and Thane P. Molecular Phylogeny of Microorganisms. (2010). Academic Press.
11. https://www.mimuw.edu.pl/~lukaskoz/teaching/sad2/books/Molecular-Evolution-and-Phylogenetics.pdf.
12. https://www.cs.cmu.edu/~durand/Phylogenetics/Readings/Page-book.pdf
13. https://www.ncbi.nlm.nih.gov/books/NBK21122/
14. https://www.nhbs.com/an-introduction-to-molecular-evolution-and-phylogenetics- book

COURSE OUTCOME:

After successfully completion of the course, the students will gain knowledge on:

- The theories, practices, and applications of phylogenetic inference from molecular data
- Current status of microbial taxonomy
- Phylogenetic inference and reconstruction of phylogenetic trees,
- Applying the State-of-the-Art bioinformatics tools in the field.
- Recombinant RNA based fingerprinting and DNA sequences.

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First Year **CORE PRACTICAL I** **Semester I**

GENERAL MICROBIOLOGY &
BIOLOGICAL MACROMOLECULES

Code: **(Practical)** **Credit: 3**

GENERAL MICROBIOLOGY

COURSE OBJECTIVES:

- To educate hands-on skills on the first-line experimental methods of the fundamental microbiology.
- To deepen students' understanding on the importance of lab sterility.
- To understand sterilization and decontamination procedures as to maintain a good microbiology laboratory.
- To provide a better practice on various media preparation and pure culture methods.
- To describe assessment of microbes using microscopes after staining.

EXPERIMENTS:

1. Sterility control test
2. Principles and methods of sterilization, decontamination and laboratory fumigation, Preparation and use of glassware cleaning solutions.
3. Staining and direct microscopic observations of bacterial shape- cocci, rods and chains; fungal spore- mycelium, yeast budding
4. Preparation of media: Liquid and Solid media, Agar deep, slant and plate and soft agar
5. Pure & axenic culture techniques - serial dilution - pour plate, spread plate, streak plate methods, decimal dilution and stab culture techniques
6. Bacterial Staining methods - simple, Gram's, acid fast, flagella, capsule and spore.
7. Fungal Staining methods - Lacto-phenol cotton blue
8. Motility of bacteria - Hanging drop and soft agar inoculation
9. Enumeration of microorganisms from soil: Bacteria, Fungi and Actinomycetes, total count (Haemocytometer)
10. Isolation and purification of cyanobacteria, actinomycetes and fungi
11. Phenol Co-efficient test.
12. Micrometry – counting & measurements of microbes

REFERENCES:

1. James G Cappuccino (2014) Microbiology – A Laboratory Manual. 10th edition, Pearson Education India
2. David R Brooke. (2007) Bergey's Manual of systematic bacteriology (Vol 1), Eastern Halz, Springer publication, US..
3. Gunasekaran P. (2008) Laboratory Manual in Microbiology, New Age International Pvt. Ltd. Publishers, New Delhi.
4. Kanika Sharma. (2009) Manual of Microbiology – Tools and Techniques. 2nd Edition, Ane Books Pvt. Ltd., New Delhi.

5. Keith Wilson and John Walker. (1995). Principles and Techniques of Practical Biochemistry. 4th edition. Cambridge University press, Britain.
6. Nizhny Novgorod. (2008) Laboratory manual on Biochemistry: Publishing House of Nizhny Novgorod State medical academy.
7. Rajan S and Selvi Christy R. (2015) Experiments in Microbiology. Anjana Books House, Chennai.
8. Merck (2010) Microbiology Manual 12th Edition.
9. Shawn O' Farrell and Ryan T Ranallo. (2000) Experiments in Biochemistry: A Hands on Approach-A manual for the undergraduate laboratory, Thomson Learning, Inc., Australia.
10. Wilson K and Walker J. (2000). Practical biochemistry, 5th edition, Cambridge University Press, London.
11. Mahatma Gandhi-Doerenkamp Centre (MGDC) for Alternatives to Use of Animals in Life Science Education. http://www.mgdcaua.org/

COURSE OUTCOMES:

Students who undergo the course will be able to:

- Independently check the sterility of the microbiology or other laboratories.
- Carry out sterilization and decontamination of various articles.
- Determine the size of microbes.
- Isolate and preliminarily identify different microbes.
- Check whether a bacterium is motile or non- motile.

BIOLOGICAL MACROMOLECULES COURSE OBJECTIVES:

- To understand the biological macromolecules' types and structures.
- To provide hands- on experience on analytical techniques.
- To describe the principles of analytical agents in confirmation tests.
- To teach the estimation procedure for biochemical test
- To motivate towards innovative findings in microbial molecular mechanism.

EXPERIMENTS:

1. Carbohydrate reducing sugars-Anthrone method/Benedicts method.
2. Aminoacids-Ninhydrin method
3. Protein–Lowry's method/Biuret method/ Bradford assay
4. Estimation of Cholesterol-Acetic anhydride method,
5. Estimation of lipid.
6. DNA-Diphenylamine method
7. RNA-Orcinol method
8. Determination of Phosphorous content of nucleic acids-Perchloric acid test.
9. Pigments (Chlorophyll-Carotenoids–Phycobili Proteins)–Spectrophotometric

10. Estimation of Vit. C concentration by DCPIP method Estimation of haemoglobin on Blood
11. Immobilization of cell: RBC
12. Determination of A/G ratio in serum

REFERENCES:

1. Palanivel P. 2013. Analytical Biochemistry and Seperation Techniques – A laboratory manual. Twentyfirst century publications
2. Boyer, R.2012. Biochemistry Laboratory: Modern Theory and Techniques, 2nd Edition, Benjaminand Cummings Publishing Company Inc.
3. Wilson .K and Walker 2012, Practical Biochemistry-Principles and technics of Biochemistry and Molecular Biology 7th edition Cambridge Press India,
4. Switzer, R.L., Garrity, L.F.1999. Experimental Biochemistry, 3rd edition, WH Freeman and Co.
5. Awasthi D, Santosh Kumar, Ashwani S and Shiv S S. 2013. Biochemistry Laboratory Manual. International E – Publication

COURSE OUTCOMES:

Upon successful completion of the course, the students can:

- Practice laboratory safety and precautionary measures.
- Understand the basic analytical instruments, principles and their calibration.
- Learn the molecules separation and filtration techniques.
- Understand the pigmentation profiles of biological materials.
- Comprehend the biochemical differences among animal, plant and microbial cells.

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First Year **ELECTIVE COURSE I** **Semester I**

1) BIOLOGICAL TECHNIQUES

Code: **(Theory)** **Credit: 4**

COURSE OBJECTIVES:

- To become familiar with microscopic techniques
- To develop the skills as to understand the theory and practice of bio analytical techniques.
- To elaborate the applications of spectroscopic methods in biology
- To attain knowledge on purification of macromolecules using various biological techniques.
- To update with the current knowledge of molecular techniques.

UNIT - I MICROSCOPIC TECHNIQUES:

Components of microscopes - Basic principles and methods of Bright field, Dark field, Phase contrast, Fluorescence, Polarization and confocal microscopes. Electron Microscopy – Principle, Techniques and applications of Transmission Electron microscope (TEM), Scanning Electron Microscope (SEM) and Atomic Force Microscope (AFM). Microtomy – Basic and Freezing microtome – specimen preparation.

UNIT - II ANALYTICAL TECHNIQUES SPECTROSCOPIC METHODS:

UV- Visible, Atomic Absorption Spectrophotometer, Atomic Emission Spectroscopy. Centrifugation – Principle, types and applications. Electro-analytical methods- Potentiometric, Conductimetric, Coulometric and Voltametric analyses. Biosensors. Principles of radioactivity, GM and LS counter.

UNIT - III CHROMATOGRAPHIC TECHNIQUES:

Chromatography - Paper, Thin layer, Ion exchange, affinity and gel permeation - Principle, preparation of columns, adsorption and elution. GC, GC - MS and HPLC - principle and their applications.

UNIT - IV ELECTROPHORESIS AND ITS APPLICATIONS:

Electrophoresis – Principle and applications of Agarose and Pulse field gel electrophoresis, counter current and rocket immune-electrophoresis, SDS-PAGE and 2D gel electrophoresis.

UNIT - V MOLECULAR TECHNIQUES:

Isolation and quantification of nucleic acid – DNA, RNA and Plasmids. Amplification of DNA - Polymerase chain reaction and Real time and reverse transcriptase PCR. Gene cloning techniques – Restriction digestion and phosphatase treatment of cloning vectors. Gene transfer mechanisms – chemical and electroporation. Method of detection of clones–colony hybridization, Blue - White selection and immunochemical detection.

UNIT – VI CURRENT CONTOUR (For Continuous Internal Assessment Only):

Students may undergo internship training program to become expertise in

handling instruments like SEM, TEM, HPLC, GC-MS etc. Self-reading, assignment, seminar, quiz, group discussion, posters on recent advances in biological techniques.

REFERENCES:

1. Cynthia, G., Per, J. Developing Bioinformatics computer skills, Shroff publishers and Distributors Pvt. Ltd. 2001.
2. Yadav, P.R. Biological techniques, Discovery Publishing House. 2020.
3. Upadhyay, A., Upadhyay, K., Nath, N. Biophysical chemistry principles and techniques, 4th edition, Himalaya Publishing House Pvt. Ltd. 2020.
4. Hofmann. A., Samuel, C. Wilson and Walkers Principles and techniques of biochemistry and molecular biology, 8th edition, Cambridge University Press. 2018.
5. Demain, A.L., Davies, J.E. Manual of Industrial Microbiology and Biotechnology, ASM Press, US. 1999.
6. John, G. W. Bioinstrumentation. University of Wisconsin, John Wiley and Sons, Inc. US. 2004.
7. Misener, S., Krawetz, S.A. Bioinformatics Methods and Protocols, Humana Press, Totowa, New Jersey. 2000.
8. Rashidi, H.H., Buehler, L.K. Bioinformatics Basics: Applications in Biological Science and Medicine, CRC Press, London. 2002.
9. Sambrook, J., Russell, D.W. Molecular cloning – A Laboratory Manual (3rd edition, Vol1, 2, 3), Cold spring Laboratory press, New York. 2001.
10. Webster, G. Bioinstrumentation. University of Wisconsin, John Willey and sons, US. 2004.
11. Wittwer, C.T., Kusukawa, N. Nucleic acid techniques. In: Tietz Textbook of Clinical Chemistry and Molecular Diagnostics, 4th edition Elsevier, New York. 2005.
12. Wittwer, C.T., Kusukawa, N. Nucleic Acid Techniques, In: Fundamentals of Molecular Diagnostics, (Eds; Bruns DE, Ashwood ER, Burtis CA), Saunders WB, Philadelphia. 2007.
13. Wilson, K., Walker. Practical Biochemistry Principles and Techniques, Cambridge University press, London. 1995.
14. https://www.biologydiscussion.com/micro-biology/chromatography/thin-layer- chromatography-with-diagram/18037
15. https://microbiologynotes.org/gel-electrophoresis-types-principles-instrumentation-and-applications/

COURSE OUTCOMES:

Upon completion of this course, students be able to:

- Understand the fundamental principles, types and uses of light and electron microscopy.
- Explain basic principles and application of spectroscopic analytical techniques.
- Carryout separation of molecules by chromatographic methods.
- Attain a comprehensive idea about gene cloning, gene transfer and methods to detect clones.
- Develop valuable aptitudes to prepare samples for a multifariousness of analytical methods.

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First Year **ELECTIVE COURSE I** **Semester I**

2) FOOD AND DAIRY MICROBIOLOGY

Code: **(Theory)** **Credit: 4**

COURSE OBJECTIVES:

- To enable the students to imbibe essential knowledge in key concepts of food and dairy microbiology
- To understand various methods of food fermentations and fermented food products.
- To portray the conceptual basis for understanding probiotics.
- To impart an awareness about microbial illness in foods, food sanitations and other related aspects.
- To provide the skills of preparing fermented milk products.

UNIT - I FOOD AND MICROBES:

Types of microorganisms in food – Bacteria, molds, yeast and protozoa. Source of contamination- Factors influencing microbial growth in food- pH, moisture, oxidation – Reduction potential, Nutrient content and Inhibitory substances and biological structure.

UNIT - II FOOD FERMENTATION AND FERMENTED FOOD PRODUCTS:

Food fermentations: methods of fermentations and organisms used -Cheese, bread, wine, beer. Fermented vegetables. Food and enzymes from microorganisms - single cell protein and mushrooms. Prebiotics, Probiotics and symbiotics. Advantages of probiotics. Contamination, spoilage and preservation of cereals and cereals products, sugar and sugar products, vegetables, fruits, meat and meat products, Fish and other sea foods, egg and poultry, dairy and fermentative products.

UNIT - III FOOD BORNE DISEASES AND CONTROL:

Food borne diseases and food poisoning. General principles underlying food spoilage and contamination – *Staphylococcus, Clostridium, Escherichia coli* and *Salmonella* infections, Hepatitis, Amoebiosis and Mycotoxins. Spoilage in canned foods. Food sanitation and control measures, HACCP, GMP, GLP.

UNIT – IV FOOD PRESERVATION METHOD:

Food preservations: principles- methods of preservations- Physical and chemical methods. Canning: classification of can, structure of cans, canning of food items, Thermal process time calculations for canned foods.

UNIT – V DAIRY MICROBIOLOGY:

Microbes in milk, sources of contamination, microbiological changes in milk during production and processing. Starter cultures- lactic acid bacteria. Fermented milk products- dahi, lassi, yoghurt, cultured buttermilk, kefir, cheese. Microbiological standards and quality of dairy products- cream, butter, dried and evaporated milk, sweetened condensed milk, frozen dairy products and indigenous dairy products.

UNIT – VI CURRENT CONTOUR (For Continuous Internal Assessment Only):

To enrich knowledge on the production, processing and preservation of foods and food products Learners may visit food / dairy industry and shall submit a report. May prepare fermented food in groups or individual.

REFERENCES:

1. Adams, M.R., Moss, M.O., Peter McClure. 2015. Food Microbiology. The Royal Society of Chemistry, Cambridge.
2. Adrian, E. 1996. Microbial food poisoning, Springer Science and Business Media, e- book.
3. Barrett, D.M., Somogyi, L., Ramaswamy, H. 2004. Processing fruits, CRC press, Boca raton, US.
4. Frazier., Westhoff, D.C. 2003. Food Microbiology, 5th edition, TATA McGraw Hill Publishing Company Ltd., New Delhi.
5. Halasz, A., Lasztity, R. 2013. Use of yeast biomass in food production, CRC press, Boca raton, US.
6. Hui, Y.H., Goddick, L.M., Hansen, A.S., Josephsen, J., Wai-Kit-Nip., Stanfield, P.S., Doldra, F. 2008. Hand book of food and beverage fermentation technology, CRC press, Boca raton, US.
7. Jacobs, M.B., Gerstein, M.J., Watter, W.G. 1960. Dictionary of Microbiology, Vanwostrant co. Inc, Princeceton, US.
8. Kaferstein, F. 1988. Ten golden rules for safe food preparation. Magazine of the World Health Organization, Geneva.
9. Kiss, I. 1984. Test in methods in food microbiology, Akademiai kiado, Budapest, Hungary.
10. Reed, G. 2014. Prescott's and Dunn's Industrial Microbiology. 4th edition. AVI publishing co Inc., West port.
11. Sofos, J. 2013.Advances in microbial food safety. Center for Meat Safety and Quality, The College of Agricultural Sciences, Colorado State University, USA.
12. Subbulakshmi, G., Shoba, A.U. 2009. Food processing and preservation – New Age Publisher, Chennai.
13. Swaminathan, M. 2008. Advanced Text Book: Foods Nutrition, Bappco Publication, Jaipur.
14. https://www.slideshare.net/mohitjindal/principles-and-methods-for-food-preservation
15. https://www.onlinebiologynotes.com/food-borne-disease-food-poisoning-and-food- infection-with-example/

COURSE OUTCOMES:

After completion of this course, the students will be able to:

- Know Food and microbes and food borne diseases and control.
- Understand the Food fermentation.
- Acquire knowledge on Fermented food products.
- Get a comprehensive idea about the process of Food preservation.
- Develop an understanding of Microbiological standards and quality of dairy products.

