Syllabus
For
B.Sc. (Hons.)MICROBIOLOGY

THREE YEAR FULL TIME PROGRAMME UNDER CBCS

RANI DURGAVATI UNIVERSITY

JABALPUR-482001

Note: Syllabus applicable for students seeking admission in the B.Sc. (HONS) Microbiology Course from the academic year 2019-2020 onwards

Syllabus For
B.Sc. (Hons.) MICROBIOLOGY
(CBCS Pattern)

ACADEMIC YEAR 2020-2021 Onwards

The B.Sc. (Hons.) Microbiology course would be of three years duration, divided into three parts- Part I, Part II and Part III. Each part would consist of two semesters. Semester I to V would comprise of three theory papers including practicals and one Elective with practical out of two choices, making a total of 20 papers in five semesters. Students will carry out Research work and submit a Dissertation in Semester VI. There would be 12 cores, 8 common (elective) and 4 interdisciplinary papers. The new course will commence from the academic session 2020-21. The syllabus has been prepared keeping in view the unique requirements of B.Sc. (Hons.) microbiology students under CBCS Programme. The contents have been drawn to accommodate the widening horizons of the Microbiology discipline. It reflects the changing needs of the students, pertaining to the fields of Chemistry, Statistics and Computational skills. The detailed syllabus for each paper is appended with a list of suggested readings. Teaching time allotted for each paper shall be 4 periods for each theory paper and 4 periods for each practical class per week and 1 tutorial period for each paper per week. Each practical batch should not have more than 20 students. Any number exceeding 20 will be divided into two equal batches. This is because microbiology practicals require individual attention for imparting correct and adequate hands – on training to the students.

The six common papers (Cell Biology - I and II, Genetics and Genomics – I and II and Molecular Biology I and II) will be taught by teachers of the department of Biological Sciences. The interdisciplinary courses like Fundamental of Statistics, Basics of Computers, Computational Skills, Chemistry and Technical Writing and Communication in English) will be taught by teachers of the respective departments. One short educational trip will be conducted to industry/national/research institutes in the $5^{th}/6^{th}$ semester to keep the students abreast with latest developments in the field of microbiology.

BACHELOR OF SCIENCE IN MICROBIOLOGY
THREE YEAR FULL TIME PROGRAMME,
PROGRAMME STRUCTURE

PART	SEMESTER	PAPER
PART-I	**Semester-1**	
	UMB 101	Introduction to Microbial World
	UMB 102	Techniques in Microbiology
	UMB 103	Chemistry-I
	UMB 104	Practical based on UMB 101&102
	UMB 105	Practical based on UMB 103 & UMBE 101/102
	UMBE 101/	Communicative English
	UMBE 102	Fundamentals of Statistics
	Semester-2	
	UMB 201	Bacteriology
	UMB 202	Medical Microbiology
	UMB 203	Chemistry-II
	UMB 204	Practical based on UMB 201& 202
	UMB 205	Practical based on UMB 203 & UMBE 201/202
	UMBE 201/	Basics of Computers
	UMBE 202	Bioanalytical Techniques
PART II	**Semester-3**	
	UMB 301	Cell Biology-I
	UMB 302	Phycology & Mycology
	UMB 303	Virology
	UMB 304	Practical based on UMB 301& 302
	UMB 305	Practical based on UMB 303 & UMBE 301/302
	UMBE 301/	Molecular Biology-I
	UMBE 302	Recombinant DNA Technology
	Semester- 4	
	UMB 401	Microbial Physiology & Metabolism
	UMB 402	Genetics & Genomics-I
	UMB 403	Cell Biology-II
	UMB 404	Practical based on UMB 401& 402
	UMB 405	Practical based on UMB 403 & UMBE 401/402
	UMBE 401/	Molecular Biology-II
	UMBE 402	Immunology
PART III	**Semester-5**	
	UMB 501	Food & Dairy Microbiology
	UMB 502	Microbial Ecology
	UMB 503	Industrial Microbiology
	UMB 504	Practical based on UMB 501& 502
	UMB 505	Practical based on UMB 503& UMBE 501/502
	UMBE 501/	Genetics & Genomics-II
	UMBE 502	Plant Pathology
	Semester-6	
	DISSERTATION	

(B) SCHEME OF EXAMINATION

FIRST SEMESTER

(A) Continuous evaluation, Theory, Practical		**Credits**	**Maximum Marks**		
Course Code	**Course Title**		**Continuous Evaluation**	**End Semester Exam**	**Total**
I-Core Courses					
UMB 101	Introduction to Microbial World	**3**	**40**	**60**	**100**
UMB 102	Techniques in Microbiology	**3**	**40**	**60**	**100**
UMB 103	Chemistry-I	**3**	**40**	**60**	**100**
II-Practical Core Courses					
UMB 104	Practical based on UMB 101 and UMB 102	**4**	**40**	**60**	**100**
UMB 105	Practical based onUMB103 and UMBE 101/ UMBE 102	**4**	**40**	**60**	**100**
III-Elective Courses (Any one to choose)					
UMBE 101	Communicative English	**3**	**40**	**60**	**100**
UMBE 102	Fundamentals of Statistics				
IV- Skill Development course					
SKILL	Skill Development module 1	**2**	Grade Point will be provided by Skill Development Centre		
Total valid credits		**22**			
(B) Comprehensive viva voce (Virtual credits)		**4**			**50**

SECOND SEMESTER

(A) Continuous evaluation, Theory, Practical		Credits	Maximum Marks		
Course Code	**Course Title**		**Continuous Evaluation**	**End Semester Exam**	**Total**
I-Core Courses					
UMB 201	Bacteriology	**3**	**40**	**60**	**100**
UMB 202	Medical Microbiology	**3**	**40**	**60**	**100**
UMB 203	Chemistry-II	**3**	**40**	**60**	**100**
II-Practical core courses					
UMB 204	Practical based on UMB 201 and UMB 202	**4**	**40**	**60**	**100**
UMB 205	Practical based on UMB 203 and UMBE 201/ UMBE 202	**4**	**40**	**60**	**100**
III-Elective Courses (Any one to choose)					
UMBE 201	Basics of Computers	**3**	**40**	**60**	**100**
UMBE 202	Bioanlytical Techniques				
IV- Skill Development course					
SKILL	Skill Development module 2	**2**	Grade Point will be provided by Skill Development Centre		
Total valid credits		**22**			
(B) Comprehensive viva voce (Virtual credits)		**4**			**50**

THIRD SEMESTER

(A) Continuous evaluation, Theory, Practical		Credits	Maximum Marks		
Course Code	**Course Title**		**Continuous Evaluation**	**End Semester Exam**	**Total**
I-Core Courses					
UMB 301	Cell Biology-I	**3**	**40**	**60**	**100**
UMB 302	Phycology & Mycology	**3**	**40**	**60**	**100**
UMB 303	Virology	**3**	**40**	**60**	**100**
II-Practical core courses					
UMB 304	Practical based on UMB 301 and UMB 302	**4**	**40**	**60**	**100**
UMB 305	Practical based on UMB 303 and UMBE 301/ UMBE 302	**4**	**40**	**60**	**100**
III-Elective Courses (Any one to choose)					
UMBE 301	Molecular Biology-I	**3**	**40**	**60**	**100**
UMBE 302	Recombinant DNA Technology				
IV- Skill Development course					
SKILL	Skill Development module 3	**2**	Grade Point will be provided by Skill Development Centre		
Total valid credits		**22**			
(B) Comprehensive viva voce (Virtual credits)		**4**			**50**

FOURTH SEMESTER

(A) Continuous evaluation, Theory, Practical		Credits	Maximum Marks		
Course Code	**Course Title**		**Continuous Evaluation**	**End Semester Exam**	**Total**
I-Core Courses					
UMB 401	Microbial Physiology & Metabolism	**3**	**40**	**60**	**100**
UMB 402	Genetics & Genomics-I	**3**	**40**	**60**	**100**
UMB 403	Cell Biology-II	**3**	**40**	**60**	**100**
II-Practical core courses					
UMB 404	Practical based on UMB 401 and UMB 402	**4**	**40**	**60**	**100**
UMB 405	Practical based on UMB 403 and UMBE 401 / UMBE 402	**4**	**40**	**60**	**100**
III-Elective Courses (Any one to choose)					
UMBE 401	Molecular Biology-II	**3**	**40**	**60**	**100**
UMBE 402	Immunology				
IV- Skill Development course					
SKILL	Skill Development module 4	**2**	Grade Point will be provided by Skill Development Centre		
Total valid credits		**22**			
(B) Comprehensive viva voce (Virtual credits)		**4**			**50**

FIFTH SEMESTER

(A) Continuous evaluation, Theory, Practical		Credits	Maximum Marks		
Course Code	**Course Title**		**Continuous Evaluation**	**End Semester Exam**	**Total**
I-Core Courses					
UMB 501	Food & Dairy Microbiology	**3**	**40**	**60**	**100**
UMB 502	Microbial Ecology	**3**	**40**	**60**	**100**
UMB 503	Industrial Microbiology	**3**	**40**	**60**	**100**
II-Practical core courses					
UMB 504	Practical based on UMB 501 and UMB 502	**4**	**40**	**60**	**100**
UMB 505	Practical based on UMB 503 and UMBE 501/ UMBE 502	**4**	**40**	**60**	**100**
III-Elective Courses (Any one to choose)					
UMBE 501	Genetics & Genomics-II	**3**	**40**	**60**	**100**
UMBE 502	Plant Pathology				
IV- Skill Development course					
SKILL	Skill Development module 5	**2**	Grade Point will be provided by Skill Development Centre		
Total valid credits		**22**			
(B) Comprehensive viva voce (Virtual credits)		**4**			**50**

SIXTH SEMESTER

(A) DISSERTATION	Credits	Maximum Marks
A. Valuation (i) Language & Presentation (ii) Review of Literature (iii) Methodology (iv) Analysis & interpretation of Result	**18**	**300**
B. Viva-Voce EXTERNAL		**50**
C. Viva-Voce INTERNAL		**50**
Total		**400**

(B) Comprehensive viva voce (virtual credits)	**4**	**50**

PROGRAMME OUTCOME

The aim of the undergraduate degree in Microbiology is to make students knowledgeable about the various basic concepts in a wide ranging contexts which involve the use of knowledge and skills of Microbiology. Their understanding, knowledge and skills in Microbiology needs to be developed through a thorough teaching learning processes in the class, practical skills through the laboratory work, their presentation and articulation skills, exposure to industry and interaction with industry experts, write short research-based projects where they are guided and mentored by the academic and other experts of the subject.

PROGRAMME SPECIFIC OUTCOMES

A candidate who is conferred an UG (Hons) degree i.e. B.Sc. (Hons) degree in microbiology needs to have acquired/developed following competencies during the programme of the study:

1. Acquired knowledge and understanding of the microbiology concepts as applicable to diverse areas such as medical, industrial, environment, genetics, agriculture, food and others.
2. Demonstrate key practical skills/competencies in working with microbes for study and use in the laboratory as well as outside, including the use of good microbiological practices
3. Competent enough to use microbiology knowledge and skills to analyze problems involving microbes, articulate these with peers/ team members/ other stake holders, and undertake remedial measures/ studies etc.
4. Developed a broader perspective of the discipline of Microbiology to enable him to identify challenging societal problems and plan his professional career to develop innovative solutions for such problems.

FIRST SEMESTER

Course Code UMB 101: INTRODUCTION TO MICROBIAL WORLD

Course Objectives: The main objective of this course is to give students an insight into the world of microorganisms. The paper discusses the historical developments and major milestones leading to the development of microbiology as a separate discipline of science. The students will understand the diversity, structure, evolution and impact of microbes in our day to day life and for the sustenance of life on Earth in general.

Course Learning Outcomes: Upon successful completion of the course, the students:

- will be acquainted with the historical account and development of microbiology as a scientific discipline.
- will have gained knowledge on different systems of classification. They will also acquire an overview of acellular and cellular microorganisms.
- will have acquired in-depth knowledge of the diversity, distribution, cell structure, life cycles and economic importance of algae.
- will have gathered detailed information on the diversity, distribution, structure, life cycles and economic importance of fungi.
- will be aware of general characteristics of protozoa and their economic importance.
- will have a broad perspective of the scope of microbiology.

COURSE CONTENTS

UNIT I

History of Development of Microbiology

History- Discovery and Development of Microbial World, Spontaneous generation vs. biogenesis, Fermentation, Germ Theory of Disease , Contribution of following scientists in the field oh=f Microbiology : Anton von Leeuwenhoek, Joseph Lister, Paul Ehrlich, Edward Jenner, Louis Pasteur, Robert Koch, Martinus W. Beijerinck, Sergei N. Winogradsky, Alexander Fleming, Selman A. Waksman, Elie Metchnikoff, Norman Pace, Carl Woese and Ananda M. Chakraborty

UNIT II

Microbial Diversity and Classification

Occurrence, Binomial Nomenclature, Haekel's Classification, Whittaker's five kingdom and Carl Woese's three kingdom classification systems and their utility. Taxonomy- Principle and its types (Classical Approaches-Numerical, molecular Approach, Chemical, Serological and Genetics), Bacterial taxonomy- Bergey's manual of systematic bacteriology (Eubacteria and Archaebacteria) Difference between prokaryotic and eukaryotic microorganisms

General characteristics of different groups:

A cellular microorganisms (Viruses, Viroids, Prions) and Cellular microorganisms (Bacteria, Algae, Fungi and Protozoa) with emphasis on distribution and occurrence, morphology, mode of reproduction and economic importance.