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First Year **VALUE ADDED COURSE I** **Semester I**

MEDICAL LABORATORY TECHNOLOGY

Code: **(Theory)** **Credit: *2**

COURSE OBJECTIVES:

- To teach conventional methods of disease diagnosis and their moderation in the current era.
- To provide the knowledge of collection and processing of clinical samples
- To study the pathogenic microbial culture and their identification techniques.
- To give awareness of how to manage and dispose the biomedical waste.
- To strengthen the learners with the knowledge of current diagnostic methods including molecular methods required to secure a profession/career in health care sectors.

UNIT - I LAB TECHNOLOGIST, SOLUTIONS AND MEASUREMENTS:

Medical lab technologist: role, responsibility & ethics to be followed - types of hazards and laboratory accidents – first aid and safety measures to be followed. Preparation of normal, molar, percent & buffer solutions, dilutions, w/v, v/v, standard and aqueous solutions, concepts of acid and base. Units of measurement: SI Unit, reference range, conversion factor, Units for measurement of bio metabolite, enzymes, protein, drugs, hormones, vitamins.

UNIT - II CLINICAL SPECIMENS AND TESTING:

Clinical specimen collection and processing: Blood, Urine, Stool and & other body fluids - normal & abnormal constituents. Semen analysis - Hyper & hypoglycemia - *Diabetes mellitus*, Histopathology: Tissue Processing - Fixing, Embedding, Microtomy, Staining, mounting, decalcifications.

UNIT - III MICROBIAL CULTURE & IMMUNOLOGICAL:

Microbial culture techniques, Bacterial & Fungal culture media & their uses, Antibiotic sensitivity test, Diagnostic test for HIV, Hepatitis B, Hepatitis C, Malaria, Tuberculosis. WIDAL, RPR, CRP, Pregnancy test, Stool examination- Identification of different ova & cysts.

UNIT - IV SEROLOGY AND LAB AUTOMATION:

Liver, Renal functions & their assessment, Jaundice, its types and their biochemical findings, Blood urea estimation, Serum uric acid, total protein, albumin, globulin, glucose, total, HDL LDL cholesterol, Triglyceride, Bilirubin total estimation, Serum SGOT, SGPT estimation, Clinical enzymology - automation of microbiology labs: merits and impediments.

UNIT - V ENDOCRINOLOGY AND BIOMEDICAL WASTES:

Hormones of the Thyroid gland- chemistry and normal physiology, Thyroid test. Hormones of the gonads- Estimation of fertility hormones: FSH, LH, Beta-hCG, Progesterone. Cancer – Estimation of cancer marker: PSA & Pap smear test for cervical cancer. Drug abuse screening. Biomedical waste management.

UNIT – VI CURRENT CONTOUR (For Continuous Internal Assessment Only):

A visit to a diagnostic laboratory and a hospital/primary health center – semester end internship for 'one day' at a hospital or a clinical laboratory – seminar classes on molecular methods of diagnosis like PCR - assignments submission on result interpretation of various diagnostic tests - Quiz classes - short seminar presentations after internship – debates on biomedical waste management – discussion of previous year question papers.

REFERENCES:

1. Dacie and Lewis, (2016). Practical Haematology, Elsevier
2. Praful Godkar, Darsan, (2014). Textbook of Medical Laboratory Technology Vol I&II, Bhalani Publishing House
3. Baker F.J. and R.E. Silverton. (1976). Introduction to Medical Laboratory Technology. Fifth Edition,
4. Mehdi SR. (2013) Essentials of Blood banking. Jaypee Brothers, Medical Publishers Pvt. Limited.
5. Rajan S. (2012) Manual for Medical Laboratory Technology. Anajanaa Book House, Chennai.
6. Satish Gupte. (2014). The short text book of Medical Laboratory for technicians-Jaypee Brothers Pvt.Limited
7. Jayaraman J (1981). Laboratory manual in Biochemistry, New Age Int. Publishers, New Delhi
8. Sood Ramnik. (2009). Medical Laboratory Technology: Methods and Interpretations. Jaypee Brothers, Medical Publishers Pvt. Limited.
9. Ochei. J and A. Kolhatkar, (2000). Medical Laboratory science: Theory and practice, McGraw Hill Education.
10. Myers R.M, Koshi G (1982) Diagnostic procedures in medical microbiology. IELC Combodia Press.
11. Gerhardt P, Murray R.G, Wood W.A and Kreig N.R. (ed) (1994) Methods for General and Molecular Bacteriology - American Society for Microbiology, Washington D.C
12. https://www.mooc-list.com/tags/medical-diagnosis
13. https://www.mooc-list.com/tags/clinical-diagnostics
14. http://www.winthrop.org/diagnostic-technology-techniques
15. http://www.ttsglobalinitiative.com/newsletter/clinical-diagnostic-technologies- face-new-obstacles/

COURSE OUTCOMES:

Students who undergo the course will be able to:

- Prepare various solutions required for diagnostic procedures in laboratories.
- Conduct immunological tests towards diagnosis of various clinical conditions.
- Handle histopathology-based disease diagnosis.
- Learn various serology & molecular based diagnostic tests; exposures to automation part of diagnostic laboratories.
- Understand the management of biomedical waste and disposing mechanisms.

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First Year **CORE COURSE III** **Semester II**

MICROBIAL PHYSIOLOGY AND METABOLISMS

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To provide the learners a strong base of bacterial cell physiology so as to impart them with the principal knowledge of functions of bacterial organelles.
- To describe the anabolic and catabolic sections of metabolism deeply.
- To impart the knowledge of extremophilic organisms and their merits.
- To understand metabolic processes of energy substrates.
- To teach unique physiological features like methanogenesis, bioluminescences and quorum sensing.

UNIT - I BACTERIAL CELL STRUCTURE AND FUNCTION:

Ultrastructure of and differences between Prokaryotic and Eukaryotic cells – Exopolysaccharides, cytoplasmic membrane, Capsules, pili, fimbriae, Slime layer of prokaryotes. Bacterial cell wall - Biosynthesis of peptidoglycan - outer membrane, teichoic acid. Electron carriers – artificial electron donors – inhibitors uncouplers – energy bond – phosphorylation.

UNIT - II MICROBIAL NUTRIENTS AND GROWTH:

Common nutrient requirements, Growth factors - nutritional groups/ types - Bacterial growth - Phases of growth curve – measurement of growth – calculations of growth rate – generation time – synchronous growth – induction of synchronous growth, synchrony index – factors influencing growth – Uptake of nutrients by the cell – Facilitated diffusion – Active transport – Group translocation, Iron uptake - Pinocytosis and Phagocytosis. Survival at extreme environments – starvation – Extremophiles: adaptative mechanisms in thermophilic, alkalophilic, osmophilic and psychrophilic organisms.

UNIT - III PHOTOTROPHY AND CHEMOLITHOTROPHY:

Autotrophs - photosynthetic bacteria and green algae – heterotrophs – bacteria, fungi, myxotrophs. Photosynthetic and accessory pigments: Chlorophyll, bacteriochlorophyll, carotenoids, phycobilliproteins, fluorescence, phosphorescence, rhodopsin, Oxygenic and anoxygenic Photosynthesis– Autotrophic generation of ATP. Fixation of CO_2. – C3, C4 pathways. Chemolithotrophy – Sulphur, Iron, Hydrogen, Nitrogen oxidations. Physiology and regulation - methanogenesis, bioluminescences and quorum sensing.

UNIT - IV CARBOHYDRATE METABOLISM AND FERMENTATION:

Glycolytic pathways – Embden – Meyerhoff pathway - the pentose phosphate pathway – the Entner Douderoff pathway – the tricarboxylic acid cycle –

glyoxyate cycle. Electron Transport Chain. Substrate level phosphorylation – Oxidative phosphorylation & ATP synthesis – reverse TCA cycle – gluconeogenesis – lipid catabolism – beta oxidation. Anaerobic respiration – sulfur compounds – nitrate and carbon dioxide as electron acceptors. Homo and heterolactic acid fermentations. Fermentation by *Ruminococcus albus*

UNIT - V NITROGEN METABOLISM & BACTERIAL SPORULATION:

Biological nitrogen fixation – nitrogenase enzymes – structure and properties – '*nif*' gene – regulation – functions. Assimilation of inorganic nitrogen –nitrate, nitrite – dinitrogen – ammonia. Cell division – endospore – structure – properties – germination. Microbial sporulation and morphogenesis: Bacteria including cyanobacteria and actinobacteria, fungi and algae.

UNIT – VI CURRENT CONTOUR (For Continuous Internal Assessment Only):

Chart preparation showing bacterial cell structure and functions of each part, biochemical pathways of Phototrophy and chemolithotrophy, Carbohydrate metabolism and Fermentation, and Nitrogen metabolism & bacterial sporulation - preparation of a biofertilizer using any one nitrogen fixing organism and a locally available carrier material - Quiz classes - short seminar presentations on the prepared charts.

REFERENCES:

1. Harley JP and Klein DA. Microbiology. Latest edition, (2013). Prescott LM,. McGraw Hill, New York.
2. Byung Hong Kim & Geoffrey Michael Gadd. (2016) Microbial physiology and metabolism
3. Moat. A.G. and Foster. J.W. (2017). Microbial Physiology, John Wily sons. White J.D. Motteshead. D.W. Harrison S.J. Enivronmental system.
4. Stainier R.Y. Ingraham, J.L. Wheolis, H.H. and Painter. P,R. 1986. Microbiology.
5. Lehninger (2017) Principles of Biochemistry: International Edition
6. David White, James Drummond, and Clay Fuqua, (2011) The Physiology and Biochemistry of Prokaryotes. 4 th Edition, Oxford University Press
7. Michael M. Madigan, Kelly S. Bender, Daniel H. Buckley, W Matthew Sattley, David A. Stahl, (2017) Brock Biology of Microorganisms, 15th edition,. Published by Pearson
8. Caldwell DR. (1995) Microbial Physiology and metabolism, Wm. C. Brown Publishers, USA.
9. Rajan S and Selvichristy. (2019). Exam Oriented Biochemistry. CBS Publishers, New Delhi.
10. Lansing M. Prescott, John P. Harley and Donald A. Klein. (2003) Microbiology.5th edition. McGraw-Hill Company, New York.
11. Pelczar Jr MJ, Chan ECS and Kreig NR. (2013) Microbiology, 5th edition. Mc. Graw Hill. Inc, New York.

12. Kenneth P. Murphy (2001) Protein Structure, Stability and Folding. Published by Humana Press Inc.
13. Salle AJ. (1996) Fundamental principles of Bacteriology, 7th edition. Tata McGraw-Hill publishing company limited, New Delhi.
14. White D. The physiology and biochemistry of Prokaryotes, Oxford University Press, Oxford, New York. 1995.
15. Robert Poole K. (2007). Advances in Microbial Physiology, Volume 53, Elsevier Science and Technology.
16. https://www.academia.edu/35258859/Microbial_Physiology_4th_Edition_A_ G Moat J W oster and M P Spector pdf
17. https://dl.icdst.org/pdfs/files3/0bc9d88695de86f1fbad48fe3fccffc9.pdf
18. file:///C:/Users/Admin/Downloads/microbial-trishul-sci-gu-edu-au.pdf
19. https://fccljohnson.files.wordpress.com/2012/10/kim-and-gadd-bacterial- physiology-and-metabolism-b-h-kim-g-m-gadd-cambridge-university-press- 2008.pdf.

COURSE OUTCOMES:

Students who undergo the course will be able to:

- Understand the functional principles of various bacterial cell structures
- Assimilate the mechanism of bacterial cell wall synthesis.
- Differentiate the types of energy generating mechanisms among prokaryotes.
- Understand the microbial adaptation on chemical-ecological processes.
- Clearly understand carbohydrate and nitrogen metabolisms.

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First Year **CORE COURSE IV** **Semester II**

MEDICAL MICROBIOLOGY

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To make the students understand various attributes which make the microbes pathogenic or disease-causing, the emergence of newer pathogens with relevance to India and various routes of local or global spread.
- To learn the mechanisms of resistance of bacteria to antibiotics and role of newer vaccines in controlling infectious diseases.
- To describe the molecular diagnostic methods and automated equipments used for diagnosis of diseases caused by microorganisms.
- To understand the common infections and diseases of medical importance, their microbial causes and pathogenic action.
- To understand the fungal and protozoan diseases and their preventive measures

UNIT - I INTRODUCTION TO MEDICAL MICROBIOLOGY:

Significance of Microbiology in Medicine. Koch Postulates and Molecular Koch's postulates - Classification of medically important microbes - Normal microbial flora of the human body-Host bacterial interactions – Transmission, attachment, entry mechanisms, microbial pathogenicity. Virulence factors of bacteria. Quantitative measures of pathogenicity: minimal lethal dose (MLD), LD50, ID50, TCID50. Nosocomial and community acquired infections - investigation of epidemic diseases. Type three secretion system (TTSS, T3SS), Role of biofilms and quorum sensing in microbial pathogenicity.

UNIT - II MEDICAL BACTERIOLOGY:

Morphological, cultural and biochemical characteristics of and epidemiology, pathogenesis, lab diagnosis, prophylaxis and control of medically important diseases caused by*: Staphylococcus aureus, Streptococcus pyogenes*, *Corynebacterium diphtheriae, Clostridium tetani, Bacillus anthracis, Leptospira interrogans, Treponema pallidum, Mycobacterium tuberculosis, Escherichia coli, Vibrio cholerae, Niesserriae, Haemophilus influenza, Helicobacter pylori, Pseudomonas* and *Salmonella.* Zoonotic bacterial pathogens, Antibiotic susceptibility test: Kirby – Bauer disk diffusion method. General methods ofBacterial diagnosis.

UNIT - III MEDICAL MYCOLOGY:

Morphological and cultural characteristics of and epidemiology, mechanism of fungal pathogenesis, lab diagnosis and treatment of medically important diseases caused by*:* Superficial mycosis – *Tinea versicolor*. Cutaneous mycoses: *Microsporum*, *Trichophyton*, *Epidermophyton*. Subcutaneous mycoses: Sporotrichosis, Chromoblastomycosis, Zygomycosis. Systemic Mycoses – *Histoplasma*

capsulatum, *Blastomyces dermatitidis*, *Cryptococcus neoformans*, *Coccidioides immitis*, *Paracoccidioides brasiliensis*. Opportunistic mycoses: Candidiasis, Cryptococcosis and Aspergillosis. Antifungal susceptibility testing.

UNIT - IV MEDICAL VIROLOGY:

General properties of and epidemiology, pathogenesis, lab diagnosis and treatment of medically important viral diseases - Influenza, Measles, Mumps, Rubella, monkey pox, Chicken Pox, Poliomyelitis, HIV, Rabies, Yellow fever, Dengue, Covid-19 and Japanese Encephalitis. Brief note on oncogenic viruses. Emerging viral diseases - Antiviral drugs, antiviral vaccines.

UNIT - V MEDICAL PARASITOLOGY AND EMERGENCE OF ANTIBIOTIC RESISTANT PATHOGENS:

Morphology of, and pathogenesis, laboratory diagnosis and treatment of medically important protozoan diseases caused by: *Entomoeba histolytica, Giardia lamblia, Trichmonas vaginalis*, *Plasmodium vivax*, *Leishmania donovani*, *Taenia solium, Ascaris lumbricoides, Ancyclostoma duodenale* and *Wuchereria bancrofti.* Diagnosis of parasitic infection using clinical samples. Role of Nucleic acid probes in diagnostic microbiology.

UNIT – VI CURRENT CONTOUR (For Continuous Internal Assessment Only):

Survey of dermatophytic infections in student's communities. Analysis of worm infections in animal and human stool samples. Daily news and research paper collection and recording of recent outbreak of bacterial, fungal, viral, protozoan diseases. Universal Immunization Programme (UIP) and IAP. Making awareness and celebration of world AIDS day, World TB, cancer Day, Pulse polio immunization day etc., awareness programme on personal hygiene and vaccination.

REFERENCES:

1. Aejaz Iqbal and Zafar Nowshad. 2020. Medical Microbiology: Millennium Edition. Notion Press
2. Jawetz, Melnick, &Adelberg's. 2016. Medical Microbiology by Carroll KC, Hobdon JA, Miller S, Morse SA, Mietzner TA. 27th edition. Lange Publication.
3. Wilson BA, Salyers AA, Whitt DD, Winkler ME. 2011. Bacterial Pathogenesis: A molecular approach. 3rd edition. American Society for Microbiology Press, Washington, DC USA.
4. Locht C, Simonet M, Caister. 2012. Bacterial Pathogenesis: Molecular and Cellular Mechanisms by Academic Press,
5. Persing DH, Tenover FC, Hayden R, Leven M, Miller MB, Nolte FS, Tang YW, Belkum AAV. 2016. Molecular Microbiology: Diagnostic Principles and Practice, 3rd edition. Washington, American Society for Microbiology Press.
6. David Greenwood. Mike Barer, Richard Slack and Will Irving. 2012.

Medical Microbiology. A Guide to Microbial Infections: Pathogenesis, immunity, Laboratory investigation and Control, 18th edition, Churchill Livingstone.
7. Parija SC. 2004. Text book of Medical Parasitology, 1st Ed. All India publishers and Distributors Regd. 920. Poonamallee High Road, Madras.
8. Rajan S and Selvichristy J. 2018. Essentials of Microbiology, CBS Publishers, New Delhi.
9. Prescott, Harley and Klein's. 2007. Microbiology, 7th edition McGraw Hill Medical Publication division.
10. Rajan S. 2007. Medical Microbiology, MJP Publishers Chennai. 2007.
11. Topley and Wilsons. Principles of Bacteriology, Virology and Immunology. Edward Arnold, London. 1995.
12. Kenneth j. Ryan, C. George Ray. 2014. Sherris Medical Microbiology, 4th edition. McGraw-Hill Medical Publishing Division. New York.
13. https://www.aspergillus.org.uk/mycology-courses?page=5
14. https://www.mooc-list.com/tags/human-parasitology
15. https://www.mooc-list.com/tags/tropical-parasitology

COURSE OUTCOMES:

Upon successful completion of the course, the student will be able:

- Understand classical and molecular determinants of disease-causing microbes
- Describe the characteristics of newer disease-causing bacteria and viruses
- Operate and critique the various molecular tools available to work on the molecular epidemiology of disease-causing microorganisms
- Evaluate mechanisms underlying resistance of bacteria to antibiotics, spread of resistance and the use of newer vaccines to control infectious diseases
- Understand how the infectious diseases are diagnosed using newer diagnostic tools and what automated equipments are available for use in diagnostic microbiology laboratories

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First Year **CORE CHOICE COURSE II** **Semester II**

1. BIOINFORMATICS AND BIOSTATISTICS

Code **(Theory)** **Credit 5**

COURSE OBJECTIVE:

- To develop an expertise in biological website.
- To gain insights about computer-based technology for the study of biological molecules.
- To equip with statistical skills as to solve biological problems.
- To know about protein sequencing, nucleic acid sequencing methods and their analyses.
- To find proteins and their interaction, activity, modification and function.

UNIT - I BIOLOGY AND COMPUTER:

Basics of computers –types, servers, operating systems, UNIX, Linux. Finding scientific articles – PubMed – Public Biological databases, search engines. - Applications of Bioinformatics field of biology and medicine.

UNIT - II GENOMICS:

Biological databases NCBI, EMBL, DDBJ – sequencing genomes - sequence assembly- pairwise sequence comparison - BLAST and FASTA. Multiple sequence alignments, Phylogenetic alignment – Phylip – profiles and motifs – annotating and analysis of genome sequences – sequence queries against biological databases.

UNIT - III PROTEOMICS:

Protein Data Bank, Swiss- prot – PIR, SCOP, CATH – predicting protein structure and function from sequences - secondary structure prediction – Chou Fassman, GOR method -predicting 3 D structure - protein modeling, abinitio - visualization tool RASMOL.

UNIT – IV BIOSTATISTICS I. DATA AND DESCRIPTIVE STATISTICS:

Introduction – Population and sample – Variables – Collection and presentation of data – Descriptive statistics - Measures of Central tendency – Mean (arithmetic, harmonic and geometric) Median and Mode – Measures of dispersion – range, mean deviation, variance and standard deviation. Skewness and kurtosis.

UNIT – V BIOSTATISTICS II. PROBABILITY AND VARIANCE TESTING:

Inferential statistics – Probability and distributions – Poisson, Binomial and Normal distribution – Chi square test – Hypothesis test - Student's t-test – Correlation and Regression – ANOVA.

UNIT – VI CURRENT CONTOUR (For Continuous Internal Assessment Only):

Literature seminar on bioinformatics and biostatistics. Learn on how the application of computers, make ease of these two courses with the advancement. Give a work to the students to know about best statistical software and bioinformatics databases and tools available. Demonstration of various software available with the institute.

REFERENCES:

1. Ewens WJ, Gregory Grant. Statistical Methods in Bioinformatics: An Introduction (Statistics for Biology and Health), Springer. 2013.
2. Chavali LN. Bioinformatics and Bioprogramming in C, Universities Press, (India) Pvt. Ltd, Hyderabad, India. 2009.
3. Ruchi Singh and Richa Sharma. Bioinformatics: Basics, algorithms and applications, Universities Press, (India) Pvt. Ltd, Hyderabad, India. 2010.
4. molecBryan Bergeron. Bioinformatics Computing First Indian Edition, Prentice Hall.2003.
5. Rashidi HH and Buehler LK. Bioinformatics Basics: Applications in Biological Science and Medicine, Second Edition CRC Press, London. 2005.
6. Des Higgins and Willie Taylor Bioinformatics: Sequence, structure and databanks, Oxford University Press (2002).
7. Baxevanis AD and Ouellette BEF, Bioinformatics: A practical guide to the analysis of genes and proteins, First Edition Wiley Interscience – New York (2001)
8. Arora PN and Malhon PK Biostatistics Himalaya Publishing House, Mumbai (2008).
9. Pranabkumar Banerjee Introduction to Biostatistics, S.chand and company Ltd., (2007).
10. www.bioinformaticssoftwareandtools.co.in.
11. www.bioinformaticsweb.net/datalink.html.
12. Evolution.genetics.washington.edu/phylip.html.

COURSE OUTCOME:

After completion of the course, the students will be able to:

- Know the theory behind fundamental bioinformatics.
- Analyze protein and nucleotide sequences.
- Know concepts of probability and statistics.
- Assess biological results statistically and understand the significance ofexperimental data.
- Know the applications and limitations of bioinformatics methods.

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First Year **CORE CHOICE COURSE II** **Semester II**

2) PHARMACEUTICAL MICROBIOLOGY

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To provide the basics of antimicrobials with special reference to antibiotics and antifungals.
- To present antimicrobials' assessment procedures along with sterilization, sterility testing of various pharmaceutical products.
- To impart production and quality control of prophylactic compounds.
- To teach methods of controlling pharma products microbial contamination and role of cell culture in pharmacy.
- To bring an awareness about antimicrobial resistance.

UNIT - I ANTIMICROBIALS, TYPES AND ACTION MECHANISMS:

Antibiotics-Natural and synthetic - antifungal agents, Peptide antibiotics, Chloramphenicol, Sulphonamides and Quinolinone antimicrobial agents. Chemical disinfectants, antiseptics and preservatives - Laboratory evaluation of antimicrobial agents - Mechanism of action of antibiotics and synthetic anti-infective agents - Clinical uses of antimicrobial drugs.

UNIT - II DRUG DELIVERY AND DELIVERY SYSTEMS:

Molecular principles of drug targeting. Drug delivery system in gene therapy- Bacterial resistance to antibiotics. Mode of action of non-antibiotic antimicrobial agents. Delivery systems – formulations, targeted drug delivery, Sustained release of drugs. Drug distribution in body, bio-availability and pharmacokinetic studies.

UNIT - III PHARMA PRODUCTS, PROCEDURE, NOVEL VACCINE TECHNOLOGY

Microbial contamination and spoilage of pharmaceutical products – infection risk and contamination control - and their sterilization. Manufacturing procedures, in-process control of pharmaceuticals. Chemical disinfectants, antiseptics and preservatives- Other pharmaceuticals produced by microbial fermentations. New vaccine technology, DNA, synthetic peptide, multivalent subunit vaccines.

UNIT - IV ANTIMICROBIAL BIOASSAY AND ANTIMICROBIAL TESTING:

Bioassay of antibacterial agents in liquid media and in agar media using CLSI (NCCLS) guidelines - Factors affecting bioassay, Laboratory methods to assess activity of antimicrobial combinations (antagonism, synergism and additive effect). Methodologies for testing of antimycobacterial, antifungal, antiparasitic and antiviral drugs *(in vivo* and *in vitro* infectivity models). Application of cell cultures in pharmaceutical industry and research.

UNIT - V QUALITY CONTROL AND CLINICAL STUDIES:

Government regulatory practices and policies, Sterilization control and sterility testing- Chemical and biological indicators. Regulatory authorities for introduction of medicines in market – Role of Food and Drug Administration, FDA guidelines for drugs / biologicals, Validation of GMP, GLP & GCP. Clinical studies: Phase I, phase II, phase III and phase IV of clinical trials –Objectives, Conduct of trials, Outcome of trials.

UNIT – VI CURRENT CONTOUR (For Continuous Internal Assessment Only):

A visit to a pharmaceutical industry / pharmacy institution - assignments submission on various topics of the pharmaceutical microbiology - Quiz classes - short seminar presentations after a visit – debates on GMPs, GLPs and clinical trials – discussion of previous year question papers.

REFERENCES:

1. Vyas SP and Dixit VK (2010). Pharmaceutical Biotechnology, CBS Publishers &Distributors, New Delhi.
2. Joseph D Nally (2016). Good Manufacturing Practices for Pharmaceuticals, CRC Press, 6thedn.
3. Stephen P Denyer, Norman A Hodges, Sean P Gorman, Brendan F Gilmore (2011). Hugo and Russell's Pharmaceutical Microbiology, John Wiley and Sons, 8thedn.
4. Chakrabarty AM, Omenn and Gilbert S (1990). Biopharmaceuticals in Transition: Advances in Applied Biotechnology, Portfolio publisher, Vol. 10.
5. Hill RG (2012). Drug Discovery and Development-E-Book: Technology in Transition, Elsevier Health Sciences.
6. Tille P (2015). Bailey & Scott's Diagnostic Microbiology-E-Book, Elsevier Health Sciences.
7. Kim SK (2012). Marine pharmacognosy: Trends and applications, CRC Press.
8. Denyer S, Russell A (2004). Non-Antibiotic Antibacterial Agents: Mode of Action and Resistance, Hugo and Russell's: Pharmaceutical Microbiology, 7thEdn, 306-22.
9. Denyer SP, Hodges NA and Gorman SP eds., (2008). Hugo and Russell's pharmaceutical microbiology, John Wiley & Sons.
10. Zhang R *et al.*, (2018). Mxra8 is a receptor for multiple arthritogenic alphaviruses, *Nature* DOI: 10.1038/s41586-018-0121-3
11. https://medicine.wustl.edu/news/why-chikungunya-other-arthritis-causing-viruses-target-the-joints/
12. https://www.news-medical.net/news/20180511/Addressing-Antimicrobial-Resistance-Through-Industry.aspx
13. https://www.eurekalert.org/pub_releases/2018-05/uon-nlb050918.php
14. https://pubs.acs.org/stoken/presspac/presspac/full/10.1021/acsami.8b04433
15. https://www.cell.com/cell-host-microbe/fulltext/S1931-3128(18)30198-7

COURSE OUTCOMES:

Students who undergo the course will be able to:

- Know how to evaluate a new drug for its antimicrobial property in the laboratory
- Perform standard sterility testing procedures of pharmaceutical products.
- Prepare and control the quality of pharmaceutical products representing various categories.
- Understand the contaminants & spoilage of pharmaceutical products & their prevention.
- Recognize the importance of good manufacturing, laboratory & clinical practices as well as the role of animal cell culture in pharmacy industries.

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First Year **CORE PRACTICAL II** **Semester II**

MICROBIAL PHYSIOLOGY AND METABOLISH & MEDICAL MICROBIOLOGY

Code **(Practical)** **Credit 3**

MICROBIAL PHYSIOLOGY AND METABOLISM

COURSE OBJECTIVES:

- To provide hands-on practice on microbial physiology and metabolism-based experiments so as to enlighten the learners on the fundamental principles of the course.
- To impart skills required for estimating protein & nucleic acids
- To study the microbial growth influencing factors.
- To understand the colorimetric estimating principles of biological molecules.
- To practice the students on the cultivation methods of anaerobic microbes

EXPERIMENTS:

1. Colorimetric estimation of Protein (Biuret method/Lowry et. al. method)
2. Colorimetric estimation of amino acid (Ninhydrin method)
3. Colorimetric estimation of DNA (Diphenylamine method), RNA (Orcinol method)
4. Carbohydrate fermentation tests: Glucose, Lactose, Sucrose and Mannitol.
5. Biochemical test to identify bacterial isolates - IMViC test, Oxidase test, Catalase test, Urease test, Hydrogen sulphide, coagulase, TSI test, Nitrate reduction test
6. Enzymatic hydrolysis of Starch, Gelatin, Casein & lipid.
7. Bacterial Growth curve: Cell count/viable count/absorbance (total count)
8. Measurement of Microbial growth –Turbidity methods – Determination of Generation time, Neubaur Counting chamber.
9. Studying the influence of osmotic pressure, pH, temperature, moisture, radiations, different chemicals, carbon and nitrogen sources.
10. Anaerobic cultivation- candle jar, gas pack method. Wrights tube – Mclntosh and Fildes' jar

REFERENCES:

1. Aneja KR (2017). Experiments in Microbiology, Plantpathology and Biotechnology. 5th Edition, New Age International Publishers, Chennai.
2. Dubey RC and Maheswari DK (2012). Practical Microbiology 3rd Edition, S. Chand & Company Ltd., New Delhi.
3. Kannan N (2003). Handbook of Laboratory Culture Media, Reagents, Stains and Buffers. Panima Publishing Corporation,New Delhi.
4. Rajan S and Selvi Christy R.2018. Experimental Procedures in Life

Sciences. CBS Publishers, New delhii
5. Sundararaj T. Microbiology laboratory manual. Revised and published by AswathySundararaj.No.5 First Cross Street, Thirumalai Nagar, Perungudi, Chennai.
6. https://www.frontiersin.org/books/Microbial_Physiology_and_Metabolism
7. https://onlinelibrary.wiley.com/doi/book/10.1002/0471223867COURSE OUTCOMES:

Students who undergo the course will be able to:

- Independently estimate concentrations of amino acid, protein or carbohydrate of a sample.
- Test & determine sugar fermenting/ utilizing abilities of different bacterial species.
- Determine growth stages of a test bacterial species.
- Evaluate the impact of various external components which would affector effect microbial growth.
- Cultivate anaerobic bacteria and thus will be able to growsuch organisms.