UNIT III

Viruses

Definition- Virion, prions, viroids and virusoides.

History, general characterstics and Structure, Virus-host (bacteria, animal and plants), Classification, Replication (TMV, poliovirus, T4 and λ phage), lytic and lysogenic cycles.

Bacteria

A General Characterstics- Morpholgical, Chemical , Cultural , Metabolic , Antigenic, very precise account of typical eubacteria, chlamydiae, rickettsiae, mycoplasma, and archaebacteria (extremophiles).

UNIT IV

Algae

History of phycology with emphasis on contributions of scientists; General characteristics of algae including occurrence, Classification, Morphology, Reproduction. Physiology and Cultivation.

UNIT V

Fungi

Historical developments in the field of Mycology, contributions of mycologists. General characteristics of fungi including habitat, distribution, Classification, Morphology, physiology, cultivation and Reproduction.

PRACTICALS

1. Study of the life history of the following scientists and their contributions with the help of their photographs: Anton von Leeuwenhoek, Joseph Lister, Paul Ehrlich, Edward Jenner, Louis Pasteur, Robert Koch, Martinus W. Beijerinck, Sergei N. Winogradsky, Alexander Fleming, Selman A. Waksman, Elie Metchnikoff and Ananda M. Chakraborty.
2. To study the principle and applications of important instruments (biological safety cabinets, autoclave, incubator, BOD incubator, hot air oven) used in the Microbiology laboratory.
3. Study of the following algae by preparing temporary mounts: *Chlamydomonas* and *Spirogyra*.
4. Study of the following fungi by preparing temporary mounts: *Rhizopus* and *Aspergillus*.
5. Study of the following protozoans using permanent mounts/photographs*: Amoeba, Paramecium* and *Giardia.*
6. Study of the following viruses using electron micrographs : TMV, Polio virus, T4 and λ phage.

SUGGESTED READINGS

1. Alexopoulos CJ, Mims CW, and Blackwell M. (1996). Introductory Mycology. 4th edition. John and Sons, Inc.
2. Atlas RM. (1997). Principles of Microbiology. 2nd edition. WM.T.Brown Publishers.
3. Cappucino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education limited.
4. Kumar HD. (1990). Introductory Phycology. 2nd edition. Affiliated East Western Press.
5. Madigan MT, Martinko JM and Parker J. (2009). Brock Biology of Microorganisms. 12th edition. Pearson/Benjamin Cummings.
6. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGraw Hill Book Company.
7. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5th edition. McMillan.

8. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9th edition. Pearson Education.
9. Vashishta BR and Sinha AK. (2008). Fungi. S. Chand and Company Ltd.
10. Vashishta BR. (2005). Algae. 3rd edition. S. Chand and Company Limited, New Delhi.
11. Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education.

FIRST SEMESTER

Course Code UMB 102: TECHNIQUES IN MICROBIOLOGY

Course learning outcomes: Major learning outcome of this course is that students develop a very good understanding of several microbiological techniques and instruments which are commonly used in a microbiology laboratory. The students have learnt-

- Principles which underlies sterilization of culture media, glassware and plastic ware to be used for microbiological work.
- .Principles of a number of analytical instruments which the students have to use during the study and also later as microbiologists for performing various laboratory manipulations.
- Handling and use of microscopes for the study of microorganisms which are among the basic skills expected from a practicing microbiologist. They also get introduced a variety of modifications in the microscopes for specialized viewing.
- Several separation techniques which may be required to be handled later as microbiologists.

COURSE CONTENTS

UNIT I

Pure culture techniques-

Definitions- Pure Culture, Auxenic culture, Mixed Culture, isolates, strains, Clone; Koch's postulates, Pure culture techniques; pour plate, streak plate and spread plate method; Culture media: components of media, natural and synthetic media, chemically defined media, complex media, selective, differential, indicator, enriched and enrichment media.; Techniques for cultivation of Obligate anaerobes (rolling tube and candle jar method).

Control of Microorganisms-

Definitions- Thermal death time, Decimal reduction time, sterilization, Disinfection, antiseptic, Sanitizer, Germicide (Microbicide), Bactericide, Fungicide, Virucide, Sporicide, Bacteriostasis. Control of Microbes-Physical and Chemical Agents with their mode of action and practical applications.

UNIT II

Principle and application of staining techniques-

Definitions-Stain, Dye, Simple Staining, Differential Staining, Negative Stating.

Principle of Staining Techniques- cell wall, capsule, flagella, endospore, cytoplasmic inclusions, acid fast stain, GIEMSA stain and Negative staining.

UNIT III

Instrumentation

Basic Principles, Applications and certain limitations of Instruments- Microscope Resolving power, Numerical Aperture, Magnification.(Bright Field, Dark Field, Fluorescence, phase contrast microscopy, Electron Microscope), pH meter, fluorimeter, colorimeter, Spectrophotometer (visible, UV, infra-red), centrifuge, Oven & Autoclave.

UNIT IV

Principle and application of electrophoresis: Agarose gel electrophoresis, Density gradient gel electrophoresis, capillary electrophoresis, Pulsed field gel electrophoresis, SDS-PAGE, NATIVE-PAGE, Isolectric focusing, 2- D PAGE, Western Blotting, Southern blotting, Northern blotting.

UNIT V

Principles and methods used for analysis biopolymers- X-ray Crystallography, fluorescence, ORD/CD, NMR & ESR spectroscopy; Hydrodynamic methods; Atomic absorption spectroscopy. DNA sequencing, MALDI-TOF, N-terminal sequencing.

SUGGESTED READINGS:

1. Wilson K. and Walker J. (2008). Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press.
2. Nelson D and Cox MM. (2009). Principles of Biochemistry. W.H. Freeman and Company, New York.
3. Talaro K. P. & Talaro A. (2006). Foundations in Microbiology. McGraw-Hill College Dimensi.
4. Potter GWH and Potter GW (1995). Analysis of Biological Molecules: An Introduction to Principles, Instrumentation and Techniques, Kluwer Academic Publishers.
5. Willey J, Sherwood L. and Woolverton C (2007). Prescott/Harley/Klein's Microbiology, McGraw Hill.
6. Willard, HH and Merritt LL (1986). Instrumental Methods of Analysis. CBS Publishers and Distributors.
7. Williams, BL. and Wilson, K. (1975). A Biologists Guide to Principles and Techniques of Practical Biochemistry.John Wiley and Sons. Inc., New York.

FIRST SEMESTER

Course Code UMB 103: CHEMISTRY

Course Objective:

- To introduce the basicconcepts and principles of general chemistry.
- To familiarize the students with principles, fundamentals and application of current chemical and scientific theories including those in Analytical, Inorganic, Organic and Physical Chemistry.
- Students will be able to explore new areas of research in both chemistry and allied fields of microbiology.

Course Learning Outcomes:

- The students will learn about the principle, methodology, calculation and application involved in quantitative, chemical and spectrophotometric methods.
- The student shall learn the essential concepts of chirality, configuration, isomerism in organic chemistry and nomenclature of isomers. Students will familiarize with the elementary concept of saturated aliphatic hydrocarbons reactions
- The students shall learn about the fundamentals of organic chemistry with references to structure and reactivity, reagents and reactions & reaction and mechanism.
- The students will learn about ionic, covalent bonding in molecules .compare/contrast the properties of molecular and ionic compounds.
- The students will learn the elementary concepts of ionic chemical equilibrium with respect to acid – base, salt hydrolysis and solubility of ionic substances.
- Students will learn the IUPAC nomenclature, stereochemistry, structures, reactivity, and mechanism of the chemical reactions.

COURSE CONTENTS

UNIT I

Quantitative methods. Significant figures. Mole concept. Empirical and molecular formula. Molar and molal solutions, mole fraction, ppm and ppb solutions. Stoichiometry and calculations based on it involving acid-base, precipitation, redox, and complex formation reactions. *Chemical methods:* Principle, methodology and calculations involved in for dissolved oxygen (Winkler method), biological oxygen demand, chemical oxygen demand, and hardness of water. Determination of nitrogen in proteins (Kjeldahl method). *Spectrophotometric methods:* Determination of ammonia (by indophenol formation), nitrate (by nitrophenol formation), nitrite (by azo dye formation), and phosphorus (by molybdenum blue formation).

UNIT II

Chemical bonding and molecular structure.

Kossel-Lewis theory, octet rule, electrovalent and covalent bond. Formal charge. Polarity of bonds. The valence shell electron pair repulsion (VSEPR) theory, its postulates and geometry of molecules. Valence bond theory, orbital concept, hybridisation (sp, sp^2, sp^3, sp^3d and sp^3d^2). Molecular orbital theory. Linear combination of atomic orbitals (LCAO). Types and energy level diagram of molecular orbitals. Bond order. Bonding in homonuclear diatomic molecules. Magnetic properties.

UNIT III

Fundamental organic chemistry.

Structure and reactivity. Inductive and electromeric effects. Tautomerism, hyperconjugation and resonance. Intramolecular and intermolecular hydrogen bonding. Structure and stability of carbocations, carbanions and free radicals. Relative strength of organic carboxylic acids, phenols and amines. pKa and pKb values.

Reagents and reactions. Periodic acid, Grignard reagent, ethyl acetoacetate and diethyl malonate.

Reaction and mechanism. Claisen condensation, Benzoin condensation, Perkin reaction, Pinacol-pinacolone rearrangement,

UNIT IV

Stereochemistry of organic compounds.

Conformations. Fisher, sawhorse and Newman structures. IUPAC namenclature of conformational isomers. Conformations and their analysis of ethane, n-butane, cyclohexane and decalins.

Configurations. Chirality. Elements of symmetry. Optical activity, specific rotation. Enantiomers, diastereomers, and meso compounds. Racemic modification. Thereo and erythro compounds. R and S configuration, sequence rules. Geometrical isomerism, E and Z nomenclature.

Stereochemical aspects of chemical reactions. Addition of bromine to Z- and E-butene. E2 reactions.

UNIT IV

Ionic equilibria.

Ostwald dilution law and its experimental verification. Application of Ostwald dilution law. Ionization of water. The pH value, relation between pH and pOH, the pH scale (numerical problems). The salt hydrolysis, and application to (i) salts of strong acids and strong bases, (ii) salts of weak acis and strong bases, (iii) salts of strong acids and weak bases, and (iv) salts of weak acids and weak bases. Hydrolysis constant and degree of hydrolysis.

Buffer solutions. Solubility and solubility product of sparingly soluble salts. Applications of solubility product principle.

PRACTICAL

1. Determination of hardness of water by titration with EDTA.
2. Determination of dissolved oxygen in environmental waters by the Winkler method.
3. Determination of chemical oxygen demand in environmental waters.
4. Determination of strength of a solution of sulphuric acid by titration with sodium hydroxide using pH meter.
5. Determination of ammonia by the indophenol formation, and spectrophotometry.
6. Determination of solubility product of mercuric iodate or lead iodate.

Suggested reference materials

1. Analytical Chemistry, G.D. Christian, John Wiley & Sons (Asia), Singapore
2. Fundamentals of Analytical Chemistry, D.S. Skoog, D.M. West, F.J. Holler and S.R. Cruch, Thomson, Singapore.
3. Organic Chemistry, R.T. Morrison and R.N. Boyd, Pearson Education, Delhi.
4. Organic Chemistry, P.Y. Bruice, Pearson Education, Delhi.
5. A Guidebook to Mechanism in Organic Chemistry, P.Sykes, Orient Longman, New Delhi.
6. Essentials of Physical Chemistry, A. Bahl, B.S. Bahl and G.D. Tuli, S. Chand & Company Ltd, New Delhi.

FIRST SEMESTER
Course Code UMBE 101: COMMUNICATIVE ENGLISH

Course Objective- To develop the learner's communication skills in oral, written and interpersonal, by reinforcing the basics of English grammar.

Course Learning outcomes: Students will

- Improved LSRW- listening, speaking, reading and writing skills and the related sub-skills.
- Recognize and use formal elements of organizational communications: Paper writing, reports, proposals, memorandums, letters etc.
- Enhanced vocabulary with right pronunciation and improved accuracy in grammar.
- Effective oral presentations.

COURSE CONTENTS

UNIT I

Communication: Language and communication, differences between speech and writing, distinct features of speech, distinct features of writing. Speech drills, pronunciation and ascent, stress and intonation.

UNIT II

Writing Skills; Selection of topic, thesis statement, developing the thesis, introductory, developmental, transitional and concluding paragraphs. Articles, parts of speech, tenses, sentence structure, subject- verb agreement, punctuation.

UNIT III

Use of dictionary. Use of words: Diminutives, Homonyms and Homophones. Linguistic unity, coherence and cohesion, descriptive, narrative, expository and argumentative writing.