MEDICAL MICROBIOLOGY

COURSE OBJECTIVES:

- To provide hands- on training as to identify bacteria, fungi, protozoa and helminths from clinical specimens.
- To provide the knowledge of clinical specimens' collection and methods of scrutinization.
- To educate diagnostic and public health microbiology and to expose to the modern techniques employed to identify pathogens in diagnostic laboratories.
- To train on the usage of various instruments.
- To ensure a familiarity with all conventional methods of microbial identification.

EXPERIMENTS:

1. Collection, coding and transport of clinical specimens for microbiological examinations.
2. Isolation and identification of *Streptococcus pyogenes* from throat swab.
3. Isolation and identification of *Staphylococcus aureus* from pus.
4. Isolation and identification *of Klebsiella pneumoniae* from sputum.
5. Isolation and identification of *Salmonella* and *Shigella* from stool.
6. Isolation and identification of *E. coli* from urine.
7. Antibiotic susceptibility test – Disc diffusion method (Kirby –Bauer).
8. Determination of MIC of any one antibiotic against any one bacterial species.
9. Laboratory diagnosis of dermatophytic diseases- Wood lamp examination and culture and identification of dermatophytes – KOH

Mount, LPCB staining and other related tests.

10. Identification of *Candida albicans* – Microscopy (LPCB stain), culturing, germ tube technique.
11. Identification of *Cryptococcus neoformans* – Negative staining (India Ink), culturing.
12. Laboratory diagnosis of intestinal protozoan and helminthic infections – Direct examination and concentration of stool – Saline and Iodine wet mount to detect cysts, trophozoites and eggs.
13. Examination of blood for protozoa and helminths (malaria, filaria) by wet mount, thin and thick stained smears (Giemsa, Wrights or Leishman's staining)

Note: Identification of bacteria should be done using microscopic methods, culturing on selective cum differential media and biochemical tests (Indole, Methyl Red, Voges Proskauer, Citrate utilization, TSI, Urease, Nitrate, Catalase, Oxidase Carbohydrate fermentation tests, Sensitivity test for gram positive organisms, Hippurate hydrolysis, Coagulase test, Salt tolerance test, Bile solubility etc.,

REFERENCES:

1. Monica Cheesbrough 2006. District Laboratory Practice in Tropical Countries - Part I and II 2nd edition. Cambridge University Press, New Delhi.
2. Rajan S. 2012. Manual for Medical Laboratory Technology. Anajanaa Book House, Chennai.
3. Betty A Forbes, Daniel F Sahm and Alice S Weissfeld. 2007. Bailey and Scott's Diagnostic Microbiology, Mosby Elsevier. 12th edition.
4. Mackie and McCartney. 2006. Practical Medical Microbiology, South Asia Edition. 14th edition.
5. Rajan S and Selvi Christy R. 2018. Experimental Procedures in Life Sciences. CBS Publishers, New Delhi.

COURSE OUTCOME:

After completion of this course the student can:

- Describe the collection and transportation of clinical specimens and diagnosis of various important infections.
- Learn all the identification methods of bacterial pathogens.
- Understand the laboratory diagnosis of all system-based diseases.
- Learn the diagnostic techniques of fungal and parasitic diseases.
- Understand all biochemical tests and the process of antibiotic sensitivity assay.

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First Year **ELECTIVE COURSE II** **Semester II**

1) MARINE MICROBIOLOGY

Code: **(Theory)** **Credit: 4**

COURSE OBJECTIVES:

- To explain the basic concepts of Marine Microbiology and to differentiate various marine groups of microbes
- To understand microbial diversity of the marine environment.
- To understand various biotechnological applications of marine microbiology, marine extremophiles and Bioremediation.
- To learn about the significance and dynamics of marine environment
- To provide a detailed knowledge about marine microbial products and theirimportance.

UNIT - I MARINE MICROBIAL HABITATS AND DIVERSITY:

Marine environment–properties of seawater, chemical and physical factors of marine environment-Ecology of coastal, shallow and deep-sea microorganism - significance of marine microflora. Diversity of microorganism - Archaea, bacteria, actinobacteria, cyanobacteria, algae, fungi, viruses and protozoa in the mangroves and coral environments - Microbial endosymbionts – epiphytes - coral-microbial association, sponge-microbial association.

UNIT - II CULTIVATION OF MARINE MICROBES AND NUTRIENT CYCLING:

Methods of studying marine microorganisms- sample collection- isolation and identification: Cultural, Morphological, physiological, biochemical and Molecular characteristics- Preservation methods of marine microbes. Role of microorganisms in carbon, nitrogen, phosphorous and sulphur cycles in the sea under different environments and mangroves.

UNIT - III MARINE EXTREMOPHILES AND BIOREMEDIATION:

Survival at extreme environments – starvation – adaptive mechanisms in thermophilic, alkalophilic, osmophilic and barophilic, psychrophilic microorganisms – hyperthermophiles, halophiles and their importance. Microbialconsortia and genetically engineered microbes in bioremediation of polluted marine sites - heavy metals and crude oil. Biofouling and their control. bio- corrosion

UNIT - IV SEAFOOD MICROBIOLOGY:

Pathogenic microorganisms, distribution, indicator organisms, prevention and control of water pollution, quality standards, International and National standards. Microbiology of processed finfish and shellfish products. Rapid diagnosis of contamination in seafoods and aquaculture products.

UNIT - V MARINE MICROBIAL PRODUCTS:

Marine microbial products-Carrageenan, agar-agar, sea weed fertilizers-Astaxanthin, β-carotene-enzyme-antibiotics-antitumour agents-

polysaccharide- biosurfactants and pigments. Preservation methods of sea foods. Quality control and regulations for microbial quality of fishes, shellfish and Marine living resources used for food and drugs.

UNIT – VI CURRENT CONTOUR (For Continuous Internal Assessment Only):

Give a seminar topic related to oceans and the threats they face in recent days. Field trip visit to aquatic and marine ecosystem – Learn about Internationally important marine related Research stations and centres and works going on their places including Idea. To learn about some international and national rules and norms for marine environment protection.

REFERENCES:

1. Bhakuni DS and Rawat DS. Bioactive marine natural products. Anamaya Publishers, New Delhi. 2005.
2. Hunter-Cevera J, Karl D and Buckley M. Marine Microbial Diversity: the key to Earth's habitability, American Academy of Microbiology. 2005.
3. Jamesh W. Nybakker Marine Biology, Benjamin Cummings. 2001.
4. Krichman DL. Microbial ecology of the oceans. Wiley – liss, New York. 2000.
5. Munn C. Marine Microbiology: ecology and applications, Garland Science, Taylor and Francis group, NY. 2011.
6. Raina M. Maier, Ian L. Pepper, Charles, P. Gerba Environmental Microbiology, Academic press. 2006.
7. Shimshon Belkin and Rita R Colwell Ocean and Health: Pathogens in the marine environment. Springer. 2005.
8. https://www.worldcat.org/title/marine-microbiology-ecology-and-applications/oclc/59224413
9. https://www.ncbi.nlm.nih.gov/books/NBK559439/
10. https://www.researchgate.net/publication/265413799_A_BOOK_ON_MARI NE_MICROBIOLOGY.

COURSE OUTCOME:

After successful completion of the course, the students will learn:

- How the marine microbes play an important role in the earth system.
- The details of marine diversity, organisms, sea food and its importance, microbial marine products.
- Apply the principles of marine microbiology to understand the biological phenomena occurring in marine environments.
- The current problems and importance of marine eco system.
- Realize and counteract the marine pollution, the control measures, bio-corrosion and bioremediation

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First Year **ELECTIVE COURSE II** **Semester II**

2) MICROBIAL BIOTECHNOLOGY

Code: **(Theory)** **Credit: 4**

COURSE OBJECTIVES:

- This course summarizes the role of microorganisms and their scope in the diverse processes of microbial biotechnology.
- To transpire a knowledge about production of pharmaceuticals.
- To portray about microbial biopolymers.
- To impart the potential applications of microbial and molecular biotechnology in medicine, agriculture and various other current industrial processes.
- Enable the students to become familiar with potential application of PGPR

UNIT – I MICROBIAL PRODUCTION OF THERAPEUTIC AGENTS AND VACCINES:

History – Microbial vs molecular biotechnology and Commercialization – concerns and consequences - Pharmaceuticals - interferons and growth hormones, enzymes: DNase I and alginate lyase, Monoclonal antibodies - HIV therapeutic agents. Subunit vaccines: Herpes simplex virus, Foot and mouth disease virus, TB, Peptide vaccines – genetic immunization – vector vaccines.

UNIT – II MICROBIAL PRODUCTION OF COMMERCIAL PRODUCTS:

Microbial production of restriction endonucleases: *Pst*I, Dye: Indigo, Antibiotics: Synthesis of Novel antibiotics. Biopolymers: Xanthan gum and PHA. Microbial production of alcohol, lactic acid, streptomycin, L- glutamic acid, lipase and riboflavin.

UNIT – III PRODUCTION OF PGPR, BIOFERTILIZERS AND BIOCONTROL AGENTS:

Plant growth promoting bacteria (PGPR) – genetic engineering of nitrogenase gene cluster, hydrogenase and Nodulation. Mass cultivation of microbial biofertilizers: Cyanobacteria (*Sprirulina*), *Azolla* and other nitrogen fixers (*Rhizobia, Azospirillum, Azotobacter* and AMF) Biocontrol of pathogens: Siderophores, antibiotics and enzymes. Release of genetically engineered organisms - Ice nucleation and anti-freeze proteins. Microbial herbicides. Microbial insecticides (*Pseudomonas* and *Bacillus thrungiensis*): - genetic engineering of Bt strains – Bt cotton – viral insecticides – entomopathogenic fungi.

UNIT – IV PLANT AND ALGAL BIOTECHNOLOGY AND BIOREMEDIATION:

Ti plasmid derived vector systems - Development of insect, virus and herbicide resistant plants, stress and senescence tolerant plants, modification of flower nutritional content, sweetening by genetic engineering. Plant as bioreactors. Production of food, colourant and fuel from microalgae.

UNIT – V ANIMAL BIOTECHNOLOGY AND IPR:

Transgenic animals: methods of creating transgenic mice, cattle and sheep. Human gene therapy – *in vivo* and *ex vivo* gene therapy. Molecular diagnostics for genetic diseases. Biosafety and Bioethics. Intellectual Property Rights: Patents - copy right and neighboring rights, patents for invention, Drafting and

filing a patent application, exploitation of patented invention. Indian patent laws.

UNIT – VI CURRENT CONTOUR (For Continuous Internal Assessment Only):

Group discussion, quiz and seminar on recent advances in production PGPR, biofertilizers, recombinant bioinoculant for sustainable agriculture, biofuel.

REFERENCES:

1. GIick, B.R., Pasternak, J.J. 2003. Molecular Biotechnology – Principles and Applications of Recombinant DNA, ASM Press, Washington DC.
2. Winnacker, E.L. 2003. From Genes to Clones – Introduction to Gene Technology. First Indian reprint, PANIAMA publishing Co-operation, New Delhi. 2003.
3. Elsa Cooper. 2009. Microbial biotechnology. Syrawood Publishing House.
4. Padma Singh. 2009. Recent Trends in Microbial Biotechnology, CBS Publishers and Distributors.
5. Sandeep Gupta., Pawan Kumar B. 2016. Bioremediation and Microbial Biotechnology. Discovery Publishing House.
6. Swarna Latha, C. D., Bhaskara Rao, D. 2007. Microbial Biotechnology. Discovery Publishing House.
7. Ratul Saikia. 2008. Microbial Biotechnology. New India Publishing Agency.
8. Brown, T.A. 2001. Gene cloning and DNA analysis introduction, 4th edition, Blackwell Science Ltd, London.
9. Raledge, C., Kristiansen, B. 2001. Basic Biotechnology, 2nd edition, Cambridge University Press.
10. Puvanakrishnan, R., Sivasubramanian, S., Hemalatha,T. 2021. Microbial Techology, 1st edition. MJP publishers.
11. Borowitzka, M.A. Borowitzka, L.J. 1989. Microalgal Biotechnology, Cambridge University Press.
12. Glazer, A.N., Nikaido, H. 1994. Microbial Biotechnology – Fundamentals of Applied Microbiology, WH Freeman and Company, New York.
13. https://www.biotechnologynotes.com/industrial-biotechnology/anaerobic-fermentations/production-process-of-ethyl-alcohol-production-and-applications- anaerobic-fermentations/13723
14. https://archive.nptel.ac.in/courses/102/105/102105058/
15. https://www.biologydiscussion.com/biotechnology/microbial-polysaccharides-application-production-and-features/10412

COURSE OUTCOMES:

Subsequent to accomplishment of this course, the students would be able to:

- Receive a fundamental knowledge on therapeutic agents and vaccines
- Understand the microbial production of commercial products
- Acquire idea about the role of PGPR, biofertilizers and biocontrol agents
- Carry a knowledge on plant and algal biotechnology and bioremediation
- Impart ideas on animal biotechnology and IPR

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First Year **NON-MAJOR ELECTIVE COURSE I** **Semester II**

MEN AND MICROBES

Code: **(Theory)** **Credit: 2**

COURSE OBJECTIVES:

- To educate the developments in microbiology field and its essential components.
- To understand the environmental microbiology and human values.
- To realise the primary producers of functional and supportive systems.
- To get awareness on the beneficial & harmful attributes of microbes.
- To understand the microbial products' importance and their usage in day-to-day life.

UNIT - I GENERAL MICROBIOLOGY:

History of microbiology: Discovery Era and Transition Period; Historical development in the field of Microbiology; Golden Age of Microbiology, Era of Molecular Biology and Nobel Laureates in Microbiology. Evolution of microorganism. Classification of microorganism: Major Differential Features among Bacteria, Archaea and Eukarya. Modern Trends in Classification: Genome Comparison; RNA Finger Printing and Sequencing; DNA Sequencing; Microbial Phylogeny and Trees.

UNIT - II ENVIRONMENTAL MICROBIOLOGY:

Terrestrial environment: Porous media and microbial activities. Microorganisms in soils and air. Aquatic and extreme environments. Microbial transport. Biogeochemical cycles and consequences. Microorganisms with organic and metal pollutants. Bioremediation and waste management.

UNIT - III AGRICULTURAL MICROBIOLOGY:

Soil-plant-microorganism systems: Rhizosphere environments and populations dynamics. Organic compounds released by plant. Plant-microbe interactions: Biologically nutrient fixation, solubilization and mobilization. Plant-microbial symbiosis. Plant diseases caused by microbial pathogens and biological controlling agents.

UNIT - IV MEDICAL MICROBIOLOGY:

Microbiology and medicine. Infection and immunity. Microbial pathogens and associated diseases. Parasitic infections and medical entomology. Diagnosis, treatments and control of infections. Hospital infections and management. Emerging and re-emerging disease.

UNIT - V INDUSTRIAL MICROBIOLOGY:

Traditional practices in microbial products. Industrial fermentation and bioreactors. Microbial products (at least on example): Organic acids, solvents, polysaccharides, enzymes, vitamins, hormones, antibiotics, vaccines, alcoholic beverages, food productions and biofuels. Microbial products quality control and monitoring practices.

UNIT – VI CURRENT CONTOUR (For Continuous Internal Assessment Only):

Human microbiome projects and Earth microbiome projects. Microbes and immune regulations, gut microbiota and brain functions, metabolic disorders and dietary interventions. Microbiota in gastrointestinal issues.

REFERENCES:

1. Joanne Willey, Kathleen Sandman and Dorothy Wood, 2022.ISE Prescott's Microbiology, ISBN-13: 978-1265123031. Publisher: McGraw Hill; 12th edition.
2. Michael J. Pelczar, JR, E.C.S. Chang and Noel R.Krieg, 2019. Microbiology, ISBN: 9780175623907. Publisher: McGraw Hill.
3. Dr. Reba Kanungo, 2022.Ananthanarayan and Paniker's Textbook of Microbiology 12th edition, 2022.ISBN-13: 978-9393330017.Publisher: Universities Press (India) Pvt. Ltd.;
4. SastryApurba S and Bhat Sandhya, 2020. Essentials of Medical Microbiology: (Revised Edition), ISBN-13: 978-8194709015, Publisher: Jaypee Brothers Medical Publishers; Third edition.
5. Buckley, RG, 2019. Environmental Microbiology.ISBN-13: 978-8123928333, Publisher: CBS
6. Aneja.K.R, 2017. Fundamental Agricultural Microbiology, 2017. Publisher : NewAge International Private Limited, ISBN-13 : 978-9386070883
7. SubbaRao,NS, 2020. Agricultural Microbiology, 2020. ISBN-13 : 978-9388716956. Publisher : Medtech; 3rd edition
8. Michael J. Waites, Neil L. Morgan, John S. Rockey and Gary Higton, 2001. Industrial Microbiology: An Introduction, 2001. ISBN-13: 978-0632053070.Publisher : Wiley-Blackwell; 1st edition
9. https://www.omicsonline.org/open-access/application-of-bioremediation-on-solid- waste-management-a-review-2155-6199.1000248.pdf
10. https://www.sciencedirect.com/science/article/pii/B9780128203187000010
11. https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/rhizosphere
12. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3963198/#:~:text=Measures%20of%20infection%20control%20include,need%20to%20be%20emphasized%20upon.
13. https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/industrial-fermentation
14. https://www.sciencedirect.com/topics/engineering/industrial-fermentation

COURSE OUTCOMES:

Subsequent to accomplishment of this course, the students would be able to:

- Know the microbiological field developments and essential components.
- Understand the environment, microbiology & human values.
- Realise the primary producers' functional and supportive systems.
- Comprehend microbes beneficial & harmful attributes.
- Understand the microbial products' importance and their usage in day-to-day life.

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Second Year **CORE COURSE V** **Semester III**

MOLECULAR BIOLOGY AND MICROBIAL GENETICS

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- In addition to the most essential fundamentals of the subject, the paper aims to impart the current updated knowledge on molecular genetics of prokaryotes.
- Understand the Genetic replication and repair mechanisms
- Learn about gene transfer mechanisms and their importance in natural evolution
- To provide the required fundamental details on prokaryotic and eukaryotic molecular genetics.
- Explain the processes behind mutations and other genetic changes, identify and distinguish genetic regulatory mechanisms at different levels

UNIT – I GENETIC MATERIAL, DNA REPLICATION AND REPAIR:

Identification of genetic material (Griffith, Avery and Hershey and Chase experiments). Organization of genetic material: Bacteria – Eukaryotes: nucleus and nucleosomes, lamp brush and giant chromosomes. DNA replication - Meselson – Stahl experiment, Molecular mechanisms of DNA Replication – bidirectional and rolling circle replication. Differences between prokaryotic and eukaryotic replication. Pi X 174 replication. Plasmids – types, structure and replication. Inhibitors of DNA replication - DNA repair – mechanism of excision repair, SOS repair and mismatch repair.

UNIT – II TRANSCRIPTION AND TRANSLATION:

Process of transcription – initiation, elongation – termination. Synthesis of mRNA in prokaryotes and eukaryotes. RNA splicing. Synthesis of rRNA and tRNA. RNA processing – capping and polyadenylation. Inhibitors of transcription. Genetic code, process of translation – initiation, elongation and termination. Signal sequences and protein transport. Inhibitors of translation.

UNIT – III REGULATION OF GENE EXPRESSION:

Organization of Genes in Prokaryotes and Eukaryotes - Introduction - Operon concept, lac, trp, arabinose operons, promoters and repressors. Regulation of gene expression – Transcriptional control – promoters, terminators, attenuators and anti-terminators; Induction and repression; The *lac* operon – catabolite repression; *trp* operon, two component regulatory system. Translational control – ribosome binding, codon usage, antisense RNA; post-transcriptional gene silencing – RNAi.

UNIT – IV GENE TRANSFER AND GENETIC RECOMBINATION MECHANISMS:

Transformation – competence cells, regulation, general process; Transduction – general and specialized; Conjugation – Discovery, mechanism of F+ v/s F-, Hfr+ v/s F-, F' v/s F-, triparental mating, self-transmissible and mobilizable plasmids, pili. Linkage and genetic maps – genetic mapping of T4 phage. C- value paradox. Hardy Weinberg Equilibrium.

UNIT V MUTATION AND TRANSPOSABLE ELEMENTS:

Types and molecular basis of mutation– Agents of mutation - Importance of mutations in evolution of species. Discovery of insertion sequences, complex and compound transposons – T10, T5, and retroposon – Nomenclature- Insertion sequences – Mechanism – Transposons of E. coli, Bacteriophage and Yeast. Isolation, analysis and detection methods of Mutants. Uses of Mutants. Importance of transposable elements in horizontal transfer of genes and evolution. Mobile genetic Elements – IS elements.

UNIT VI: CURRENT CONTOURS (For continuous internal assessment only):

Discuss gene-therapy workflow from production to quality control - Quiz related to Covid 19 and its mutations and genetic structure-Round table chat section on Molecular computation strategy for classifying complex gene expression- splice Detector- Nanobot- motifs inside human cells, literature seminar on Genome editing technique in embryo- Open talk on - Biomedical tattoo, Disorder due to Mutation to the FGFR2 gene.

REFERENCES:

1. Friedberg EC, Walker GC, Siede W. DNA repair and mutagenesis. ASM press. 2005.
2. James D Watson, Tania A Baker, Stephen P Bell and Alexander Gann. Molecular Biology of the Gene, 5th edition. 2008.
3. Antony JF, Griffiths, Gilbert WM, Lewontin RC and Miller JH. Modern Genetic Analysis, Integrating Genes and Genomes, 2nd edition, WH. 2002.
4. Ajoy Paul. Text Book of Cell and Molecular Biology, Books and Allied (P) Ltd. Kolkata. 2007.
5. Gardner EJ, Simmons MJ, Snustad DP. Principles of Genetics. 8th edition. John Wiley and sons. 2008.
6. George M Malacinski. Freifelder's Essentials of Molecular Biology. 4th edition. Narosa Publishing House. 2008.
7. Stanly R Maloy, John E Cronan and David Freifelder Jr. Microbial Genetics. Narosa publishing house, New Delhi. 2nd edition. 2006.
8. Channarayappa A. Cell Biology, Universities Press, (India) Pvt. Ltd, Hyderabad, India. 2010.
9. 9. Channarayappa A. Molecular Biology, Universities Press, (India) Pvt. Ltd, Hyderabad, India. 2010.
10. http://www.dailymail.co.uk/sciencetech/article-4884760/DNA-nanobot- deliver-medicine-human-bloodstream.htm
11. https://cen.acs.org/biological-chemistry/genomics/DNAmotifs-found-human-cells/96/i1

COURSE OUTCOME:

After the successful completion of this course, the students would be able to:

- Explain the processes behind mutations and other gene transfer mechanism.
- Understand genetic regulatory mechanisms at different aspect.
- Describe mechanisms of transcription, translation and gene expression in detail.
- Investigate interesting biological problems with genetic relevance.
- Evaluate the current topics of microbial genetics and related fields.

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Second Year **CORE COURSE VI** **Semester III**

ENVIRONMENT AND AGRICULTURAL MICROBIOLOGY

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- This course aims to communicate the students with basic principles of microbiology and their applications to environment and agriculture.
- To explore the field of environmental microbiology by educating about microbes of soil, water and air.
- To prepare as to redress pressing environmental challenges by developing a fundamental understanding of the microbial communities and processes in natural and built-in environments.
- To study pathogens of drinking water
- To provide an in-depth exploration of the diverse role of microbes and microbial communities in each sector.

UNIT – I AEROMICROBIOLOGY:

Microbiology of air - Composition of air, Number and types of microorganisms in air. Distribution and sources of air borne organisms - Droplet and Droplet nuclei, Aerosol. Airborne diseases in Plants, animals and human beings. Methods for assessment of air borne microbes. Air sanitation - Physical and chemical methods.

UNIT – II MICROBIOLOGY OF WATER:

Fresh water and marine Environment - Different kinds of water body, Water pollutants, Physico-chemical properties of water. Aquatic microbiology - Sources of microorganisms in water, Microbial assessment of water. Aquatic biota in lake, ponds, river, estuary, mangrove and sea. Extremophiles –Thermophiles, mesophiles, psychrophiles, Deep Sea, Desert, Acidophilic, Alkalophilic and Halophilic microorganisms. Impact of environmental factors on the aquatic biota.

UNIT – III MANAGEMENT OF LIQUID AND SOLID WASTES:

Classification of wastes. Waste treatment - Types and characterization of liquid and solid wastes. Treatment of liquid wastes - Primary, secondary (anaerobic and aerobic) - trickling, activated sludge, oxidation pond, oxidation ditch-tertiary and disinfection. Treatment of solid wastes - composting, vermiform composting, silage, pyrolysis and saccharifications. Xenobiotic compounds and their degradation - Crude oil, hydrocarbons, pesticides and heavy metals. Bioleaching of copper and uranium. Biodegradation of natural substances - Cellulose, xylan, hemicellulose, starch, fructose, mannan, pectin and lignin.

UNIT – IV MICROBIOLOGY OF SOIL:

Soil microbiology: Distribution of microorganisms in soil, Factors influencing the soil microflora, Biogeochemical cycles: Carbon, Nitrogen, Phosphorus and Sulfur, Interactions among microorganisms: Mutualism, commensalism, ammensalism, synergism, parasitism, predation and competition. Interaction of microbes with plants: Rhizosphere, phyllosphere, mycorrhizae. Nitrogen fixation: Symbiotic and asymbiotic. Soil reclamation.

UNIT – V PLANT PATHOGENS AND ITS CONTROL:

Introduction to plant pathology - Bacterial, viral and fungal plant pathogens. Morphological, physiological changes with reference to disease establishment in plants. Role of insect Entomopathogenic nematodes, viruses, bacteria, fungi and protozoa in biocontrol and their

mode of action. Plant protection-phenolics – phytoalexins and related compounds. Disadvantages of chemical pesticides. Microbial pesticides- types, mechanisms, advantages and limitations. Brief conception of Integrated Pest Management (IPM), Integrated Pest and Disease Management (IDPM).

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Assignment shall be given based on the syllabus and seminar shall be given to students related to their assignment topics individually. A project shall be assigned in the topic of leguminous plants submission. Mini project in various recent research topics related to the subject shall also be given.

REFERENCES:

1. Borkar, S.G., 2015. Microbes as Bio-fertilizers and their Production Technology (Woodhead Publishing India in Agriculture), WPI Publishing, ISBN: 9380308574.
2. Subba Rao, N.S., 1995. Soil Microorganisms and plant growth, Oxford and IBH, New york.
3. Totawat, K.L., Somani, L.L., Sharma, R.A., Maloo, S.R., 2004. Biofertilizer Technology, Agrotech Publishing Academy. Udaipur, Rajasthan.
4. Subba Rao, N.S., 1995. Biofertilizer in agriculture and forestry, Oxford and IBH, New york.
5. Christon J Hurst, 2002. Manual of Environmental Microbiology. 2nd edition. American Society for Microbiology, Washington.
6. Clescri, L.S., Greenberg, A.E., Eaton, A.D., 1998. Standard Methods for Examination of Water and Waste Water, 20th Edition, American Public Health Association.
7. Dirk, J. Elasas, V., Trevors, J.T, Wellington, E.M.H., 1997. Modern Soil Microbiology, Marcel Dekker INC, New York, Hong Kong.
8. Duncan Mara, Nigel Horen, 2003. The Handbook of water and waste water Microbiology. Academic press-An imprint of Elsevier.
9. Gareth M. Evans, Judith C Furlong, 2003. Environmental Biotechnology-Theory and Application, John Wiley and sons Ltd.
10. http://ssu.ac.ir/cms/fileadmin/user_upload/Daneshkadaha/dbehdasht/behdasht_imani/book/Microbiology_Handbook__Dairy_Products.pdf
11. http://www6.zetatalk.com/docs/Soil/Principles_Of_Soil_Microbiology_Waksman_1927.pdf
12. http://www.textbooksonline.tn.nic.in/books/11/std11-microbio-em.pdf
13. http://site.iugaza.edu.ps/tbashiti/files/2010/02/Environmental_Microbiology.pdf
14. https://www.kobo.com/us/en/ebook/microbial-ecology-2
15. https://www.pdfdrive.com/principles-and-applications-of-soil-microbiology-d8264286.html

COURSE OUTCOMES:

After the successful completion of this course, the students would be able to:

- Know about the significance of the microbes in atmosphere and water.
- Get in-depth information about the harmful effects and beneficial role of microbes in each sector.
- Acquire in depth knowledge on water and waste water treatment to tackle the current environmental problems.
- Provide meticulous thoughts on the task of microbes in waste water treatment and solid waste management.
- Get in-depth information about exploitation of natural wastes by producing bioorganic fertilizers.

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Second Year **CORE CHOICE COURSE III** **Semester III**

1. BIOPROCESS TECHNOLOGY

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To educate the current technology employed to utilize the natural resources to produce microbial products.
- To impart with broad theoretical skills of industrial microbiology.
- To bring out the bio-resources, industrially important microorganisms, up and down stream process.
- To explore the functions of the fermentors, primary and secondary metabolites and production of recombinant products.
- To comprehend production of steroids, sterols and non-steroid compounds through microbial transformations.

UNIT – I ORIGIN OF BIOPROCESS TECHNOLOGY:

Introduction to bioprocess technology - Scope, Current processes in environment, agriculture and pharma industry. Biological wastes - Biomass, wastes from domestic, agriculture and industries. Scope and current processes in fermentation methods - The range of fermentation process, Chronological development, Component parts of a fermentation process, Fermentation economics.

UNIT – II INDUSTRIALLY IMPORTANT MICROORGANISMS:

Industrially important microorganisms - Isolation, screening, preservation and handling the microbial strains. Improvement of the strains – Mutation, recombinant DNA techniques and modifying the properties of the strains. Industrial media for industrial fermentation - Formulation and sterilization. Development of inoculum for various upstream process.

UNIT – III FERMENTOR DESIGN AND TYPES:

Structural components and parts of a fermentor - body construction, heat production, gas liquid exchange, mass transfer, heat transfer, oxygen transfer, stirring and mixing. Sterilization of a fermentor vessels and nutrients. Scale up and scale down fermentation process. Control of temperature, pH, form pressure Computer application in fermentation technology. Fermentation types – Submerged, solid state, batch and continuous fermentation.

UNIT – IV DOWNSTREAM PROCESSING:

Recovery of intracellular and extra cellular products - Biomass separation by centrifugation, filtration, chemical and Electro flocculation. Cell disintegration- physical, chemical and enzymatic methods. Extraction - solvent, two phase, liquid extraction, whole broth, aqueous multiphase extraction. Purification by different methods, Concentration by precipitation, ultrafiltration, reverse osmosis. Drying and crystallization.

UNIT – V MICROBIAL PRODUCTS:

Production of varying products - Organic acids - Amino acids, Antibiotics, Enzymes, Vitamins, Alcoholic beverages - wine and beer, Fermented foods - bread, cheese and soy sauce. Recombinant Products - insulin, interferon and growth hormone, Fermentation products from natural wastes - molasses, starch wastes and cellulosic wastes. Microbial transformations - steroids and sterols. Non-steroid compounds - Antibiotics.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Field trip to dairy, beverage Industry and food processing research Institutes. Analysis of microbiological quality in industrial products. Fermented food preparation. Mycotoxin detection in food samples. Awareness to the industrialists about the prevention of contamination in fermentation products. Daily news and research paper on bioprocess technology.