UNIT IV

Effective writing skills, avoiding common errors. Technical Writing: Scientific and technical subjects; formal and informal writings; formal writings/reports, handbooks, writing assignments.

UNIT V

Purpose and scope of Report, Memo, Agenda and Minutes. Notice, Letters; types and minutes, Manuals.

SUGGESTED READINGS

1. M. Frank. Writing as thinking: A guided process approach, Englewood Cliffs, Prentice Hall Reagents.
2. L. Hamp-Lyons and B. Heasely: Study Writing; A course in written English. For academic and professional purposes, Cambridge Univ. Press.
3. R. Quirk, S. Greenbaum, G. Leech and J. Svartik: A comprehensive grammar of the English language, Longman, London.
4. Daniel G. Riordan & Steven A. Panley: "Technical Report Writing Today" - Biztaantra.
Additional Reference Books

5. Daniel G. Riordan, Steven E. Pauley, Biztantra (2004).: Technical Report Writing Today, 8th edition.
6. Contemporary Business Communication, Scot Ober, Biztantra, 5th Edition (2004).

FIRST SEMESTER

Course Code UMBE 102: FUNDAMENTALS OF STATISTICS

THEORY

UNIT I

Sets, Functions and their graphs: polynomial, sine, cosine, exponential and logarithmic functions, Motivation and illustration for these functions through projectile motion, simple pendulum, biological rhythms, cell division, muscular fibres etc. Simple observations about these functions like increasing, decreasing and, periodicity. Sequences to be introduced through the examples arising in Science beginning with finite sequences, followed by concepts of recursion and difference equations. For instance, the Fibonacci sequence arising from branching habit of trees and breeding habit of rabbits.

UNIT II

Intuitive idea of algebraic relationships and convergence, Infinite Geometric Series, Series formulas for ex, log (1+x), sin x, cos x. Step function. Intuitive idea of discontinuity, continuity and limits.

UNIT III

Differentiation. Conception to be motivated through simple concrete examples as given above from Biological and Physical Sciences. Use of methods of differentiation like Chain rule, Product rule and Quotient rule. Second order derivatives of above functions. Integration as reverse process of differentiation. Integrals of the functions introduced above.

UNIT IV

Points in plane and space and coordinate form. Examples of matrices inducing Dilation, Rotation, Reflection and System of linear equations. Examples of matrices arising in Physical, Biological Sciences and Biological networks. Sum and Produce of matrices upto order 3.

UNIT V

Measures of central tendency. Measures of dispersion; skewness, kurtosis. Elementary Probability and basic laws. Discrete and Continuous Random variable, Mathematical Expectation, Mean and Variance of Binomial, Poisson and Normal distribution. Sample mean and Sampling variance. Hypothesis testing using standard normal variate. Curve Fitting. Correlation and Regression. Emphasis on examples from Biological Sciences.

SUGGESTED READINGS

1. H. S. Bear: Understanding Calculus, John Wiley and Sons (Second Edition); 2003.
2. E. Batschelet : Introduction to Mathematics for Life Scientists,Springer Verlag, International Student Edition, Narosa Publishing House, New Delhi (1971, 1975)

3. A. Edmondson and D. Druce : Advanced Biology Statistics, Oxford University Press; 1996.
4. W. Danial : Biostatistics : A foundation for Analysis in Health Sciences, John Wiley and Sons Inc; 2004.

Note: It is desirable that softwares should be used for demonstrating visual, graphical and application oriented approaches.

SECOND SEMESTER
Course Code UMB 201:BACTERIOLOGY

Course Objectives: The main objective of this course is to provide in-depth knowledge of bacterial cell structure, its cultivation, growth and reproduction. Further, it gives insight into bacterial diversity and its significance. It will also give hands on training of basic and very important bacteriological techniques which will give the student a strong base in microbiology.

Course learning Outcomes: Upon successful completion of the course, the student:

Will gain knowledge about morphology, structure and organisation of different cell components and be able to differentiate between cell walls of Gram positive and Gram-negative bacteria, cell walls and cell membranes of archaea and eubacteria. Will also be able to explain gram and acid-fast staining reactions and effect of antibiotics and enzymes on cell wall structure.

Will get familiar with various techniques used for isolation, cultivation and preservation of different types of bacterial cultures. Will gain insight into working and importance of compound microscope.

Will understand nutritional requirements of different types of bacteria and formulation of media for bacterial growth.

Will be able to briefly explain methods of asexual reproduction in bacteria. Will understand different phases of growth curve and be able to define generation time and growth rate.

Can define and differentiate various types of classifications. Will gain insight into techniques used in polyphasic bacterial taxonomy.

Will get acquainted with differences between archaea and eubacteria and can list their important general characteristics along with ecological significance and economic importance.

COURSE CONTENTS

UNIT I

Cell organization

The morphology and fine structure of bacteria. Cell size, shape and arrangement, glycocalyx, capsule, flagella, endoflagella, fimbriae and pili.Cell-wall: Composition and detailed structure of gram positive and gram-negative cell walls, Archaebacterial cell wall, Gram and acid fast staining mechanisms, lipopolysaccharide (LPS), sphaeroplasts, protoplasts, and L-forms. Effect of antibiotics and enzymes on the cell wall.

Cell Membrane: Structure, function and chemical composition of bacterial and archaeal cell membranes.

Cytoplasm: Ribosomes, mesosomes, inclusion bodies, nucleoid, chromosome and plasmids

Endospore: Structure, formation, stages of sporulation.

UNIT II

Cultivation of Bacteria

Types of growth media (natural, synthetic, complex, enriched, selective media), Anaerobes (Thioglycolate & Anaerobic chamber), liquid shake culture of aerobic bacteria.

Growth and nutrition Definitions- photoautotrophs, photohetrotrophs, chemoautotrophs, chemohetrotrophs, prototrophs and auxotrophs; Nutritional categories among microorganisms Nutritional requirements in bacteria and nutritional categories; The requirements

for carbon, nitrogen and sulphur, growth factors, the role oxygen, Continous cultures, their applications, chemostats and turbidostats.

Reproduction in Bacteria

Definitions- Diauxie growth, synchronous growth, generation time and specific rate growth. Asexual methods of reproduction, logarithmic representation of bacterial populations, phases of growth, calculation of generation time and specific growth rate.

UNIT III

Bacterial Systematics

Definitions-Nomenclature, Taxon, identification, phylogenetic, isolate, strain and clone.

Aim and principles of classification, systematics and taxonomy, concept of species, taxa, strain; conventional, molecular and recent approaches to polyphasic bacterial taxonomy, evolutionary chronometers, rRNA oligonucleotide sequencing, signature sequences, and protein sequences. Differences between eubacteria and archaebacteria

UNIT IV

Important archaeal groups

According to Bergey's Manual of Systematic Bacteriology (Second Edition)

Archaebacteria: General characteristics, phylogenetic overview and economic importance of following group belonging to Methanogens, Halophiles and Thermoacidophiles.

UNIT V

Important eubacterial groups

Eubacteria: Morphology, metabolism, ecological significance and economic importance of following groups:

Gram Negative:

• **Alpha proteobacteria**

Rickettsia, Coxiella, Rhizobium,

• **Beta proteobacteria**

Neisseria, Burkholderia

• **Gamma proteobacteria**

Enterobacteriaceae family, Pseudomonas

• **Delta proteobacteria**

Myxococcus

• **Epsilon proteobacteria**

Helicobacter, Campylobacter

Gram Positive:

• Low G+ C (Firmicutes)

Mycoplasmas, Clostridium, Lactobacillus, Staphylococcus, Streptococcus, Bacillus.

• High G+C (Actinobacteria)

Arthrobacter, Corynebacterium, Mycobacterium, Streptomyces

PRACTICALS

1. Introduction to light microscope
2. Preparation of different media: synthetic media BG-11, Complex media-nutrient agar, McConkey agar, EMB agar.
3. Simple staining
4. Negative staining

5. Gram's staining
6. Acid fast staining-permanent slide only.
7. Capsule staining
8. Spore staining.
9. Isolation of pure cultures of bacteria by streaking method.
10. Estimation of CFU count by spread plate method.
11. Motility by hanging drop method.

SUGGESTED READINGS

1. Atlas RM. (1997). Principles of Microbiology. 2nd edition. WM.T.Brown Publishers.
2. Black JG. (2008). Microbiology: Principles and Explorations. 7th edition. Prentice Hall
3. Madigan MT, and Martinko JM. (2006). Brock Biology of Micro-organisms. 8th edition. Parker J. Prentice Hall International, Inc.
4. Pelczar Jr MJ, Chan ECS, and Krieg NR. (2004). Microbiology. 5th edition Tata McGraw Hill.
5. Srivastava S and Srivastava PS. (2003). Understanding Bacteria. Kluwer Academic Publishers, Dordrecht
6. Stanier RY, Ingraham JL, Wheelis ML and Painter PR. (2005). General Microbiology. 5th edition McMillan.
7. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9th edition Pearson Education.
8. Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and 9. Klein's Microbiology. 7th edition. McGraw Hill Higher Education.

SECOND SEMESTER

Course Code UMB 202: MEDICAL MICROBIOLOGY

Course Objectives: The major objective of this course is to introduce and acquaint the students with the key aspects of medical microbiology related to the diverse microbial pathogens, their virulence mechanisms, diagnostic methods and brief outline of the functional aspects of antimicrobial chemotherapy. The paper deals with the recent development of new molecular diagnostic methods and the global spread and re-emergence of infectious diseases.

Course Learning Outcomes: Upon successful completion of the course, the student:

- Will have understood the diverse nature of the normal microflora of the body and its significance as well. Student will have also acquainted themselves with the terminology and scientific nomenclature used in describing disease causation and pathogenic features of microbial agents of disease.
- Will have gained an in depth knowledge about the spectrum of diseases caused by bacterial pathogens, and an understanding of the course of disease development and accompanying symptoms. Will become familiar with the methods of transmission, epidemiological aspects as well as prevention and control methods.
- Will become acquainted with the spectrum of diseases caused by viral pathogens. Also will understand the course of disease development and symptoms seen in diseases of different organ systems.
- Will understand the causation of fungal and protozoal diseases and methods of prevention and control.
- Will learn about the current approaches to diagnosis of diseases.

- Will have learnt basic concepts of handling clinical specimens and approaches used to aid in detection/diagnosis of diseases using immunological and molecular biology based methods. Will also understand the mode of action of different antimicrobial agents and concept of antimicrobial resistance.

COURSE CONTENTS:

UNIT-I

Microbial Interactions with Human

Definitions-invasion, infection, pathogen, parasite, pathogenicity, toxigenicity, virulence, exotoxins, enterotoxins, endotoxins and neurotoxins.

Normal microbial population of healthy human body - Skin, mouth, upper respiratory tract, intestinal tract, urino-genital tract, eye.

Harmful Microbial Interactions with Human- Entry of pathogens into the host, types of pathogens, Mechanism of pathogenicity, colonization and growth, Virulence, Virulence factors – exotoxins, enterotoxins, endotoxins, neurotoxins. – avoidance of host defense mechanisms, damage to host cell, Host factors for infection and innate resistance to infection.

UNIT-2

Sample collection, transport and diagnosis

Collection, transport and culturing of clinical samples, principles of different diagnostic tests (ELISA, Immunofluorescence, Agglutination based tests, Complement fixation, PCR, DNA probes).

Infection- Sources of infection, method of transmission of infection, factors predisposing to microbial pathogenicity and types of infectious disease

Unit 3

Diseases (with reference to symptoms, pathogenesis, transmission, prophylaxis and control)

Bacterial diseases - *Bacillus anthracis, Corynebacterium diphtheriae, Streptococcus pyogenes, Escherichia coli, Salmonella typhi and paratyphi.*

Viral diseases- Polio, Chicken pox, Herpes, Hepatitis, Rabies, Influenza.

Unit 4

Diseases (with reference to symptoms, pathogenesis, transmission, prophylaxis and control)

Protozoan diseases- Malaria, Kala-azar, and Toxoplasmosis

Fungal diseases-Different types of mycoses with particular reference to Dermatomycoses and Opportunistic mycoses

UNIT 5 Chemical control of Pathogens

Definition and Classification of antibiotics on the basis of structure and mode of action. Assay of antibiotics, antibiotic spectrum .Naturally produced drugs. Antibiotics produced by bacteria, actinomycetes and fungi used in chemotherapy. Semisynthetic antibiotic. Sulfa drugs their use and mechanism of action. Naldixic acid, nitrofurans, isonicotinic hydrazide, metronidazole.

PRACTICALS

1. To identify pathogenic bacteria (any three of *E. coli, Salmonella, Pseudomonas, Staphylococcus, Bacillus)* based on cultural, morphological and biochemical characteristics,

Cultural characteristics on nutrient agar and in nutrient broth, Gram characteristic, motility, presence of endospore and capsule, IMViC, TSI, sugar fermentation, nitrate reduction, urease production, oxidase and catalase tests.

2. To study composition and use of important differential media for identification of pathogenic bacteria EMB agar, McConkey agar, TCBS agar and Salmonella-Shigella agar (any two).

3. To perform antibacterial testing by Kirby-Bauer method.

4. To study symptoms of the diseases with the help of photographs Polio, anthrax, herpes, chicken pox, HPV warts, AIDS (candidiasis, kaposi's sarcoma), dermatomycoses (ring worms), kala-azar

SUGGESTED READINGS

1. Ananthanarayan R and Paniker CKJ. (2005). Textbook of Microbiology. 7th edition (edited by Paniker CKJ). University Press Publication.

2. Brooks GF, Carroll KC, Butel JS and Morse SA. (2007). Jawetz, Melnick and Adelberg's Medical Microbiology. 24th edition. McGraw Hill Publication.

3. Goering R, Dockrell H, Zuckerman M and Wakelin D. (2007). Mims' Medical Microbiology. 4th edition. Elsevier.

4. Joklik WK, Willett HP and Amos DB (1995). Zinsser Microbiology. 19th edition. Appleton-Centuary-Crofts publication.

5. Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education.

SECOND SEMESTER

Course Code UMB 203: CHEMISTRY

Course Objectives:

- To introduce the basic concepts and principles of general chemistry.
- To familiarize the students with principles, fundamentals and application of current chemical and scientific theories including those in Analytical, Inorganic, Organic and Physical Chemistry.
- Students will be able to explore new areas of research in both chemistry and allied fields of microbiology.

Course Learning Outcomes:

1. The students will learn about the energy and electromagnetic spectrum.
2. The student shall learn the principle, theory and applications of UV Visible spectroscopy and Infrared spectroscopy.
3. The students will get knowledge in the field of Electrochemistry special in references with Electrochemical cell, Nerst equation Gibbs energy.
4. The students will learn general structure, configuration and properties of Carbohydrates, Amino acids, Proteins and Peptides.

COURSE CONTENTS

UNIT I

Energy and the electromagnetic spectrum.

Units (wavelength, wavenumber, frequency) and energy of radiation.

UV-Visible spectroscopy.

Theory of electronic spectroscopy. Types of electronic transitions. Allowed and forbidden transitions. Solvent effects on electronic transitions. Beer and Lambert law. Molar absorptivity. Components of UV-Visible spectrophotometer. Application of electronic spectroscopy to conjugated dienes, and α,β-unsaturated carbonyl compounds. Woodward and Fieser rules.

Infrared spectroscopy.

Molecular vibrations, and calculation of vibrational frequencies. Factors affecting vibrational frequency, Vibrational coupling, hydrogen bonding, electronic effects and bond angles. Components of IR spectrophotometer. Interpretation of IR spectra of model organic compounds.

UNIT II

Electrochemistry.

The electrochemical cell. Galvanic and electrolytic cells. Electrode potential and its measurement. Nernst equation. Measurement of equilibrium constant by Nernst equation. Gibbs energy of the reaction. Conductance of electrolytic solutions. Measurement of conductivity of ionic solutions. Molar conductivity. Kohlrausch law of independent migration of ions. Faraday laws of electrolysis.

UNIT III

Carbohydrates.

Classification and general properties of carbohydrates. Osazone formation with phenylhydrazine. Open chain and cyclic structures. Mutarotation. Ascending and descending of monosaccharides. Anomers and epimers. Determination of structure of glucose and fructose. Determination of ring size. Disaccharides and polysaccharides, and general ideas about the structure of sucrose, maltose, lactose, starch and cellulose.

UNIT IV

Amino acids.

Amino acids. General structures. Configuration of amino acids. The zwitter ion, isoelectric point and electrophoresis. Reactions of amino acids, acetylation, esterification and complexation. Ninhydrin test. Synthesis of amino acids by amination of α-haloacids, Gabriel synthesis and diethyl malonate synthesis.

UNIT V

Peptides and proteins.

The peptide bond. General idea about the structure of oxytocin. Primary, secondary, tertiary and quaternary structure of proteins. Determination of primary structure of proteins by N-terminal (Edmann degradation using 1-fluoro-2,4-dinitrobenzene, and phenylisothiocyanate) and C-terminal (hydrazinolysis) methods. Peptides (up to 3 amino acids) synthesis by N-protection and C-activation methods. Merrifield solid-phase synthesis.

PRACTICAL

1. Interpretation of bands in the pre-recorded standard IR spectra of model organic compounds.
2. Separation of mixture of amino acids (2 or 3 components) by paper chromatography.

3. Preparation of thin layer plates, and separation of organic compounds (coloured and colourless).
4. Preparation of chromatographic column and separation of carotenoids and chlorophyll from spinach.
5. Identification of glucose, fructose, sucrose, lactose and starch by standard chemical tests.
6. Determination of glucose by the Fehling reaction (titration and spectrophotometric methods). Demonstration on the application of glucometer.

Suggested reference materials

1. Organic Spectroscopy, W. Kemp, ELBS, Hampshire, UK.
2. Spectroscopic methods in Organic Chemistry, D.H. Williams and I. Fleming, Tata McGraw-Hill, New Delhi.
3. Organic Chemistry, R.T. Morrison and R.N. Boyd, Pearson Education, Delhi.
4. Organic Chemistry, P.Y. Bruice, Pearson Education, Delhi.
5. Essentials of Physical Chemistry, A. Bahl, B.S. Bahl and G.D. Tuli, S. Chand & Company Ltd, New Delhi.
6. Organic Chemistry, T.W.G. Solomons and C.B. Fryhle, Wiley India, New Delhi.

SECOND SEMESTER
Course Code UMBE201: BASICS OF COMPUTERS

Course Objective:

This is a skill based paper that introduces the students to the basics of computer operations

The student is imparted with knowledge on both hardware and software.

The student has a better understanding on the use of computers for various applications

Course Learning outcomes:

- The students shall learn about the introduction, basics, organization, types and preliminary knowledge of operating systems and system tools.
- Students will get the idea about data representation, networks terminologies, multimedia and its applications.
- Students will getgeneral awareness about the IT Act, system security and preliminary knowledge about the I-Tax, E banking and E reservations.

COURSE CONTENTS

UNIT I

Computer Fundamentals

Introduction to Computers: Characteristics of Computers, Uses of computers, Types and generations of Computers Basic Computer Organization - Units of a computer, CPU, ALU, memory hierarchy, registers, I/O devices User Interface with the Operating System, System Tools

UNIT II

Data Representation

Binary representation of integers and real numbers, 1's Complement, 2's Complement, Addition and subtraction of bi

UNIT III

Networks terminology

Types of networks, router, **switch, server-client architecture**

Multimedia

Introduction, Characteristics, Elements, Applications

UNIT IV

Problem Solving

Notion of algorithms, stepwise methodology of developing an algorithm, developing macros in spreadsheet

UNIT V

General Awareness

IT Act, System Security (virus/firewall etc.) I-Tax, Reservations,Banking

PRACTICALS

1. Defined projects will be done by the students and evaluated by the instructor.
2. Document Preparation
3. Presentation Software
4. Familiarizing with the Operating System, Control Panel, Networking Configuration, Firewall setting
5. Spreadsheet Handing, Working with worksheets, Creating a spreadsheet, entering and formatting information, basic functions and formulas, creating charts, tables and graphs.

SUGGESTED READING

1. V Rajaraman, Fundamentals of Computers, Fourth Edition, PHI.
2. Anita Goel, Fundamentals of Computers; Forthcoming title in Pearson-Education

Note: Use of Open Office/Star Office is recommended, as they are freely downloadable.
Reference manual for Open Office available at: http://www.openffice.org
Reference manual for Star Office available at: http://www.sun.com/software/staroffice/

SECOND SEMESTER
Course Code UMBE 202: BIOANALYTICAL TECHNIQUES

Course Objectives: The major objective of this paper is to develop understanding of the key concepts of basic as well as some advanced experimental techniques used across biological sciences, with a focus on principle and design of the instruments. This will enable the students to connect between theoretical concepts of these techniques and their immense biological applications in diverse fields.

Course Learning Outcomes: Upon successful completion of the course, the student:

- Will have identified the principle components of a light microscope, fluorescence microscope, phase contrast microscope, confocal and electron microscope, simultaneously learning about their principles and practical applications in visualizing, identifying and measuring cell, its components and biomolecules. The student will be familiar with staining and preparation of samples for microscopy
- Will have gained an in-depth knowledge of principles and applications of paper chromatography, thin layer chromatography, gel filtration chromatography, ion- exchange chromatography, affinity chromatography, GC, HPLC. This enables the students to apply the acquired knowledge in isolation and separation of biomolecules for analysis.
- Will have learnt basic concepts of various techniques used to resolve and analyze nucleic acids and proteins - agarose gel electrophoresis, native polyacrylamide gel electrophoresis, SDSpolyacrylamide gel electrophoresis, isoelectric focusing, 2D gel electrophoresis, zymogram preparation.
- as well as be able to understand absorption spectra of biomolecules, and will be able to interpret UVvisible and fluorescence spectroscopy outputs.
- Will have clear fundamentals of centrifugation, RCF, sedimentation coefficient, different types of rotors used, principle and working of differential and density gradient centrifugation, preparative and analytical scales of centrifuge, and the specific uses of ultracentrifuge. Students will also be acquainted with limitations of each method.
- Will be introduced to the concepts of advanced techniques like flow cytometry, circular dichroism, surface plasmon resonance and mass spectrometry. Students will also appreciate the applications of these techniques and recent developments that have come about due to these advanced techniques.

COURSE CONTENTS:

Unit- I

Instruments, basic principles and usage:

pH meter- working of pH meter, Types of electrodes,

Centrifuge- Theory of centrifugation, Types of centrifugation, Density gradient centrifugation, Types of centrifuge.

Unit- II

Instruments, basic principles and usage:

Spectrophotometers- Laws of absorption and emission, Visible and UV, IR, Atomic absorption, NMR, X-Ray crystallography.

Unit- III

Chromatography- Paper chromatography, thin layer chromatography, Basic principle of column chromatography, gel filtration, ion exchange chromatography, affinity chromatography, Gas chromatography and its application.

Unit- IV

Electrophoresis – SDS-Polyacrlamide Gel electrophoresis, Agarose Gel electrophoresis, Immuno electrophoresis, Iso electric focusing, MALDI-TOF, ESI.

Unit- V

Radioisotope tracer technique- Introduction, Radioisotopes and Radioactivity, Types of Radioactivity, Isotopic labeling, Autoradiography, Detection and measurement of radioactivity, scintillation counting.

Suggested reading

• Practical Biochemistry, Principles and Techniques, Keith Wilson and John Walker
• Bioinstrumentation, Webster
• Advanced Instrumentation, Data Interpretation, and Control of Biotechnological Processes, J.F. Van Impe,Kluwer Academic
• Crystal Structure Analysis, J.P. Glusker and K.N. Trueblood, Oxford University Press
• Modern Spectroscopy, J.M. Hollas, John Wiley and Son Ltd.
• NMR Spectroscopy: Basic Principles, Concepts and Applications in Chemistry, H. Gunther, John Wiley and Sons Ltd.
• Principles of Physical Biochemistry, K.E. Van Holde, Prentice Hall.
• Principles and Practice of Bioanalysis, Richard F. Venn
• Microscopic Techniques in Biotechnology, Michael Hoppert
• Principles of Fermentation Technology, P.F. Stanbury, A. Whitaker, S.J. Hall

THIRD SEMESTER
Course Code UMB 301: CELL BIOLOGY-I

Course Objectives: The major objective of this course is to educate students about the fundamental concepts in eukaryotic cell biology. The students will be taught the latest developments in cell communication, regulation of cell cycle, and modern tools used to study cell biology. Advances in cancer biology including etiology, diagnosis and therapeutics, as well as the basics of stem cell technology and its applications will be covered.

Course Learning Outcomes: Upon successful completion of the course, the student:

- Will have gained knowledge about features of the cell wall, plasma membrane, cell transport mechanisms and cytoskeleton.

- Will be able to understand the structures and functions of the nucleus and different cell organelles. The structural organization and function roles of chromatin will be learnt.
- Will have understood the mechanisms of protein sorting, intracellular trafficking, protein export.
- Will have gathered understanding of how cells perceive and respond to various signals from within and outside.
- Will have learnt the mechanisms of cell division and the significance of cell cycle and its regulation. Will become familiar with stem cell technology and its applications.
- Will understand the basics of cancer biology including diagnostic techniques and therapy.

COURSE CONTENTS

Unit- I

An Overview of cells: Overview of prokaryotic and eukaryotic cells, cell size and shape, Phages, Viroids, *Mycoplasma* and *Escherichia coli*:

Unit- II

Composition of cells: Molecules of cells, cell membranes, cell proteins; The Nucleus: Nuclear Envelope- structure of nuclear pore complex, nuclear lamina, transport across Nuclear Envelope. Chromatin: Molecular organization, Nucleolus and rRNA Processing.

Unit- III

Mitochondria, chloroplasts and peroxisomes: Structural organization, Function; Semiautonomous nature of mitochondria and chloroplast, chloroplast DNA, Peroxisome assembly.