REFERENCES:

1. Kumar, Sachin, Sani, Rajesh, K. (eds) 2018. Biorefining of Biomass to Biofuels, Springer Publisher, ISBN: 978-3-319-67678-4.
2. Agarwal, A.K., Pradeep Parihar, 2006. Industrial Microbiology. Published by Student Edition, Behind Nasrani Cinema, Chopasani Road, Jodhpur.
3. Banwart, G.J., 2004. Basic Food Microbiology. 2nd edition, CBS Publishers and Distributors, New Delhi.
4. Casida, L.E. Jr., 1993. Industrial Microbiology, 5th edition, Wiley Eastern Ltd., New Delhi.
5. Crueger, W., Crueger, A., 2000. Biotechnology: A Test Book of Industrial Microbiology, 2nd edition, Panima Publishing corporation, New Delhi.
6. Kalaichelvan, P.T., Arul Pandi, 2007. Bioprocess Technology, MJP Publishers, Chennai.
7. Patel, A.H., 2005. Industrial Microbiology. Publisher Macmillan India Ltd., Delhi.
8. Sivakumar, P.K., Joe M.M., Sukesh, K., 2010. An introduction to Industrial Microbiology. First edition, S. Chand and Company Ltd, New Delhi.
9. Chisti, Y., 1999. Fermentation, Biocatalysis and Bioseparation, Encyclopedia of Bioprocess Technology, Vol. 5, John Wiley and Sons, N,Y.
10. https://bmcenergy.biomedcentral.com/articles/10.1186/s42500-019-0004-7
11. https://www.biologydiscussion.com/fermentation/fermentation-technology-meaning-methodology-types-and-procedure/17492
12. https://www.omicsonline.org/enzyme-production-by-fermentation-technology-scholarly-open-access-journals.php
13. https://www.biologydiscussion.com/industrial-microbiology-2/fermentor-bioreactor-history-design-and-its-construction/55756
14. https://thebiologynotes.com/design-of-a-fermenter/
15. https://www.bioxcellence.com/our-business/upstream-downstream-processing

COURSE OUTCOMES:

After the successful completion of this course, the students would be able to:

- Know about the nature and current status of the bio-resources.
- Obtain in-depth information about utilization of natural resources in the production of microbial products like enzymes, organic acids, antibiotic, vitamins, alcoholic beverages, steroid and non-steroid components.
- Carry in-depth theoretical knowledge of natural resources' utilization.
- Comprehend ideas on different types of fermentors and their functions.
- Understand the available opportunities to develop bio-entrepreneurship by producing microbial products using natural wastes.

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Second Year **CORE CHOICE COURSE III** **Semester III**

2. BIOETHICS AND INTELLECTUAL PROPERTY RHIGHTS

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To educate the ethical practices appropriate to the discipline at all times.
- To gain knowledge about Hippocratic tradition.
- To create awareness on human embryonic development.
- To adopt safe working practices relevant to the bioindustries & field of research.
- To educate the students to acquire knowledge about IPR.

UNIT – I BIOETHICS:

Definition - Basic human values such as the rights to life and health - The use of nature, Different views of Nature, Dynamic Nature, Interfering with Nature, Integrity of Species; Reducing Genetic Diversity; Biological Warfare; General Ethical Concerns for recombinant research.

UNIT – II HISTORY OF MEDICAL ETHICS:

The Hippocratic tradition: A Profession, Philanthropy, Do no harm. Adoption to the Oath by Western Medicine - Retaining the Hippocratic Oath – modern medical code of ethics – essential features of a good physician.

UNIT – III STATUS OF HUMAN EMBRYO:

Human Embryonic Development; Ethics through Embryo Development: Fertilization, The Fetus and feeling pain; Scientific Research on Human Embryos and its Experimental goals - Ethical issues in Embryo Research.

UNIT – IV ANIMAL RIGHTS:

Making New Strains of Animal: Ethical limits and regulations of Animal use: Religious views of Animal status. Human Gene Therapy: Ethical issues in Gene Therapy: Efficiency of treatment; Safety of Transferred Genes; Human rights, Ethical guidelines for genetically modified foods.

UNIT – V INTELLECTUAL PROPERTY RIGHTS:

Definition, types, tools – Patenting; Trademark; Trade secret; Copyrights; related rights; Geographical Indications; Industrial Designs. TRIPS. National (IPO) and International Agencies (WTO, WIPO) involved in IPR and Patenting. NABL accreditation.

UNIT – VI CURRENT CONTOURS (for continuous internal assessment only):

Current amendments in ethical issues regarding human embryo research, human gene therapy, copy right, patents may discuss in groups, conducting quiz and seminar to make the students to become familiar in biosafety and bioethics.

REFERENCES:

1. Nancy, S. J, Albert, R.J., Robert A. Pearlman. 2011. Bioethics: An Introduction to history, methods and practice. Jones and Barlett Publishers.
2. Sibi, G. 2020. Intellectual Property rights, bioethics, biosafety and entrepreneurship in biotechnology, 1st edition. IK International Publishing House Pvt. Ltd.
3. Tom, L.B., Childress, F. 2013. Principles of biomedical ethics, 5th edition, Oxford University Press, USA.
4. Vaughan Manomy. 2009. Animal Experimentation: A guide to the issues, 2nd edition, Cambridge university press.
5. Lewis Vaughn 2013. Bioethics: Principles, Issues and Cases, Oxford University Press, USA.
6. Beauchamp, T., Childress, J. 2013. A Principles of Biomedical Ethics, 7th edition, New York: Oxford University Press.
7. Macer D.R.J. 1990. Shaping Genes: Ethics, Law and Science of Using New Genetic Technology in Medicine and Agriculture, [online (Eubios Ethics Institute)].
8. Frederic, H., Erbisch., Karim, M. Maredia. 2004. Intellectual Property Rights in Agricultural Biotechnology, CABI publisher.
9. Sateesh, M.K. 2008. Bioethics and Biosafety, I.K. International Pvt. Ltd, New Delhi, India.
10. Deepa Goel., Shomini Parashar. 2013. IPR, Biosafety and Bioethics, 1st edition, Pearson Education, India.
11. https://www.slideshare.net/ishahak16/lecture-3-ethics-and-bioethics
12. https://www.asrm.org/globalassets/asrm/asrm-content/news-and-publications/ethics-committee- opinions/ ethics_ in_ embryo _research.pdf
13. https://www.ndsu.edu/pubweb/~mcclean/plsc431/students/bergeson.htm

COURSE OUTCOMES:

After the successful completion of this course, the students would be able to:

- Gain awareness about Intellectual Property Rights (IPRs) for protecting their ideas.
- Competent to devise business strategies by taking account of IPRs
- Proficient in technology upgradation and enhancing competitiveness.
- Acquire adequate knowledge in the use of genetically modified organisms and their effect on human health
- Gain more insights into the regulatory affairs.

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Second Year **CORE PRACTICAL III** **Semester III**

MICROBIAL GENETICS AND MOLECULAR BIOLOGY & ENVIRONMENT AND AGRICULTURAL MICROBIOLOGY

Code: **(Practical)** **Credit: 3**

MICROBIAL GENETICS AND MOLECULAR BIOLOGY

COURSE OBJECTIVES:

- To impart advance knowledge to the students related to the field of Microbial genetics.
- To educate about isolation of Nucleic acids
- To get a knowledge on checking the quantity and quality of the nucleic acids.
- To carry out the Blotting techniques.
- To identify the types of staining and their application in detection of microorganisms.

EXPERIMENTS:

1. Isolation of Microbial DNA
2. Isolation of Microbial RNA
3. Isolation of antibiotic resistant microbes
4. Quantification of DNA/Plasmid by Spectrophotometric method
5. characterization of DNA / plasmid DNA by agarose gel electrophoresis.
6. Isolation of plasmids from E. coli (mini preparation).
7. Competent cell preparation and Bacterial transformation
8. Polymerase Chain Reaction
9. Blotting techniques (Southern, Northern, Western and Dot blotting's)
10. Generalized transduction in E. coli.
11. Characterization of plasmid DNA by agarose gel electrophoresis.
12. Restriction digestion and Ligation of DNA
13. Isolation of mutants by spontaneous mutation – Gradient plate technique
14. Isolation of auxotrophic and antibiotic resistant mutants by physical and chemical mutagens

REFERENCES:

1. Current protocols in molecular biology (2007). John Wiley & Sons Inc. Vol. 1 & 2.
2. Sambrook J and Russell DW (2001). Molecular cloning - A laboratory manual, Cold Spring Laboratory Press, New York, 3rd Edition. Vol. 1, 2, 3.
3. Surzyeki S (2000). Basic Techniques in Molecular Biology, Springer.
4. http://www.ncbi.nlm.nih.gov/
5. www.yeastgenome.org
6. http://sequence-ww.stanford.edu/group/yeast_deletion_project/deletions3.html

COURSE OUTCOMES:

After the completion of the course, students will be able to:

- Handle the clinical samples and process them for molecular techniques
- Get a clear practical knowledge on instruments used in molecular biology lab.
- Study about the Antibiotic resistance among microbes
- Understand the Transformation mechanisms.
- Learn the quantification of macromolecules in industrial point of view.

ENVIRONMENTAL AND AGRICULTURAL MICROBIOLOGY

COURSE OBJECTIVES:

- To prepare the students for sensible knowledge in a wide range of profession.
- To provide the scientific discipline that deals with the application of microorganisms and the knowledge about them.
- To explain the applications of the course in microbial biotechnology, agriculture, food microbiology and bioremediation.
- To impart significant experiments linked with environment and agriculture.
- To train on the assessment of microbial quality of air, water and soil.

EXPERIMENTS:

1. Enumeration of Microorganisms from air by open plat technique
2. Enumeration of Microbial population from rhizosphere and non-rhizosphere soil
3. Isolation and enumeration of soil microorganisms (bacteria, fungi and actinomycetes).
4. Localization of Arbuscular Mycorrhizae (AM)
5. Isolation of *Azospirillum* and *Azotobacter* from soil
6. Isolation of *Rhizobium* sp. from root nodules of legumes
7. Evaluation of root nodule by cross section of legume roots.
8. Isolation of phosphate solubilizing bacteria from soil
9. Isolation of Cyanobacteria from agricultural soil and water
10. Isolation of bacterial and fungal pathogens from plants
11. Isolation and identification of air-borne microbes using Andersen sampler.
12. Determination of BOD and COD of polluted and pond water.
13. Assessment of water quality by MPN technique
14. Screening of antagonistic bacteria in soil by agar block overlay method.
15. Demonstration of the plant diseases: a) Tobacco mosaic; b) Bacterial blight of paddy; c) Downy mildew of bajra; d) Powdery mildew of cucurbits; e) Head smut of sorghum; f) Red rot of sugar cane; g) Citrus cancer; h) Downy mildew of bajra; i) Powdery mildew of cucurbits.

REFERENCES:

1. Aneja, K.R., 1993. Experiments in Microbiology: Plant Pathology and Tissue Culture, Wishwa Prakashan, New Delhi.
2. Cappuccino, J.G., Sherman, N., 2012. Microbiology - A Laboratory Manual. 7th Edition, Dorling Kindersley (India) Pvt. Ltd., New Delhi.
3. Gunasekaran, P., 2008. Laboratory Manual in Microbiology, New Age International (P) Ltd. Publishers, New Delhi.
4. Harry W. Seeley, J.R., Paul J Van Demark, John J Lee, 1997. Microbes in Action - A Laboratory Manual of Microbiology. W.H. Freeman and Company, New York.

5. Kanika Sharma, 2009. Manual of Microbiology – Tools and Techniques. 2nd Edition, Ane Books Pvt. Ltd., New Delhi.
6. Thangaraj, M., Santhana Krishnan, P., 1998. Practical Manual on Microbial inoculants, Centre of advanced studies in agricultural University, TNAU, Coimbatore.
7. http://www.fssai.gov.in/Portals/0/Pdf/15Manuals/MICROBIOLOGY%20MANUAL.pdf
8. http://www.unido.org/fileadmin/media/documents/pdf/Agro/MacroLab.pdf
9. http://samples.sainsburysebooks.co.uk/9780470757482_sample_385283.pdf
10. http://www.fao.org/docrep/018/aq359e/aq359e.pdf
11. http://krishikosh.egranth.ac.in/bitstream/1/2047193/1/ANAND-22.pdf
12. https://jascoinc.com/wp-content/uploads/2017/09/APP-Note-UV0004-Chromium-Quantitative-Determination.pdf

COURSE OUTCOMES:

By the end of the course, the students will able to

- Know about the techniques to isolate and assess the harmful microorganisms in environmental samples.
- Practice procedures to enumerate microbes of air and water.
- Get an idea to isolate and characterize the microbes in extreme environmental conditions.
- Acquire advanced practical knowledge.
- Exhibit their practical knowledge in research laboratories and industries.

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Second Year **ELECTIVE COURSE III** **Semester III**

1. GENETIC ENGINEERING

Code: **(Theory)** **Credit: 4**

COURSE OBJECTIVES:

- To educate the learners with the growing significance of genetic and protein engineering
- To impart the genetic molecules' cloning techniques.
- To provide the students with the advanced tools, techniques and methods employed in DNA studies
- To know the gene cloning & expression as well as protein engineering strategies.
- To study the genome mapping and human genome profile status.

UNIT – I INTRODUCTION TO DNA CLONING:

DNA cloning: Basic steps and methods of DNA cloning - Isolation and purification of nucleic acids (genomic DNA, RNA and Plasmids) – Methods of handling and quantification of DNA and RNA. Analyses of DNA/ RNA and proteins: Agarose gel, polyacrylamide and pulsed field gel electrophoresis of DNA - Blotting – Southern, Northern and Western Blottings. Labeling of probes. Chromosome walking. Native PAGE, and two-dimensional PAGE analysis of proteins.

UNIT – II TOOLS OF GENE CLONING & SCREENING OF CLONES:

Enzymes for gene manipulation - DNA polymerases, nucleases, DNA ligases, methylases – Cutting, joining and introduction of DNA into living cell: adapters, linkers and homopolymer tailing. Gene transfer techniques: electroporation, microinjection, protoplast fusion and microparticle bombardment. Screening for recombinants: Direct: Insertional inactivation, plaque phenotype and indirect methods: Immunochemical detection, nucleic acid hybridization, Dot and Colony Blotting. Construction and applications of Genomic DNA and cDNA libraries.

UNIT – III CLONING AND EXPRESSION VECTORS:

Vectors: types, properties - plasmids vectors for cloning in *E. coli* (pBR322 and derivatives, pUC vectors and pGEM3Z) - plasmids– host range and incompatibility. Vectors constructed based on bacteriophages (M13 and Lambda), cosmids, phasmids, phagemids and BACs. Eukaryotic vectors - 2µm plasmid, YACs, and P elements – animal (retroviruses) and plant vectors (Ti plasmid based vectors) – over expression vectors: *E. coli lac* and T7 phage, and Tet-regulatable promoters based vectors - shuttle vectors – Brief account on over expression systems: *Saccharomyces cerevisiae, Pichia pastoris, Schizosaccharomyces pombe and Kluyveromyces lactis*. Baculovirus & Mammalian cell over expression systems.

UNIT – IV GENOME MAPPING AND HGP:

Genomic mapping: genetic and physical - Restriction mapping, RFLP, FISH, Sequence tagged site. Polymerase chain reaction (PCR) – Principles, types and their applications. Sequencing genomes – primer walking, chain termination, chemical degradation, Pyrosequencing – DNA chips and micro array. Sequence assembly – shot gun, clone contig methods. Human Genome Project (HGP).

UNIT – V PROTEIN ENGINEERING AND PROTEOME ANALYSIS:

Site directed mutagenesis: conventional and PCR-based methods - Design and construction of novel proteins and enzymes, Basic concepts in enzyme engineering, engineering for kinetic properties of enzymes, protein folding, protein sequencing, protein crystallization. Data analysis - Mass spectrometry based Proteome analysis, MALDI-TOF and LC-MS platforms – Applications of protein engineering: Examples of engineered proteins. Protein

arrays and their applications.