Unit- IV

The Endoplasmic reticulum, the Golgi apparatus, Mechanism of vesicular transport, Lysosomes, Cytoskeleton and cell movement, Structure and organization of actin filaments; actin, myosin and cell movement.

Unit- V

Transport process: cell membrane models of membrane structure, membrane proteins and their properties, membrane carbohydrates and their role. Transport across membrane active and passive diffusion, their mechanism.

PRACTICALS

1. Separation of nucleic acid bases by paper chromatography.
2. Microscopy- Theoretical knowledge of Light and Electron microscope.
3. Study of the following techniques through electron / photo micrographs: Fluorescence microscopy,

autoradiography, positive staining, negative staining, freeze fracture, freeze etching, shadow casting.

4. Study of structure of cell organelles through electron micrographs.

Permanent slide preparation:

5. Cytochemical staining of DNA-Feulgen.
6. Cytochemical staining of DNA and RNA- Methyl Green Pyronin (MGP).
7. Cytochemical staining of Polysaccharides-Periodic Acid Schiff's (PAS).
8. Cytochemical staining of Total proteins- Bromophenol blue.
9. Cytochemical staining of Histones -Fast Green.

SUGGESTED READINGS

1. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. V Edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.

THIRD SEMESTER

Course Code UMB 302: PHYCOLOGY & MYCOLOGY

Course learning outcomes: By the completion of this course the students able to-

- Describe useful and harmful activities of fungi and algae.
- Identify commonly available fungi and algae and their characteristics.
- Discuss how fungi and algae are used as biofertilizers in agriculture and as biopesticides.
- Grow mushroom in the laboratory**.**

Section A: Phycology

UNIT I

Occurrence, Classification and Life cycles of Algae

Study of the following classes with reference to taxonomic groups listed below (occurrence, classification and life cycles):

Rhodophycota; Xanthophycota; Chrysophycota; Phaephycota; Bacillariophycota; Euglenophycota; Chlorophycota; Cryptophycota; Pyrrophycota

UNIT II

General characteristics of Algae

Morphology, algal pigments, motility, reproduction and economic importance (agriculture, biofertilizer, Industrial application of algae, medicinal importance, Nutritional value, environmental implications, algal blooms)

Section B: Mycology

UNIT III

Occurrence, Classification and Life cycles of fungi

Recent advances in fungal classification, General Characteristic, morphology, Ultrastructure, Physiology, Reproduction- asexual and sexual.

UNIT IV

Study of the following classes with reference to the genera listed below (occurrence, classification and life cycles):

a) Chytridiomycetes- Synchytrium
b) Oomycetes- Saprolegnia
c) Zygomycetes- Mucor, Rhizopus
d) Ascomycetes- Schizosaccharomyces, *Saccharomyces, Penicillium, Neurospora*
e) Deuteromycetes - *Candida, Alternaria, Aspergillus*
f) Basidiomycetes – *Agaricus*

UNIT V

Molds and their association with other organisms- Lichens, fungi and nematodes, fungi as parasites of insects , mycorrhiza.

Economic importance of fungi with examples in Agriculture, Environment, Industry, Medicine, Food, Biodeterioration (of wood, paper, textile, leather), Mycotoxins (Ch 1 Alexopoulos et al., Ch 5 Sumbali) (6 periods) Lichens: classification, physiology and importance. (Ch 13 Alexopoulos et al., Ch 5 Sumbali) (2 periods)

PRACTICALS

Section A - Phycology

1. Study of the following genera through temporary and permanent slides:

1. *Volvox, Coleochaete, Vaucheria, Ectocarpus, Polysiphonia and Nostoc*
2. Section B - Mycology
3. Preparation of Potato Dextrose Medium
4. Study of the vegetative and reproductive structures of following genera through temporary and permanent slides: *Mucor, Saccharomyces, Penicillium, Agaricus and Alternaria*

SUGGESTED READINGS

Section A - Phycology

1. Barasanti L and Guaaltieri P. (2006). Algae: Anatomy Biochemistry and Biotechnology. Taylor and Francis Group, New York.
2. Graham LE, Graham JM and Wilcox LW. (2009). Algae. 2nd edition. Benjamin Cumming, New York.
3. Kumar HD. (1990). Introductory Phycology. 2nd edition. Affiliated East Western Press.
4. Kumar HD. (1995). The Text Book on Algae. 4th edition. Affiliated East Western Press.
5. Lee RE. (1999). Phycology. 4th edition. Cambridge Press.
6. Sharma OP. (2005). Textbook of Algae. Tata McGraw Hill Publishing Co. Ltd.
7. Vashishta BR. (2005). Algae. 3rd edition. S. Chand and Company Ltd., New Delhi.

Section B - Mycology

1. Alexopoulos CJ, Mims CW and Blackwell M. (1996). Introductory Mycology. 4th edition. John Wiley and Sons, Inc.
2. DUMBE HC. (1981). An Introduction to Fungi. Vikas Publishing House Pvt. Ltd.
3. Sumbali G. (2005). The Fungi. 1st edition. Narosa Publishing India House.
4. Vashishta BR and Sinha AK. (2008). Fungi. S. Chand and Company Ltd.
5. Webster J. (1980). Introduction to Fungi. 2nd edition. Cambridge University Press.

THIRD SEMESTER
Course Code UMB 303:VIROLOGY

Course Objectives: The major objective of this course is to acquaint students with the structure of viruses of plants, animals, and bacteria, their genome organization, and replication strategies within the host cell. The student will learn how they evolve, spread and cause disease, and prevention and control methods for the same. The course also includes description of oncogenic viruses and their role in cancers, and emerging viruses in context of threat to public health and their management.

Course Learning Outcomes: Upon successful completion of the course the student

- will have acquired the knowledge in the following areas and:
- Will be able to describe the nature, properties and structure of viruses and will also gain knowledge of taxonomy of different groups of viruses.
- Will be familiar with diversity and multiplication of lytic and lysogenic bacteriophages.
- Will be able to describe different ways of viral transmission, and prominent and unusual genomic features of different viruses with their significance.
- Will understand about the replication strategies, maturation and release of important plant, animal and bacterial viruses.
- Will have gained knowledge about strategies to prevent viral infections: interferons, vaccines and antiviral compounds
- Will understand the concept of oncogenesis, DNA and RNA cancer causing viruses and will learn of newly emerging viruses which have the potential to cause serious threats to public health and have become a global concern.

COURSE CONTENTS

UNIT I Introduction

Definition- viroids, virusoids, satellite viruses and prions. Discovery of viruses, nature and definition of viruses, general properties of viruses - Detection of viruses and antigens in clinical specimens - Serological diagnosis of virus infections. Structure of viruses: Capsid symmetry, enveloped and non-enveloped viruses

Cultivation of viruses. Structure & properties of viroids, prions.

UNIT II

Isolation, purification and cultivation of viruses. Classification and nomenclature of different groups of viruses infecting microbes, plants and animals.

UNIT III

Salient features of viral genome:

Unusual bases (TMV, T4 phage), overlapping genes (ΦX174, Hepatitis B virus), alternate splicing (Picornavirus), terminal redundancy (T4 phage), terminal cohesive ends (lambda phage), ambisense genomes (arenavirus), partial double stranded genomes (Hepatitis B), long terminal repeats (retrovirus), segmented (influenza virus) and non segmented genomes (picornavirus), capping and tailing (TMV).

UNIT IV

Bacteriophages)

Diversity, classification, one step multiplication curve, lytic and lysogenic phages (lambda and P1 phage), concept of early and late proteins, regulation of transcription in lambda phage and applications of bacteriophages.

UNIT V

Viral multiplication and replication strategies

Interaction of viruses with cellular receptors and entry of viruses. Replication strategies of viruses as per Baltimore classification. Assembly, maturation and release of virions. Concept of defective particles.

PRACTICALS

1. To study structure of important animal viruses (rhabdo, influenza, paramyxo, Hepatitis B & retroviruses) using electron micrographs
2. To study structure of important plant viruses (caulimo, gemini, tobacco ring spot, cucumber mosaic & alpha-alpha mosaic viruses) using electron micrographs
3. To study structure of important bacterial viruses (λ, T4 & φX174) using electron micrographs.
4. Isolation and enumeration of bacteriophages from water/sewage sample using double agar layer technique
5. Isolation and propagation of animal viruses by cell culture and chick embryo techniques
6. Study of cytopathic effects using photographs
7. To perform local lesion technique for assaying plant viruses

SUGGESTED READINGS

1. Dimmock NJ, and Primrose SB. (1994). Introduction to Modern Virology. 4th edition. Blackwell Science Ltd.
2. Dimmock, NJ, Easton, AL, Leppard, KN (2007). Introduction to Modern Virology. 6th edition (First Indian reprint 2007), Blackwell Publishing Ltd.
3. Carter J and Saunders V (2007). Virology: Principles and Applications. John Wiley and Sons.
4. Flint SJ, Enquist, LW, Krug, RM, Racaniello, VR, Skalka, AM (2004). Principles of Virology, Molecular biology, Pathogenesis and Control. 2nd edition. ASM press Washington DC.
5. Levy JA, Conrat HF, Owens RA. (2000). Virology. 3rd edition. Prentice Hall publication, New Jersey.
6. Wagner EK, Hewlett MJ. (2004). Basic Virology. 2nd edition. Blackwell Publishing.
7. Mathews. (2004). Plant Virology. Hull R. Academic Press, New York.
8. Nayudu MV. (2008). Plant Viruses. Tata McGraw Hill, India.
9. Bos L. 1999 Plant viruses-A text book of plant virology by. Backhuys Publishers.
10. Versteeg J. (1985). A Color Atlas of Virology. Wolfe Medical Publication.

THIRD SEMESTER
Course Code UMBE 301: MOLECULAR BIOLOGY-I

Course Objectives: The major objective of this course is to develop a clear understanding of the basic concepts of molecular biology starting from the structure and function of DNA to its replication. The student will become familiar with the central dogma of molecular biology, and will learn about the conversion of information from DNA to RNA to proteins, by the study of transcriptional and translational processes.

Course Learning Outcomes: Upon successful completion of the course, the student:

- Will be acquainted with the structure of various types of DNA and RNA as well as their organization as genetic material in various living organisms.
- Will gain an in-depth knowledge of DNA replication mechanisms in prokaryotes and eukaryotes, enzymes and proteins involved in replication.
- Will have learnt the fundamental principles of transcription in prokaryotes and eukaryotes, including the RNA polymerases and general transcription factors involved. Will be able to distinguish between the process in prokaryotes versus eukaryotes.
- Will understand the concept of split genes, introns, exons, spliceosomes and alternative splicing besides learning about other processing events like polyadenylation and capping. Will become familiar with RNA interference and its significance, siRNA and miRNA.
- Will get a clear understanding of translational mechanisms in both prokaryotes and eukaryotes along with the inhibitors of protein synthesis.
- Will understand various mechanisms involved in regulation of gene expression in prokaryotes and eukaryotes at the level of transcription, post-transcriptional processes, and modifications in chromatin structure

COURSE CONTENTS

UNIT I.

Nucleic Acids convey Genetic Information

DNA as the carrier of genetic information, Key experiments establishing-The Central Dogma, DNA Double helix, Genetic code, Direction of Protein Synthesis, Genomics.

UNIT II

The Structures of DNA and RNA / Genetic Material

DNA Structure: Miescher to Watson and Crick- historic perspective, DNA structure, Salient features of double helix, Types of DNA, Types of genetic material, denaturation and renaturation, cot curves. DNA topology - linking number, topoisomerases; Organization of DNAProkaryotes, Viruses, Eukaryotes. RNA Structure Organelle DNA -- mitochondria and chloroplast DNA.

UNIT III

I. Genome Structure, Chromatin and the Nucleosome

Genome Sequence and Chromosome Diversity, Chromosome Duplication and Segregation, The Nucleosome Chromatin structure- Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin. Regulation of Chromatin Structure and Nucleosome Assembly. Organization of Chromosomes

UNIT IV

The Replication of DNA (Prokaryotes and Eukaryotes)

Chemistry of DNA synthesis, general principles - bidirectional replication, Semiconservative, Semi discontinuous, RNA priming, Various models of DNA replication including rolling circle, D-loop (mitochondrial), Θ (theta) mode of replication, replication of linear ds-DNA, replicating the 5'end of linear chromosome. Enzyme involved in DNA replication – DNA polymerases, DNA ligase, Primase, Telomerase and other accessory proteins

UNIT V. The Mutability and Repair of DNA

Definitions, Mutation, muton, replicon, principles of mutation, Replication Errors, DNA Damage, different types of mutations, deletions, duplications, UV induced mutations, repair mechanisms against mutations and their importance.

PRACTICALS

1. Preparation of Polytene chromosome from Chironomous larva/Drosophila larva
2. Demonstration of mammalian sex chromatin.
3. Preparations of temporary mount and study the different stages of Mitosis (Onion root tip).
4. Perform Southern Blot Hybridization (Restrict DNA for Southern Blot electrophoresis, perform electrophoresis of restricted DNA, perform southern transfer, hybridization and detection of gene of interest)
5. Demonstration of Northern Blotting.
6. Demonstration of Western Blotting.
7. Perform DNA amplification by PCR.
8. Study of semiconservative replication of DNA through micrographs/schematic representations.