UNIT – VI CURRENT COUNTERS (For continuous internal assessment only):

Any one demonstration related to genetic engineering/gene cloning using charts or prepared models or teaching kits – Assignments - Quiz classes - short seminar presentations – debates on genetic engineering and human ethics.

REFERENCES:

1. Old RW and Primrose SB. (2001) Principles of gene manipulations – An introduction to genetic engineering, 5 ed. University of California Press.
2. Winnacker EL. From Genes to Clones. (2003) Introduction to gene technology. New Delhi Panima publishing corporation.
3. Glick BR. (2017) Molecular Biotechnology – Principles and applications of recombinant DNA. 5th edition, ASM Press, Washington, DC
4. Nicholl DST (2008). An introduction to genetic engineering. Cambridge University Press.
5. Brown TA. Gene Cloning & DNA analysis. (2016) London; New York: Chapman and Hall.
6. Pinler A. (2001) Genetic engineering of microorganisms. Protein Structure, Stability and Folding by Kenneth P. Murphy. Published by Humana Press Inc.
7. Jeffrey L, Cleland and Charles S Craik. (1996) Protein Engineering Principles and Practice Published by Wiley-Liss Inc.
8. Paul R Carey. (1996) Protein Engineering and Design, Published by Academic Press Inc.
9. Old RW and Primrose SB. Principles of Gene Manipulation - An Introduction to Genetic Engineering. 5th edition. Blackwell Scientific Publications, London. 2003.
10. Brown TA. (2012) Genomes. 2nd Ed, John Wiley and sons.
11. D.P. Clarke, N. Pazdernik. (2012) Molecular Biology by 2nd edition. Academic Press.
12. J. Sambrook, D. Russell. (2012) Molecular Cloning: A laboratory manual by 4th edition. Cold Spring Harbor laboratory Press.
13. I. Edward Alcamo (2001) DNA Technology: The Awesome Skill by. Harcourt Academic Press.
14. J. Watson, T. Baker, S. Bell, A. Gann, M. Levine, R. Losick. (2014) Molecular Biology of the Gene by 7th edition. Pearson.
15. T.A. Brown (2016) Gene Cloning and DNA Analysis: An Introduction by. 7th edition. Wiley Blackwell Publishers.
16. http://www.bio.brandeis.edu/classes/heredity/Lecture%20Powerpoints/Chapter_13_1.pdf
17. https://www.cheric.org/files/education/cyberlecture/e200402/e200402-301.pdf
18. https://www.onlinebiologynotes.com/gene-cloning-steps-involved-gene-cloning/
19. https://uenf.br/cbb/lbt/files/2014/09/Cloning-vectors.pdf
20. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6393796/

COURSE OUTCOMES:

Students who undergo the course will be able to:

- Understand the basics of gene cloning steps and various methods of gene cloning.
- Acquire the knowledge of various tools required for genetic engineering.
- Grasp various gene cloning and expression vectors needed for gene cloning / manipulation.
- Understand genome mapping and protein engineering methods.
- Comprehend the genetic engineering knowledge that could lead to next level of research.

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Second Year **ELECTIVE COURSE III** **Semester III**

2. MICROBIAL NANOTECHNOLOGY

Code: **(Theory)** **Credit: 4**

COURSE OBJECTIVES:

- To educate the role of microbes and other eukaryotic systems in the synthesis of nanoparticles.
- To provide the knowledge of advanced methods of synthesis and designing of nano particles.
- To impart them the potential applications of nanoparticles/materials in a variety of areas.
- To analyze the nanoparticles using various instrumentation methods.
- To understand the merits and demerits of nanoparticles.

UNIT – I INTRODUCTION TO BIONANOTECHNOLOGY:

Milestones in History – Bionanotechnology – concept and future prospects – application in Life Sciences. Terminologies – nanotechnology, bionanotechnology, nanobiomaterials, biocompatibility, nanomedicine, nanowires, quantum Dots, nanocomposite, nanoparticles, nanosensors. Biotechnology to bionanotechnology, natural bionanomachines. Current status of bionanotechnology.

UNIT – II SYNTHESIS OF NANOPARTICLES:

Molecular nanotechnology – nanomachines – collagen. Uses of nanoparticles – cancer therapy – manipulation of cell and biomolecules. Cytoskeleton and cell organelles. Types of nanoparticles production – physical, chemical and biological. Microbial synthesis (bacteria, fungi and yeast) of nanoparticles – mechanism of synthesis.

UNIT – III TYPES OF NANOPARTICLES AND METHODS OF CHARACTERIZATION:

Nanoparticles – types, functions – Silver, Gold and Titanium. Physical and chemical properties of nanoparticles. Characterization of nanoparticles – UV-Vis spectroscopy, particle size analyzer, Electron Microscopy – HRTEM, SEM, AFM, EDS, XRD. Other tools and techniques required for bionanotechnology: rDNA technology, site directed mutagenesis, fusion proteins, X- Ray crystallography, NMR. Bioinformatics: molecular modeling, docking, computer assisted molecular design.

UNIT – IV APPLICATIONS OF BIONANOTECHNOLOGY:

Drug and gene delivery – protein mediated and nanoparticle mediated. Uses of nanoparticles in MRI, DNA and Protein Microarrays. Nanotechnology in health sectors. Nanomedicines, Antibacterial activities of nanoparticles. Nanotechnology in agriculture. Toxicology in nanoparticles – Dosimetry.

UNIT – V MERITS AND DEMERITS OF NANOPARTICLES:

Advantages of nanoparticles – drug targeting, protein detection, MRI, development of green chemistry – commercial viability of nanoparticles. Disadvantages – pollution and health risks associated with nanoparticles.

UNIT – VI CURRENT COUNTERS (For continuous internal assessment only):

Methods of green biosynthesis of silver, gold and zinc nanoparticles from medicinal plant extracts. Sequential characterization of nanoparticles. Assay of nanoparticles for their bioefficiency.

REFERENCES:

1. Shah MA. 2020. Principles of Nanoscience and Nanotechnology. Alpha Science Publication.
2. Parthasarathy BK. 2007. Introduction to Nanotechnology, Isha Publication.
3. Elisabeth Papazoglou and Aravind Parthasarathy. 2007. Bionanotechnology. Morgan and Claypool Publishers.
4. Bernd Rehm. 2006. Microbial Bionanotechnology: Biological Self-assembly Systems and Biopolymer-based Nanostructures. Horizon Scientific Press.
5. David E Reisner and Joseph D Bronzino. 2008. Bionanotechnology: Global Prospects. CRC Press.
6. Ehud Gazit. 2006. Plenty of Room for Biology at the Bottom: An Introduction to Bionanotechnology. Imperial College Press.
7. Kamali Kannangara. 2005. Nanotechnology: Basic science and emerging technologies- Mick Wilson, Overseas Press.
8. Mark A Ratner and Bandyopadhyay AK. 2002.Nano Materials. Nanotechnology: A gentle introduction to the Next Big Idea, New Age Publishers.
9. Pradeep T. 2007. Nano Essentials understanding nanoscience and Nanotechnology. 1st edition. TMH publications. 2007.
10. Pradeep T, 2007. Nano: The Essentials Tata Mcgraw Hill, New Delhi.
11. Niemeyer CM and Mirkin CA. 2004. Nanobiotechnology: Concepts, Applications and Perspectives, Wiley-VCH Verlag GmbH and Co., KgaA, Weiheim.
12. Mirkin CA and Niemeyer CM. 2007. Nanobiotechnology- II, More Concepts and Applications Wiley-VCH, Verlag GmbH and Co.
13. Claudio Nicolini. 2009. Nanobiotechnology and Nanobiosciences Pan Stanford Publishing Pte. Ltd. 2009.

COURSE OUTCOMES:

After a successful completion of the course, students would become familiar with:

- The nature of nanotechnology and bionanotechnology.
- The use of nano materials in biological screening.
- The use of nanotechnology in medicine.
- The use of nanotechnology in pollution control.
- The biosynthesis of nanoparticles using microorganisms.

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Second Year **NON MAJOR ELECTIVE II** **Semester III**

PUBLIC HEALTH MICROBIOLOGY

Code: **(Theory)** **Credit: 2**

COURSE OBJECTIVES:

- To acquaint the student with basic concept of public health and prophylactic measures.
- To understand air borne infection and its control measures.
- To acquire basic knowledge on gastro- intestinal infections associated with food and water.
- To assess the nature of sexually transmitted diseases of human beings.
- To understand vector borne diseases of human beings.

UNIT – I IMPORTANCE OF PUBLIC HEALTH:

Definition, scope, concept and importance of public health microbiology, Roles of microbiologist in public health, Concept of health and disease, Indicators of health. National health programs and public health hazard in the community. Vaccine - types- live, killed, toxoid, recombinant, edible vaccine. Indian vaccination schedules.

UNIT – II AIR BORNE DISEASES:

Composition of Air -Transmission of air borne infections – Causative agent characters, symptoms, control and treatment of air borne infections - Bacterial pneumonia, Diphtheria, Tuberculosis, Influenza, Measles, Covid-19. Method of measuring microorganisms in air. Air Sanitation.

UNIT – III WATER AND FOOD BORNE DISEASES:

Types of food borne diseases, Food poisoning and food intoxication. Food borne infection, Water pollution and sanitation, Nature of causative agent, Transmission, control and treatment of diseases from food and water: gastroenteritis, Cholera, Typhoid, bacillary dysentery, amoebic dysentery (Amoebiasis, Giardiasis) and Poliomyelitis. Awareness of Peptic ulcer and its consequences. Food spoilage and spoilage of food by microorganisms.

UNIT – IV SEXUALLY TRANSMITTED DISEASES:

Characters of causal organisms and control of the following diseases - Syphilis, HIV/AIDS, Hepatitis B and C, Gonorrhoea, Genital herbs, Chlamydia, Trichomoniasis. Control of sexually transmitted infections. Technique used for the diagnosis of sexually transmitted infection.

UNIT – V VECTOR BORNE HOSPITAL BORNE AND ZOONOTIC INFECTIONS:

Vector and its types- Vector borne diseases, Transmission, character, and control of the following vector borne diseases - Kala-azar, Malaria, Japanese Encephalitis, Dengue, Chikungunya and Plague. Techniques used in the diagnosis of vector borne infections. Hospital-Acquired Infection and Zoonotic diseases.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Methods of preventing common diseases of human. Methods of detecting epidemic infection in a community. Making vaccination schedules for rural community. Public awareness about vaccination and celebration of Vaccination day. Public awareness on the usage of antibiotics.

REFERENCES

1. Robert S. Burlage. 2012. Principles of Public Health Microbiology. Jones & Bartlett learning LLC, Canada.
2. Spencer, John F. T., Alicia L. Ragout de Spencer. 2004. Public Health Microbiology-Methods and Protocols. Springer.
3. Ghimire P. & Parajuli K. 2005. A Text Book of Microbiology, Vidhyarthi Pustak Bhandar Publication, Kathmandu.
4. Brownson, RC., Baker, EA., Leet. TL., Follespie. KN., 2003. Evidence Based Public Health. Oxford University Press.
5. Dixit H. 1999.The Quest for Health, Educational Enterprises, Kathmandu,
6. Friis, RH., and Sellers, TA, (1999). Epidemiology for Public Health Practice, 2nd Edition, Gaithersburg, MD: Aspen Publication.
7. Park JE and Park K., 2005. Textbook of preventive and social medicine.18th edition. Banarsidas Bhanot Publishers.
8. Jay, J, H, Modern. 1987. Food Microbiology, 3rd Edition CBS Publication and Distributors Delhi.
9. Rajan S and Selvi Christy R. Essentials of Microbiology, CBS publishers New Delhi 2018.

COURSE OUTCOMES:

After completion of this course the student can:

- Understand the process of Public health Microbiology to prevent disease, promote health, and prolong life among the population as a whole.
- Help and protect the health of people and the communities where they live, learn, work and play.
- Carry an awareness on sexually transmitted diseases and diagnosis of infectious diseases.
- Understand National disease control plans for major infectious diseases.
- Know vaccination programme and control of community infections.

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Second Year **CORE COURSE VII** **Semester IV**

ADVANCES IN VIROLOGY

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVE:

- To facilitate an understanding on the basics of viruses, virus discovery, viral structure, classification of viruses.
- To provide a general account of bacteriophages, plant, animal and human viral diseases.
- To gain a knowledge on instrumentation relevant to virology.
- To teach the strategies by which viruses spread within a host, and are maintained within populations. To describe the molecular biology of viral reproduction and addresses the interplay between viruses and their host organisms.
- To expose to molecular diagnostics and emerging infectious diseases of human and animals.

UNIT – I GENERAL VIROLOGY:

Virus – Virion - Discovery of Viruses – General properties of Viruses – Classification of Viruses (LHT, Baltimore and ICTV) - Ultra structure of Viruses – Sub viral agents- viroids, prions, virusoids and satellite viruses – Replication of Viruses - Virus attachment, Initiation of infection, cellular receptor for viruses, entry of viruses, genome replication, assembly, Packaging signals, packaging of segmented genome, acquisition of an envelope, budding strategies.

UNIT – II MICROBIAL VIRUSES:

Bacteriophages – Classification - Structure and life cycle - T4 Phage, Lambda Phage, Mu Phage, M13 Phage, P1 Phage – lytic and lysogenic Life cycles - Bacteriophage typing, Phage therapy (bacteriophage therapy), Cyanophages, Mycoviruses (Mycophages), Rhizobiophages – Cultivation strategies of phages from sewage and other ecosystem – Importance of phages in pollution control.

UNIT – III ANIMAL AND HUMAN VIRUSES:

Classification - Structure, Multiplication, Pathogenesis, Diagnosis, Prevention and Treatment of following animal viruses – Papovaviridae (Human Papilloma Virus), Adenoviridae, Herpesviridae (Chicken Pox), Poxviridae (Monkey Pox), Hepadnaviridae (HBV), Picornaviridae (Polio Virus), Rhabdoviridae (Rabies), Orthomyxoviridae (Swine Flu), Reoviridae (Rota Virus), Retroviridae (HIV) and Flaviviridae (Chikungunya virus) - Cultivation of human viruses- Embryonated eggs and Cell culture system - Serological and immunological methods of diagnosis.

UNIT – IV PLANT VIRUSES:

Classification– Transmission of plant viruses – Symptoms of Viral infection in plants - Control of plant viral diseases - Cultivation of Plant viruses – Meristem culture – TMV - CaMV- Common viral diseases in paddy, cotton, tomato and sugar cane - Name of diseases, pathogens and symptoms. Generation of virus-free planting material; vector control.

UNIT – V EMERGING VIRUSES, ONCOGENIC VIRUS AND CONTROL OF VIRUSES:

Control of Viruses - requirement of an effective vaccine, different ways of making vaccine, types of Vaccine. Anti-viral drugs - Theories on origin of virus, evolution of new viruses,

emerging viruses, Factors that drive viral emergence - viral cancer, transformation and oncogenesis-Virus-induced cancer, Avian leucosis retroviruses, Proviral DNA sequences, Proto-oncogenes, DNA tumor Viruses, the link between DNA virus biology and transformation.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Case study of health risk associated with a virus epidemic, the origin of outbreak, the spread, the intervention strategies, public health response.