SUGGESTED BOOKS

1. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
3. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.
4. Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R., (2008) Molecular Biology of the Gene (VI Edition.). Cold Spring Harbour Lab. Press, Pearson Pub.

THIRD SEMESTER

Course Code UMBE 302: RECOMBINANT DNA TECHNOLOGY

Course Objectives: The main objective of this paper is to ensure that the student develops a clear comprehension of the concepts of recombinant DNA technology. The student will get acquainted with the tools and techniques used such as the enzymes, vectors, and cloning methods that can be used, and the applications of cloning such as creation of DNA libraries and recombinant products.

A final exercise on a suitable strategy towards developing a genetically modified crop is incorporated to empower the student to apply the knowledge gained**.**

Course Learning Outcomes: Upon successful completion of the course, the student:

- Will get an overview of developments and contributions of scientists in the field of genetic engineering.
- Will get familiarized with basic cloning tools such as enzymes used to manipulate DNA, and cloning vectors.
- Will have learnt various gene delivery methods and basic essential techniques of DNA, RNA and protein analysis.
- Will gather in-depth knowledge of DNA amplification and sequencing methods.
- Will become conversant with construction and screening of genomic and cDNA libraries
- Will become aware of the applied aspects of all major techniques being used for the benefit of humankind in the areas of agriculture and pharmaceuticals. Students will design a strategy outlining all the steps of developing a novel recombinant.

COURSE CONTENTS:

UNIT I

Introduction to basic biotechnology

Milestones in genetic engineering and biotechnology

Tools of recombinant DNA technology

A. Hosts

E. coli strains; Yeast (*Saccharomyces cerevisiae, Pichia pastoris*); Fungi (*Penicillium, Aspergillus*); Mammalian cell lines - names and genotypes

B. Enzymes

Restriction modification systems: Types I, II and III. Mode of action, nomenclature. Application of Type II restriction enzymes in genetic engineering. DNA modifying enzymes and their applications: Terminal deoxynucleotidyl transferase, kinases and phosphatases, DNA ligases and DNA polymerases, reverse transcriptases, bacteriophage RNA polymerases, exonuclease III, BAL31, mung bean nuclease, S1 nuclease

C. Vectors

Cloning Vectors- Definition and Properties. Plasmid vectors-pBR and pUC series, Bacteriophage lambda and M13 based vectors. Cosmids. Shuttle vectors. BACs, YACs, MACs.

D. Mammalian Expression Vectors

SV40, Vaccinia, Retroviral promoter based vectors

UNIT II

Basic DNA Cloning

Simple cloning of DNA fragments, Vectors: Definition and properties. E. coli expression vectors-lac, tac and T7 promoter based vectors. Yeast expression vectors - pET yeast vectors, YIp, YEp and YCp vectors.

Baculovirus based vectors. Ti based vectors (Binary and Cointegrated vectors) and cloning using linkers and adaptors. Transformation of DNA by chemical method and electroporation

Methods of gene delivery in plants and animals

Microinjection, biolistic method (gene gun), liposome and viral-mediated delivery, Agrobacterium-mediated delivery.

UNIT III

Methods of DNA, RNA and Protein analysis and DNA typing

Agarose gel electrophoresis, Southern - and Northern - blotting techniques, dot blot and colony hybridizations. Chromosome walking and jumping. DNA fingerprinting by RFLP and RAPD. Gel retardation assays. DNA footprinting by DNase I, DNA microarray analysis. SDS-PAGE and Western blotting. Phage display

Amplification of nucleic acids

Polymerase chain reaction - enzymes used, primer design. Cloning PCR products. RT-PCR and principles of real time PCR. Ligation chain reaction

UNIT IV

Construction of Genomic and cDNA libraries

Genomic and cDNA libraries: Preparation and uses. Screening of libraries by colony hybridization and colony, PCR

DNA sequencing and synthesis

Maxam-Gilbert's and Sanger's method. Automated sequencing. Human genome sequencing project

UNIT V

Product of DNA technology

Human protein replacements-insulin, hGH and Factor VIII. Human therapies - tPA, interferon, antisense molecules. Bt transgenics-rice, cotton, brinjal, Analysis of biological processes, DNA typing, gene therapy, commercial products.

PRACTICLAS

1. Digestion of DNA using restriction enzymes and analysis by agarose gel electrophoresis.
2. Ligation of DNA fragments.
3. Demonstration of PCR.
4. Interpretation of sequencing gel electropherograms.

SUGGESTED READINGS

1. Alcamo IE. (2001). DNA Technology: The Awesome Skill. 2nd edition. Elsevier Academic Press, USA.
2. Brown TA. (2006). Gene Cloning and DNA Analysis. 5th edition. Blackwell Publishing, Oxford, U.K.
3. Clark DP and Pazdernik NJ. (2009). Biotechnology-Applying the Genetic Revolution. Elsevier Academic Press, USA.

4. Glick BR and Pasternak JJ. (2003). Molecular Biotechnology. 3rd edition. ASM Press Washington D.C.
5. Nigam A and Ayyagari A. (2007). Lab Manual in Biochemistry, Immunology and Biotechnology. Tata McGraw Hill, India.
6. Primrose SB and Twyman RM. (2006). Principles of Gene Manipulation and Genomics, 7th edition. Blackwell Publishing, Oxford, U.K.
7. Sambrook J, Fritsch EF and Maniatis T. (2001). Molecular Cloning-A Laboratory Manual. 3rd edition. Cold Spring Harbor Laboratory Press.
8. Willey JM, Sherwood LM, and Woolverton CJ. (2008) Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education.

FOURTH SEMESTER

Course Code UMB 401: MICROBIAL PHYSIOLOGY AND METABOLISM

Course Objectives: The main objective of this course is to give students a comprehensive insight into various aspects of microbial physiology and metabolism. These include transport mechanisms present in microbes for the uptake of nutrients, bacterial growth and factors affecting it, and diverse metabolic pathways existing in microbes for energy production and carbon and nitrogen assimilation. The course will build the strong foundation needed by the students for further studies in the field of microbiology.

Course Learning Outcomes: Upon successful completion of the course, the student:

- Will have got acquainted with the diverse physiological groups of bacteria/archaea and microbial transport systems.
- Will have an in-depth knowledge of patterns of bacterial growth, bacterial growth curve, calculation of generation time and specific growth rate, and effect of the environment on growth.
- Will understand the variety of pathways used by bacteria for energy generation and conservation during growth on glucose under aerobic and anaerobic conditions.
- Will become conversant with two important fermentation pathways in microbes.
- Will have an added knowledge on the groups and families of chemolithotrophs and phototrophs, based on their ability to extract energy from inorganic compounds and assimilate carbon from CO2.
- Will have learnt about a typical capability of prokaryotes to reduce nitrogen gas to ammonia. Will become familiar with the physiology of nitrogen fixation and assimilation of inorganic nitrogen by bacteria.

COURSE CONTENTS

UNIT I

Microbial Growth

Definition of growth, generation time and specific growth rate. Growth curve, mathematics expression of growth, batch and continuous culture, synchronous growth, diauxie growth curve.
Effect of the environmental factors-pH, temperature, osmotic pressure, oxygen and radiation on microbial growth
Nutritional classification of microorganisms based on carbon, energy and electron sources

UNIT II

Metabolite Transport

Diffusion: Passive and facilitated, Primary active and secondary active transport, Group translocation (phosphotransferase system), symport, antiport and uniport, electrogenic and electro neutral transport, transport of Iron.

Temperature- temperature ranges for MICROBIAL growth, classification based on temperature ranges and adaptations, pH-classification based on pH ranges and adaptations, solutes and water activity, oxygen concentration, radiation and pressure.

UNIT III

Chemolithotrophic metabolism

Physiological groups of aerobic and anaerobic chemolithotrophs. Hydrogenoxidizing bacteria and methanogens. Phototrophic metabolism

Historical account of photosynthesis, diversity of phototrophic bacteria, anoxygenic and oxygenic photosynthesis, photosynthetic pigments: action and absorption spectrum, type, structure and location, physiology of bacterial photosynthesis: light reactions, cyclic and non-cyclic photophosphorylation. Calvin cycle and reductive TCA cycle.

UNIT IV

Enzymes and their regulation

Importance, structure and classification of enzymes. Apoenzyme and cofactors. Mechanism of enzyme action. Activation energy, Lock and key hypothesis, induced fit. Enzyme kinetics and inhibition. Substrate saturation curve, Michaelis-Menten kinetics, Irreversible and reversible inhibition: competitive and non-competitive inhibition. Enzyme regulation. Synthesis: introduction of enzyme induction and repression. Activity: allostery, covalent modification and feedback inhibition.

UNIT V

Microbial Energetics

Concept of aerobic respiration, anaerobic respiration and fermentation. Central metabolic pathways: EMP pathway, ED pathway, PP pathway, and TCA cycle. Components of respiratory chain, and their inhibitors. Oxidative phosphorylation: ATP synthesis and ATP synthase. Uncouplers, inhibitors and ionophores. Chemical coupling, conformational coupling and chemiosmotic hypothesis.

PRACTICALS

1. To study and plot the growth curve of *E coli* using turbidometric method and to calculate specific growth rate and generation time.
2. To study and plot the growth curve of *Aspergillus niger* by radial growth measurements.
3. To study the effect of pH on the growth of *E. coli*
4. To study the effect of temperature of *Aspergillus niger* by dry weight method.
5. Demonstration of the thermal death time and decimal reduction time of *E. coli*.

SUGGESTED READINGS

1. Devlin RM. (1975). Plant Physiology. 3rd edition, Willard Grant Press.
2. Gottschalk G. (1986). Bacterial Metabolism. 2nd edition. Springer Verlag
3. Madigan MT, Martinko JM and Parker J. (2003). Brock Biology of Microorganisms. 10th edition. Pearson/Benjamin Cummings.

4. Moat AG and Foster JW. (2002). MICROBIAL Physiology. 4th edition. John Wiley & Sons.
5. Reddy SR and Reddy SM. (2005). MICROBIAL Physiology. Scientific Publishers India.
6. Stanier RY, Ingrahm JI, Wheelis ML and Painter PR. (1987). General Microbiology. 5th edition, McMillan Press.
7. Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education.
8 Atlas RM. (1989). Microbiology: Fundamentals and Applications. 2nd Edition, MacMillan Publishing Company, New York.
9. Conn EE and Stumpf PK. (1976). Outlines of Biochemistry. John Wiley & Sons.
10. Gallon JR and Chaplin AE. (1987). An Introduction to Nitrogen Fixation. Cassell Education Ltd.
11. Gottschalk G. (1986). Bacterial Metabolism. 2nd edition. Springer Verlag.
12. Lehninger A. (1982). Biochemistry. Worth Publ.
13. Moat AG and Foster JW. (2002). MICROBIAL Physiology. John Wiley and Sons.
15. Stryer L. (1988). Biochemistry. Freeman & Co. NewYork.

FOURTH SEMESTER
Course Code UMB-402: GENETICS AND GENOMICS-I

Course Objectives: The major objective of this course is to develop clear understanding of various aspects of microbial genetics and genomes in relation to microbial survival and propagation and to enable students to better understand courses taught later such as recombinant DNA technology and other allied papers.

Course Learning Outcomes: Upon successful completion of the course, the student will have

- Knowledge of Genetic material and genetic recombination.
- Understanding the stages of gene expression: phenomena of cell division.
- Improved understanding of mutation and mutagens.
- Applying the Mendelian principles and its extensions to solve genetic problems

COURSE CONTENTS

UNIT I

Introduction to Genetics

Definition: gene, genome, trait, genetic material, genetic maps, genotype, phenotype. Mendel's work on transmission of traits, Genetic Variation, Molecular basis of Genetic Information. Mitosis and Meiosis

Interrelation between the cell structure and the genetics function, Mitosis, Meiosis (explaining Mendel's ratios).

UNIT II

The structure of genetic material

The nature of the genetic material, Discovery of DNA and RNA as genetic material, the chemical composition of DNA and RNA, Organization of DNA in chromosomes, Structural characteristics of bacterial and viral chromosomes, DNA replication in prokaryotes and Eukaryotes.

UNIT III

Mendelian Genetics and its Extension

Principles of Inheritance, Chromosome theory of inheritance, Laws of Probability, Pedigree analysis, Incomplete and codominance, Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Environmental effects on phenotypic expression, sex linked inheritance.

Linkage, Crossing Over and Chromosomal Mapping

Linkage and crossing over, Cytological basis of crossing over, Molecular mechanism of crossing over, Recombination frequency as a measure of linkage intensity, two factor and three factor crosses, Interference and coincidence, Somatic cell genetics – an alternative approach to gene mapping.

UNIT IV Mutations

Chromosomal Mutations: Deletion, Duplication, Inversion, Translocation, Aneuploidy and Polyploidy. Gene mutations: Induced versus Spontaneous mutations, Back versus Suppressor mutations, Molecular basis of Mutations in relation to UV light and chemical mutagens, Detection of mutations: CLB method, Attached X method, DNA repair mechanisms.