REFERENCES:

1. Martinez J. Hewlett, David Camerini, David C. Bloom. 2021. Basic Virology, Fourth Edition, Wiley Blackwel.
2. Rajan S and Selvichristy J. 2018. Essentials of Microbiology, CBS Publishers, New Delhi.
3. Flint, S. J., Enquist, L. W., Racaniello, V. R., and Skalka, A. M. 2015. Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses, 4th ed. 944 pp. ASM Press, Washington, DC.
4. Dimmock. N.J and Eatson, A.J., Leppard, K.N. 2016. Introduction to Modern Virology. VII edition. Blackwell Scientific Publications, Oxford.7th Edition.
5. Alan J. Cann. 2015. Principles of Molecular Virology. 6th edition, Academic press, California.
6. John Carter and Venetia Saunders. 2013. Virology: Principles and applications, 2nd Edition, John wiley and son's publishers, USA.
7. Maureen A Harrison and Ian F Rae. 2010. General techniques of cell cultures, Cambridge University Press, England.
8. Rajan S and Kumaresan. S. 2007. Virology. Saras Publications.
9. Rajan S and Selvichristy J. Essentials of Microbiology, CBS Publishers, New Delhi. 2018
10. Roger Hull. Mathews' Plant Virology, 4th edition, Academic press- A Harcourt Science and technology company, New York. 2002.
11. https://www.nature.com/scitable/topicpage/the-origins-of-viruses-14398218/
12. https://bsppjournals.onlinelibrary.wiley.com/doi/10.1111/j.1364-3703.2011.00752.x
13. https://www.sciencedirect.com/journal/virology
14. https://www.news-medical.net/health/What-is-Virology.aspx
15. Saravanan. P. Virology. MJP Publishers. 2006.

COURSE OUTCOMES:

Upon successful completion of the course, the students would be able to:

- Describe virus structure, process of virus attachment and entry, virus assembly and release.
- Explain steps in virus infection, transmission, patterns of infection, virus virulence, and host defense against virus infection.
- Know methods of making virus vaccines and anti-viral drugs, drivers of virus evolution, and emerging viruses.
- Understand unusual infectious agents, virus mediated cellular transformation and oncogenesis.
- Gain knowledge about newer emerging viral infections including the viral mutant forms for emerging.

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Second Year **CORE COURSE VIII** **Semester IV**

IMMUNOLOGY AND IMMUNOTECHNOLOGY

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To understand the various components of the host immune system.
- To study the structural organization and functions of immune cells and organs.
- To learn the antigens, antibodies and antigen antibody reactions.
- To understand the structural nature of T cells, B cells and immunity.
- To describe the concepts of immune-technology.

UNIT – I IMMUNE SYSTEM:

History of Immunology, Immunity - innate and acquired. Inflammation. Haematopoiesis – Blood Group System, Cells of the immune system- lymphocytes, macrophages, mononuclear phagocytes- dendritic cells, granulocytes, NK cells and mast cells Central and peripheral lymphoid organs- Thymus, bone marrow, spleen, lymphnode, MALT and GALT.

UNIT – II T AND B CELL:

Detailed structure and development of B cell and T cell – receptors - Structure of CD4, CD8, MHC-I, MHC-II molecules, cellular adhesion molecules (ICAM, VCAM, selectins, integrins). Activation of T and B cells- Maturation of T cell and B cell. Organization of the genes for B and T cell receptors. Genetic organization of MHC-I and MHC-II complex (both HLA and H-2). Peptide loading and expression of MHC-I and MHC-II molecules

UNIT – III ANTIGEN, ANTIBODY AND AG-AB REACTIONS:

Antigen – Types, Toxoid-vaccines -antigen recognition, processing and presentation - Cell mediated immunity – Humoral mediated immunity – antibody – types. Theories of antibody formation. Rearrangenment of genes in antibody formation - Molecular mechanisms responsible for generating diversity of antibodies and T cell receptors. Interaction of T and B cells. Antigen –antibody reactions - Precipitation, agglutination, complement fixation, RIA, ELISA, Western blotting and immunofluorescence.

UNIT – IV IMMUNE MECHANISMS:

Complement system: Basics of complement protein - different pathways of complement activation - classical and alternative. Hypersensitivity reaction and their types. Auto immune disorders, transplantation and cancer immunology. Deficiencies / defects of T cells, B cells, and phagocytic cells. Immunity to tuberculosis, malaria and HIV.

UNIT – V IMMUNOTECHNOLOGY AND ITS APPLICATIONS:

Production of polyclonal, monoclonal antibodies and phage display - techniques and applications. Immunization practices- active and passive immunization. Vaccines- killed and attenuated, recombinant vaccines, DNA and peptide vaccines. Applications of immunotechniques – Flow cytometry, Immunoelectron microscopy, Immunohistochemistry and Bioplex array.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Review and debate on latest discovery on immunology; Seminar on immune responses against SARS-CoV2 and vaccination for COVID-19. Quiz: Autoimmune diseases, Tumor immunology, immunological biosensors. Review on prospects and future of immunosensors.

REFERENCES:

1. David Male, R. Stokes Peebles and Victoria Male. 2020. Immunology. 9th Edition, Elsevier.
2. Rajan S and Selvichristy J. 2018. Essentials of Microbiology, CBS Publishers, New Delhi.
3. Charlene Sand. A reference guide to immune disorder including hypersensitivity and auto immune disease, Webster's digital service, ebook. 2013.
4. Goldsby RA, Kindt TK, Osborne BA and Kuby J. Immunology, 5th Edition, W.H. Freeman and Company, New York. 2007.
5. Ivan Roitt, Jonathan Brostoff and David Male. Immunology, 8th edition, Elsevier science Ltd., New York. 2012.
6. Kuby J. Immunology, 7th edition, W.H. Freeman and company, New York. 2008.
7. Patricks S and Larkin MJ. Immunological and molecular aspects of bacterial virulence. John wiley and sons, England. 1995.
8. Tak W Mak and Mary Saunders. Primer to the Immune Response. 2nd edition from Tak Mak, Mary Saunders, Bradley Jett. New York. 2014.
9. Thomas J Kindt, Barbara A Osborne, and Richard A Golds. Immunology online, University of South Carolina. 2006.
10. William E Paul. Fundamental Immunology. 7th revised edition, Raven press, New York. 2012.
11. Sudha Gangal and Shubhangi Sontakke. Textbook of Basic and clinical Immunology, Universities Press, (India) Pvt. Ltd, Hyderabad, India. 2013.
12. https://doi.org/10.1016/j.immuni.2020.05.002
13. https://doi.org/10.1038/s41577-020-0311-8
14. https://www.immunopaedia.org.za/immunology/
15. http://cshprotocols.cshlp.org/site/Taxonomy/immunology_11.xhtml

COURSE OUTCOMES:

Upon successful completion of the course, the student can:

- Understand the fundamental bases of immune system and immune response.
- Gather information about the structure and organization of various components of the immune system.
- Elaborate the genetic organization of the genes meant for expression of immune cell receptors and the bases of the generation of their diversity.
- Point out the operation and the mechanisms which underlie the immune response.
- Describe the phenomena like host defense, hypersensitivity (allergy), organ transplantation and certain immunological diseases.

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Second Year **ENTREPRENEURSHIP / INDUSTRY BASED COURSE ENTREPRENEURSHIP IN MICROBIOLOGY** **Semester IV**

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To project the development role of government and non-government schemes for entrepreneurship programmes.
- To know the role of skills of entrepreneurs.
- To acquire a basic understanding on biological entrepreneurial programs.
- To learn about different types of biofertilizer and its market potentials.
- To know about the techno-economical assessment.

UNIT – I CONCEPT OF ENTREPRENEUR AND ENTREPRENEURSHIP:

Definitions-concept of entrepreneurship, development. Structure of a biobased technology, start-up of biobased technology company and biobased business development. Government and non-Govt. Schemes for entrepreneurship programmes. Funding agency and opportunity.

UNIT – II SKILLS FOR ENTREPRENEURS:

communication skills, problem solving skills; Business plan development; Market need- distribution, price, promotion and market goal setting, Develop the business at Global level. Financial plan -Financial support for business, business insurance,

UNIT – III PROJECT AND BIO PRODUCT DEVELOPMENT:

Project: identification, classification, formulation, appraisal. Small, large-scale production and cost benefit analysis and marketing of edible and medicinal mushroom cultivation-button, *Oyster*, *Ganoderma*. Single cell protein -Production of Yeast and Spirulina.

UNIT – IV BIOFERTILIZER PRODUCTIONS:

Mass multiplication, production cost analysis and marketing of Cyanobacterial biofertilizer, Bacterial biofertilizer- *Rhizobium*, *Azospirillum*, Fungal biofertilizers- AMF, Actinobacterial biofertilizer-*Frankia* sp. Seaweed liquid biofertilizer, Biopesticides - *Bacillus*, *Bacillus thuringiensis*, *Bacillus sphaericus*, etc.

UNIT – V DAIRY AND FOOD PRODUCE:

Small, large-scale production and cost benefit analysis and marketing of agar-*Gellidium* and fermented foods- cheese, pickles and other probiotic food. Mass production and marketing of compost- Vermicomposting and microbial compost - types of compost pits- Laboratory and field application; cost-benefit analysis.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Visit to a nearby small scale industrial unit of biological importance. Experience the

students on how to calculate the cost benefit ratio before becoming an entrepreneur. Give seminar and problems on how to initiate and to know the process of starting a start up at a smaller level.

REFERENCES:

1. Nagendra S. (2008). Entrepreneurship and management Sanguine technical publishers
2. Bhatia, B.S. and G.S Batra. (2003). Entrepreneurship and small business management. Deep and deep publications
3. Naidu, N.V.R. (2008). Management and entrepreneurship. I.K. International Pvt. Ltd.
4. Greene. (2000). Entrepreneurship ideas in action. Thomson learning.
5. Sandera, F.E., B.Mosse and P.B.Tinke. (1975). Endomycorrhizae, Academic Press, London.
6. Rao,N.S. (1980). Biofertilizers in Agriculture. Oxford & IBH Publishing Co. Pvt. Ltd., Bombay.
7. Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies Shimasaki, CD. (2014). Amsterdam: Elsevier. Academic Press is an imprint of Elsevier, ISBN: 0124047300.
8. https://study.com/academy/lesson/what-is-an-entrepreneur-definition-characteristics examples.html
9. https://study.com/academy/lesson/institutional-entrepreneurship-theory-examples.html
10. https://study.com/articles/Fermentation_Microbiologist_Job_Description_Salary_and_Care er Outlook.html

COURSE OUTCOMES:

After completion of this course, the student can:

- Understand the basic knowledge of entrepreneurship programmes.
- Learn the resource for government and non-government schemes for entrepreneurship
- Imbibe structure of a bio-based technology.
- Initiate a Start-up of bio-based technology, bio-based business development.
- Make an impact on societal development in rural and under-privileged sectors.

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Second Year **PROJECT** **Semester-IV**

Code: **Credit: 5**

Each candidate shall be required to take up a Project Work and submit it at the end of the final year. The Head of the Department shall assign the Guide who, in turn, will suggest the Project Work to the student in the beginning of the final year. A copy of the Project Report will be submitted to the University through the Head of the Department on or before the date fixed by the University.

The Project will be evaluated by an internal and an external examiner nominated by the University. The candidate concerned will have to defend his/her Project through a Viva-voce.

ASSESSMENT /EVALUATION /VIVA-VOCE:

1. PROJECT REPORT EVALUATION (Both Internal & External):

I. Plan of the Project - 20 marks

II. Execution of the Plan/collection of Data / Organisation of Materials / Hypothesis, Testing etc and presentation of the report. - 45 marks

III. Individual initiative - 15 marks

2. VIVA-VOCE / INTERNAL& EXTERNAL - 20 marks

TOTAL **- 100 marks**

PASSING MINIMUM:

	Vivo-Voce 20 Marks	**Dissertation 80 Marks**
Project	40% out of 20 Marks (i.e. 8 Marks)	40% out of 80 marks (i.e. 32 marks)

A candidate shall be declared to have passed in the Project work if he/she gets not less than 40% in each of the Project Report and Viva-voce but not less than 50% in the aggregate of both the marks for Project Report and Viva-voce.

A candidate who gets less than 40% in the Project must resubmit the Project Report. Such candidates need to defend the resubmitted Project at the Viva-voce within a month. A maximum of 2 chances will be given to the candidate.

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Second Year **VALUE ADDED COURSE II** **Semester IV**

QUALITY CONTROL IN INDUSTRIES

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To acquire the knowledge of quality control in pharmaceutical industry.
- To learn the quality control audits in industries.
- To understand the basics of food safety and food quality.
- To realize the microbial quality control in hospitals.
- To acquire knowledge on environment monitoring and regulations.

UNIT – I QUALITY CONTROL IN PHARMACEUTICAL INDUSTRY:

Basic of pharmaceutical products and their quality control: bulk drugs, forms, vaccines – both chemical and microbiological parameters. Environmental Monitoring – Pharmaceutical industry, Manufacture of Sterile Medicinal Products- British, European, USA-US and Indian pharmacopoeias.

UNIT – II INDUSTRIAL QUALITY CONTROL AND QUALITY AUDITS:

Process quality control- sterile and nonsterile preparations, Quality control – raw materials, purity check, quality check of finished products, Industrial responsibilities – social and environmental safety.

UNIT – III FOOD SAFETY AND FOOD QUALITY:

Microbiological criteria of food, food products, beverages. Monitoring of factory hygiene and sanitation, Microbiological quality of ingredients, processing and finished products. Food Safety and Standards Authority of India (FSSAI). Food contaminants and diseases.

UNIT – IV MICROBIAL QUALITY CONTROL IN HOSPITALS:

Control of Healthcare associated infections (HAI) - Culture Identification, Sensitivity pattern, report preparations, HAI surveillance, resistance surveillance, Monitoring water quality in hospital, healthcare infrastructures. Corrective action system, Environmental monitoring and clean room commission

UNIT – V MICROBES AND THEIR APPLICATIONS:

Quality control in biodegradation and bioremediation. Microbes used in the biofertilizers and bio-pesticides and bio-fuels.

UNIT - VI CURRENT CONTOURS (For continuous internal assessment only):

Assignment shall be given based on the syllabus and seminar shall be assigned to students related to their assignment topics individually. A project shall be assigned in the topic of prevalence of microorganisms in industrial products. Mini project in various recent research topics related to subject can be given.

REFERENCES:

1. Nally, J.D. (Ed.) 2007. Good Manufacturing Practices for Pharmaceuticals, Sixth Edition, Informa Healthcare USA, Inc., ISBN 10: 0-8593-3972-3 & ISBN 13: 978-0-8493-3972-1, New York.
2. The training manual for Food Safety Regulators, 2011. Food Safety regulations and food safety management. Food Safety and Standards Authority of India, New Delhi (*http://www.fssai.gov.in/ trainingmanual.aspx*)
3. U.S. Environmental Protection Agency (EPA). Washington, D.C., 2014. 21-Food and drugs, chapter I-Food and Drug Administration.
4. WHOTRS823, 1992. WHO expert committee on specifications for pharmaceutical preparations: thirty-second report. WHO Technical Report Series: 823, ISBN 92 4140823 6, ISSN 0512-3054, Geneva.
5. EPA, 2010. Noise Pollution, 2010-05-18.
6. https://www.alten.pt/2021/06/14/quality-control-in-the-pharmaceutical-industry/
7. https://www.pharmaguideline.com/2017/09/functions-of-quality-control.html
8. https://www.slideshare.net/SihamAbdallaha/quality-control-of-pharmaceutical-products-31353025
9. https://www.cfpie.com/how-quality-control-is-done-in-the-pharmaceutical-industry
10. https://www.fssaifoodlicense.com/different-food-safety-food-quality/
11. https://pharmaphorum.com/views-and-analysis/the_importance_of_microbiological_quality_control_in_the_pharmaceutical_industry_/

COURSE OUTCOMES:

After completion of this course, the student can:

- Enhance their knowledge on quality control management in the various industries.
- Know how all the fundamental disciplines of industry are intrinsically linked with the concepts of service excellence and quality.
- Explore mainly the quality control of pharmaceutical and food products.
- Investigate the quality control of food foodstuffs to maintain their safety and quality.
- Acquire knowledge on environment monitoring and regulations.

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