UNIT V. Extrachromosomal Inheritance

Chloroplast mutation/Variegation in Four o' clock plant and Chlymodomonas, Mitochondrial mutations in Neurospora and yeast, Maternal effects, Infective heredity- Kappa particles in Paramecium.

Quantitative Genetics

Quantitative and multifactor inheritance, Transgressive variations, Heterosis.

PRACTICALS

1. Mendelian laws and gene interaction using Drosophila crosses.
2. Chi-square and probability.
3. Study of Linkage, recombination, gene mapping using marker based data from Drosophila.
4. Study of Human and Phlox/ Allium Karyotype (normal and abnormal).
5. Pedigree analysis of some human inherited traits.
6. Study of Hardy-Weinberg Law using simulations (seeds).

SUGGESTED READINGS

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). VIII ed. Principles of Genetics. Wiley India.
2. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. XI Edition. Benjamin Cummings.
4. Russell, P. J. (2009). iGenetics- A Molecular Approach. III Edition. Benjamin Cummings.
5. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
6. Pevsner, J. (2009). Bioinformatics and Functional Genomics. II Edition. John Wiley & Sons.

7. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. IX Edition. Introduction to Genetic Analysis.

ADDITIONAL READINGS

Both students as well as teachers of genetics can further benefit from knowledge of following topics as given below-

- **Epigenetics-** http://www.nature.com/nrg/focus/epigenetics/index.html
- **Tetrad Analysis in fungi**
- **Centromere Mapping**
- **Cytogenetic Mapping**

FOURTH SEMESTER
Course Code UMB 403: CELL BIOLOGY-II

Course Objective- Provide understanding of regulation of cellular processes, cell signaling and proliferation.

Course Learning Outcomes:-

- Understanding of processes that control eukaryotic cell cycle, cell division and cell death.
- Conceptualized the mechanisms of signal transduction and cell-cell interaction.
- Knowledge of stem cell and their therapeutic uses and limitations.
- Linking the rapid advances in cell biology for a better understanding of diseases like Cancer and its cytology

COURSE CONTENTS

UNIT I

The Plasma Membrane

Structure; Lipid composition and structural organization, classes of lipids, protein interaction within the membranes, trans-membrane proteins and glycolipids. Transport of small molecules, Endocytosis

Cell Wall, **the Extracellular Matrix and Cell Interactions**

Bacterial and Eukaryotic Cell Wall; the extracellular matrix and cell matrix interactions; cell-cell interactions.

UNIT II

Cell Signaling

Signaling at the cell surface, Signaling molecules and their receptor; receptor proteins, ligand binding and effector specificity, functions of cell surface receptors; Intracellular signal transduction pathway; signaling networks, conserved intracellular protein functions in signal transduction, appropriate cellular responses.

UNIT III

The Cell Cycle

Eukaryotic Cell Cycle-overview of the cell cycle and its control, Regulation of Cell cycle progression, diverse experimental systems for regulation of cell cycle, Events of Mitotic Phase, Meiosis, Biochemical studies with oocytes, eggs and early embryos.

UNIT IV

Cell Death and Cell Renewal

The birth of cells, cell type specification in yeast, regulation of asymmetric cell division, specification and differentiation of muscles, Programmed Cell Death, Stem Cells and Maintenance of adult tissues, Embryonic Stem Cells and Therapeutic cloning.

UNIT V

Cancer

Tumor cells and the onset of cancer, Development and Causes of Cancer, the genetic basis of cancer, Oncogenic mutations in growth promoting proteins, Tumor Viruses, Oncogenes, Tumor Suppressor genes, Cancer Treatment- molecular approach.

PRACTICALS

1. To demonstrate the presence of mitochondria in striated muscle cells/ cheek epithelial cell using vital stain Janus Green B.
2. Study of polyploidy in Onion root tip by colchicine treatment.
3. Preparations of temporary mount of Grasshopper testis / onion flower bud anthers and study the different stages of Meiosis.
4. Study of mitosis and meiosis from permanent slides.
5. Identification and study of cancer cells- Slides/Photomicrographs.

SUGGESTED READINGS

1. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. V Edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco

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FOURTH SEMESTER

Course Code UMBE 401: MOLECULAR BIOLOGY-II

Course Objectives - To impart knowledge about the protein synthesis and their mechanisms and regulation within the cell.

Course Learning outcomes –

- Study of RNA polymerase and mechanisms in prokaryotic and eukaryotic cell.
- Study of RNA modification, split genes, RNA splicing, m-RNA transport

- Translation process in prokaryotic and eukaryotic cell.
- Transcription regulation in prokaryotes and eukaryotes and regulatory RNAs.

COURSE CONTENTS

UNIT I.

Mechanism of Transcription

RNA Polymerase and the transcription unit, Transcription in Prokaryotes, Transcription in Eukaryotes

RNA Modifications

Split genes, concept of introns and exons, removal of Introns, spliceosome machinery, splicing pathways, alternative splicing, exon shuffling, RNA editing, and mRNA transport.

UNIT II.

Translation (Prokaryotes and Eukaryotes)

Assembly line of polypeptide synthesis - ribosome structure and assembly, various steps in protein synthesis. Charging of tRNA, aminoacyl tRNA synthetases. Proteins involved in initiation, elongation and termination of polypeptides. Fidelity of translation. Inhibitors of protein synthesis. Regulation of translation Translation-dependent regulation of mRNA and Protein Stability.

UNIT III

Transcription Regulation in Prokaryotes

Transcription Regulation in Prokaryotes: Principles of transcriptional regulation, regulation at initiation with examples from lac and trp operons, regulation of transcription termination.

UNIT IV

Transcription Regulation in Eukaryotes

Conserved mechanism of regulation, Eukaryotic activators, Signal integration, combinatorial control, transcriptional repressors, signal transduction and control of transcriptional regulator, Gene Silencing

UNIT V

Regulatory RNAs

Transcription Regulation in Eukaryotes & Regulatory RNAs: Conserved mechanism of regulation, Eukaryotic activators, Signal integration, combinatorial control, Riboswitches, RNA interference, miRNA, siRNA, Regulatory RNA and Xinactivation

PRACTICALS

1. Preparation of culture medium (LB) for E.coli (both solid and liquid) and raise culture of *E.coli.*
2. Demonstration of antibiotic resistance. (Culture of E.coli containing plasmid (pUC 18/19) in LB medium with/without antibiotic pressure and interpretation of results).
3. Isolation and quantitative estimation of salmon sperm / calf thymus DNA using colorimeter (Diphenylamine reagent) or spectrophotometer (A260 measurement).
4. To perform Ames test in Salmonella / E.coli to study mutagenicity.

SUGGESTED READINGS

1. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
3. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.
4. Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R., (2008) Molecular Biology of the Gene (VI Edition.). Cold Spring Harbour Lab. Press, Pearson Pub.

FOURTH SEMESTER
Course Code UMBE 402: IMMUNOLOGY

Course Objectives: The major objective of this course is to develop a clear understanding about the host immune system and advances in the field of Immunology. The student will become familiar with the cells, tissues, and organs constituting the immune system and the various mechanisms used to defend host against microorganisms. The student will gain an understanding of the relationship between the immune system, pathogens and the development of immunity, and will learn how the inappropriate immune response can lead to allergy, autoimmunity and other consequences. The course will further the student's understanding of how advances in immunology have changed the face of modern medicine.

Course Learning Outcomes: Upon successful completion of the course, the student

- Will be acquainted with the emergence of immunology and how the immune system protects us from infection through various lines of defense.
- Will have gained an in-depth knowledge of characteristics and functions of the cells of the immune system and the organization of organs of the immune system.
- Can understand the characteristics that make the molecules to act as antigens. The students will also be conversant with the types, properties and functions of antibodies made against the antigens. Will be able to outline the production and use of monoclonal antibodies
- Will understand the cell surface proteins essential for generation of acquired immune response to differentiate self and non-self molecules and the pathways for antigen processing and presentation.
- Will be acquainted with the mechanisms by which the complement system is recruited and enhances (complements) the ability of antibodies and phagocytic cells to clear microbes and damaged cells from an organism, promotes inflammation, and attacks the pathogen's cell membranes.
- Will be acquainted with the generation and the killing mechanisms of humoral and cell mediated immunity. Will have gained in depth knowledge of various immunological techniques. Will be able to outline the immunodeficiency disorders like autoimmunity and hypersensitivity.

COURSE CONTENTS

UNIT I

Introduction

Concept of Innate and Adaptive immunity; Contributions of following scientists to the development of field of immunology - Edward Jenner, Karl Landsteiner, Robert Koch, Paul Ehrlich, Elie Metchnikoff, Peter Medawar, MacFarlane Burnet, Neils K Jerne, Rodney Porter and Susumu Tonegawa.

UNIT II

Immune Cells and Organs

Structure, Functions and Properties of: Immune Cells – Stem cell, T cell, B cell, NK cell, Macrophage, Neutrophil, Eosinophil, Basophil, Mast cell, Dendritic cell; and Immune Organs – Bone Marrow, Thymus, Lymph Node, Spleen, GALT, MALT, CALT

Antigens

Characteristics of an antigen (Foreignness, Molecular size and Heterogeneity); Haptens; Epitopes (T & B cell epitopes); T-dependent and T-independent antigens; Adjuvants

Antibodies**)**

Structure, Types, Functions and Properties of antibodies; Antigenic determinants on antibodies (Isotypic,

allotypic, idiotypic); VDJ rearrangements; Monoclonal and Chimeric antibodies

UNIT III

Major Histocompatibility Complex

Organization of MHC locus (Mice & Human); Structure and Functions of MHC I & II molecules; Antigen processing and presentation (Cytosolic and Endocytic pathways)

Complement System

Components of the Complement system; Activation pathways (Classical, Alternative and Lectin pathways); Biological consequences of complement activation

UNIT IV

Generation of Immune Response

Primary and Secondary Immune Response; Generation of Humoral Immune Response (Plasma and Memory cells); Generation of Cell Mediated Immune Response (Self MHC restriction, T cell activation, Costimulatory signals); Killing Mechanisms by CTL and NK cells, Introduction to tolerance.

UNIT V

Immunological Disorders and Tumor Immunity

Types of Autoimmunity and Hypersensitivity with examples; Immunodeficiencies - Animal models (Nude and SCID mice), SCID, DiGeorge syndrome, Chediak- Higashi syndrome, Leukocyte adhesion deficiency, CGD; Characteristics of tumor antigens.

Immunological Techniques

Principles of Precipitation, Agglutination, Immunodiffusion, Immunoelectrophoresis, ELISA, ELISPOT, Western blotting, Immunofluoresence, Flow cytometry, Immunoelectron microscopy, RIST, RAST, MLR.

PRACTICALS

1. Identification of human blood groups.
2. To perform Total Leukocyte Count of the given blood sample.
3. To perform Differential Leukocyte Count of the given blood sample.
4. To separate serum from the blood sample (demonstration).
5. To perform immunodiffusion by Ouchterlony method.
6. To perform DOT ELISA.
7. To perform immunoelectrophoresis.

SUGGESTED READINGS

1. Abbas AK, Lichtman AH, Pillai S. (2007). Cellular and Molecular Immunology. 6th edition Saunders Publication, Philadelphia.
2. Delves P, Martin S, Burton D, Roitt IM. (2006). Roitt's Essential Immunology. 11th edition Wiley- Blackwell Scientific Publication, Oxford.
3. Goldsby RA, Kindt TJ, Osborne BA. (2007). Kuby's Immunology. 6th edition W.H. Freeman and Company, New York.
4. Murphy K, Travers P, Walport M. (2008). Janeway's Immunobiology. 7th edition Garland Science Publishers, New York.
5. Peakman M, and Vergani D. (2009). Basic and Clinical Immunology. 2nd edition Churchill Livingstone Publishers, Edinberg.
6. Richard C and Geiffrey S. (2009). Immunology. 6th edition. Wiley Blackwell Publication edition, Elsevier Science Ltd.
5. Salisbury, Whitaker and Hall. Principles of fermentation Technology

FIFTH SEMESTER

Course Code UMB 501: FOOD AND DAIRY MICROBIOLOGY

Course Objectives: The main objective of this paper is to acquaint students with the role of microorganisms in association with foods, highlighting both their beneficial and harmful activities and their applications in the food industry.

Course Learning Outcomes: On successful completion of the course, the student:

- Will be aware of the possible sources of contamination of foods and the parameters affecting microbial growth in foods.
- Will gain insight into the microbial spoilage of some foods
- Will acquire an in-depth knowledge of various physical and chemical methods used for food preservation. Will be acquainted with microbial production of fermented dairy and non-dairy food products. Will also be able to understand the health benefits of prebiotics, probiotics and synbiotics.
- Will be conversant with some food-borne diseases and will be able to explain methods for detection of food borne pathogens
- Will be able to understand the concept of quality control of food.

UNIT I

Foods as a substrate for microorganisms

Basic concepts and scope of food and dairy microbiology, Study of primary sources of microorganisms in foods,Effect of intrinsic (pH, moisture content) and extrinsic (temperature and relative humidity) factors on microbial growth in various foods.

UNIT II

Microbial Spoilage of foods

Principle, Sources and mechanism of microbiological food spoilage, Study of spoiled fruits, vegetable, bread and eggs, Study of spoilage of milk for acid, gas and proteolysis.

UNIT III

Principles and Methods of food Preservation

Physical (Temperature- pasteurization, , high temperatures, low temperature-freezing, dehydration; appertization, aseptic packaging, ionizing radiation, osmotic pressure) and chemical methods (organic acids, esters, sulphur- dioxide, nitrate, nitrites, salts and high sugar concentration). Comparison of shelf life of pasteurized, UHT milk, raw milk both at low and room temperature, Aseptic packaging – layers of tetra packs and comparison of shelf life of such packaged fruit juices, Study of specimens of various canned foods (vegetables, fruits, pickles etc) and treatments given to them for preservation.

UNIT IV

Microbiology and Process of Fermented Foods

Microbiology of milk, Cheese, Yogurt (curd), Idli, Fermented Food (dosa, sauerkraut, soy sauce and tampeh) Use of starter cultures and preparation of Dahi, To perform various tests such as pH and titratable acidity of various fermented milk products (yogurt) & Probiotic drinks available in the market

UNIT V

Food-Borne Diseases

A brief account on common food–borne diseases (Laboratory testing- causative agents, symptoms, food involved, preventing measures)

Study of food intoxications: *Staphylococcus aureus, Clostridium botulinum* and mycotoxins; Food infections: *Bacillus cereus, Vibrio parahaemolyticus, Escherichia coli, Salmonella and Shigella*

Food sanitation and control

HACCP, Indices of food sanitary quality and sanitizers

Water Potability

Treatment and safety of drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive test/MPN test, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests.

PRACTICALS

1. MBRT of milk samples and their standard plate count.
2. Alkaline phosphatase test to check the efficiency of pasteurization of milk.
3. Isolation of any pathogenic bacteria (Staphylococcus or Salmonella) from food products.
4. Isolation of spoilage microorganisms from spoiled vegetables/fruits.
5. Isolation of spoilage microorganisms from bread.
6. Preparation of Yogurt/Dahi.

7. Determination of potability and faecal contamination of water samples by presumptive test/MPN test, confirmed and completed tests.

SUGGESTED READINGS

1. Adams MR and Moss MO. (1995). Food Microbiology. 4th edition, New Age International (P) Limited Publishers, New Delhi, India.
2. Banwart JM. (1987). Basic Food Microbiology. 1st edition. CBS Publishers and Distributors, Delhi, India.
3. Davidson PM and Brannen AL. (1993). AntiMICROBIALs in Foods. Marcel Dekker, New York.
4. Dillion VM and Board RG. (1996). Natural AntiMICROBIAL Systems and Food Preservation. CAB International, Wallingford, Oxon.
5. Frazier WC and Westhoff DC. (1992). Food Microbiology. 3rd edition. Tata McGraw-Hill Publishing Company Ltd, New Delhi, India.
6. Gould GW. (1995). New Methods of Food Preservation. Blackie Academic and Professional, London.
7. Jay JM, Loessner MJ and Golden DA. (2005). Modern Food Microbiology. 7th edition, CBS Publishers and Distributors, Delhi, India.
8. Lund BM, Baird Parker AC, and Gould GW. (2000). The MICROBiological Safety and Quality of Foods. Vol. 1-2, ASPEN Publication, Gaithersberg, MD.
9. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9th edition. Pearson Education.

FIFTH SEMESTER
Course Code UMB 502: MICROBIAL ECOLOGY

Course Objectives: The objective of this paper is to make the students aware of the diverse microbial populations present in different habitats and interaction amongst them. They would also gain knowledge of the nutrient cycling occurring in the ecosystem(s). The students would learn about environmental problems and their management and will motivate them to think of novel ways to solve various environmental problems.

Course Learning Outcomes: After studying this course, the student:

- Will know about the diverse microbial populations present in various natural habitats (different types).
- Would understand the interaction of microbes with both micro and macro-organisms (plants and animals).
- Would become aware of the importance of microbes in any ecosystem with reference to nutrient cycling/ biogeo-chemical cycling.
- Would become familiar with and gain knowledge about the various methods of waste treatment (solid and liquid) and management.
- Would become aware of the degradable properties of a microbial population present in a habitat/ecosystem
- Would gain knowledge of the methods used in testing the potability of water.

COURSE CONTENTS

UNIT I

History, significance and developments in the field of MICROBIAL ecology

Contributions of Beijerinck, Winogradsky, Kluyver, Van Niel, Martin Alexander, Selman A. Waksman, Environmental chemistry, Atmosphereic pollutants, Types of wastes, The Atmosphere, Organization of life, Ecosystems.

UNIT II

Microorganisms & their natural habitats

A. Terrestrial Environment: Soil characteristics, Soil profile, Soil formation, Soil as a natural habitat of microbes, Soil microflora

B. Aquatic Environment: Stratification & Microflora of Freshwater & Marine habitats

C. Atmosphere: Stratification of the Atmosphere, Aeromicroflora, Dispersal of microbes.

D. Animal Environment: Microbes in/on human body (Microbiomics) & animal (ruminants) body.

E. Extreme Habitats: Extremophiles: Microbes thriving at high & low temperatures, pH, high hydrostatic & osmotic pressures, salinity, & low nutrient levels.

UNIT III

Succession of microbial communities in the decomposition of plant organic matter

Biological Interactions

A. Microbe–Microbe Interactions

Mutualism, Synergism, Commensalism, Competition, Amensalism, Parasitism, Predation, Biocontrol agents

B. Microbe–Plant Interactions

Roots, Aerial Plant surfaces, Biological Nitrogen fixation (symbiotic/nonsymbiotic - biofertilizers)

C. Microbe–Animal Interactions

Role of Microbes in Ruminants, Nematophagus fungi, Luminescent bacteria as symbiont

UNIT IV

Biogeochemical cycles an introduction (Ch 10, 11 Atlas and Bartha)

Carbon cycle:

Microbial degradation of polysaccharide (cellulose, hemicellulose, lignin, chitin)

Nitrogen cycle:

Ammonification, nitrification, denitrification & nitrate reduction. Nitrate pollution.

Phosphorous cycle:

Phosphate immobilization and phosphate solubilization

Sulphur Cycle:

Microbes involved in sulphur cycle

UNIT V

Solid Waste Management

Sources and types of solid waste, methods of disposal of solid waste (incineration, composting, sanitary landfill)

Liquid Waste Management

Composition of sewage; strength of sewage (BOD and COD); Primary, secondary (aerobic – oxidation pond, trickling filter, rotating biological contractor/biodisc system, activated sludge process and anaerobic – septic tank, imhoff tank, anaerobic digestor) and tertiary sewage treatment

Bioleaching

Biodeterioration

MICROBIAL deterioration of metals (corrosion), textile and paper

PRACTICALS

1. Analysis of soil - pH, moisture content, water holding capacity, percolation, capillary action
2. Isolation of microbes (bacteria & fungi) from soil (28ºC & 45ºC)
3. Isolation of microbes (bacteria & fungi) from rhizosphere and rhizoplane.
4. Detection (qualitative) of the presence of enzymes (dehydrogenase, amylase, urease) in soil.
5. Isolation of *Rhizobium* from root nodules of legumes
6. Isolation of *Azotobacter/Azospirillum* from soil
7. Isolation of phosphate solubilizers from soil

SUGGESTED READINGS

1. Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing, USA.
2. Atlas RM. (1989). Microbiology: Fundamentals and Applications. 2nd Edition, MacMillan Publishing Company, New York.
3. Madigan MT, Martinko JM and Parker J. (2009). Brock Biology of Microorganisms. 12th edition. Pearson/ Benjamin Cummings.
4. Campbell RE. (1983). Microbial Ecology. Blackwell Scientific Publication, Oxford, England.
5. Coyne MS. (2001). Soil Microbiology: An Exploratory Approach. Delmar Thomson Learning.
6. Lynch JM & Hobbie JE. (1988). Microorganisms in Action: Concepts & Application in MICROBIAL Ecology. Blackwell Scientific Publication, U.K.
7. Maier RM, Pepper IL and Gerba CP. (2009). Environmental Microbiology. 2nd edition, Academic Press.
8. Martin A. (1977). An Introduction to Soil Microbiology. 2nd edition. John Wiley & Sons Inc. New York & London.
9. Stolp H. (1988). Microbial Ecology: Organisms Habitats Activities. Cambridge University Press, Cambridge, England.
10. Subba Rao NS. (1999). Soil Microbiology. 4th edition. Oxford & IBH Publishing Co. New Delhi.

FIFTH SEMESTER
Course Code UMB 503: INDUSTRIAL MICROBIOLOGY

Course Objectives: The major objective of this course is to acquaint students with the various aspects of industrial microbiology, different types of fermentation processes, fermenters designs and operations Students will become familiar with mass scale culturing of microorganisms for industrial production of various biomolecules and /metabolites of industrial interest and different recovery methods in detail. Students will also learn about immobilization of enzymes and their applications.

Course Learning Outcomes: Upon successful completion of the course the student:

Will understand the development and importance of industrial microbiology and will be conversant with different types of fermentation processes in liquid media as well as solid state substrates media.

- Will learn about the design, operation and uses of different types of fermenters of laboratory, pilot and industrial scale.
- Will gain insight into the techniques of isolation, screening, preservation and maintenance of industrially important microbial strains and different types of media used in fermentation processes.
- Will be acquainted with principles of techniques used for the extraction and purification of industrial products produced using microbial fermentation processes.
- Will have gained in-depth knowledge of the principles of microbial production and recovery of industrial products at large scale.
- Will have an understanding of the methods of enzyme immobilization, its advantages, drawbacks and its applications in the industry

COURSE CONTENTS

UNIT I

Introduction to industrial Microbiology

Brief history and developments in industrial Microbiology

Fermentation processes

Definition- Fermentation, respiration, oxidation, prototroph and auxotroph.

Fermenter – types & operation of Bioreactors, physico-chemical standards used in bioreactors, limitations of bioreactors, stages of fermentation processes, Solid substrate fermentation, Fermenters (Stirred tank, bubble columns, airlift). Submerged fermentation, advantages & disadvantages of solid substrate & liquid fermentations.

UNIT II

Control parameters, industrially important strains, media ingredients

Measurement and control of fermentation parameters

Control and monitoring of different parameters in a bioreactor; pH, temperature, dissolved oxygen, foaming and aeration

UNIT III

Isolation of industrially important MICROBIAL strains

Primary and secondary screening, strain development, preservation and maintenance of industrial strains and strain improvement by mutation of gene transfer.

Media and ingredients for industrial fermentations

Crude and synthetic media; molasses, corn-steep liquor, sulphite waste liquor, whey and yeast extract.

UNIT IV

Down-stream Processing

extraction, separation, concentration, recovery & purification, operations (organic acids, alcohol, enzymes and vitamins).

Up-stream and Down-stream processing- Industrial production of organic acids- Acetic Acid, Citric acid and lactic acid; alcohol- ethyl alcohol, wine and beer enzymes- α-amylase, protease; antibiotics- penicillin, tetracycline and vitamins- vitamin B12; bioinsecticides (Bt) and Steroid transformations with reference to easily available raw materials.

UNIT V

Enzyme immobilization

Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase).

PRACTICALS

1. MICROBIAL fermentations for the production and estimation (qualitative and quantitative) of:

(a) Enzyme: Amylase

(b) Amino acid: Glutamic acid

(c) Organic acid: Citric acid

(d) Alcohol: Ethanol

(e) Antibiotic: Penicillin

2. A visit to any educational institute/industry to see an industrial fermenter, and other downstream processing operations.

SUGGESTED READINGS

1. Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley Eastern Limited.
2. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd edition. Panima Publishing Co. New Delhi.
3. Patel AH. (1996). Industrial Microbiology. 1st edition, Macmillan India Limited.
4. Stanbury PF, Whitaker A and Hall SJ. (2006). Principles of Fermentation Technology. 2nd edition, Elsevier Science Ltd.

FIFTH SEMESTER

Course Code UMBE 501: GENETICS AND GENOMICS II

Course Objective- This course aims to provide an insight and understanding on how connection between genes and genomes play a role in genetics and developmental biology.

Course Learning Outcomes:- Student will

- Conceptualize the mechanism of developmental biology and embryonic development of different model organism.
- Analyze and interpret biological and evolutionary problems in terms of genetics and genomics concepts.
- Knowledge of key processes involved in inheritance and expression of gene.

- Understand different biological database that provide information about protein and nucleic acid.

COURSE CONTENTS

UNIT I.

Genetic Analysis and Mapping in Bacteria and Bacteriophages

Conjugation; Transformation; Transduction, Recombination.

Genome Dynamics-Transposable genetic elements, Eukaryotic Viruses

Prokaryotic transposable elements- IS elements, Composite transposons, Tn-3 elements; Eukaryotic transposable elements- Ac-Ds system in maize and P elements in Drosophila; Uses of transposons; Eukaryotic Viruses.

UNIT II

Developmental Genetics and Model System

Study of model systems in developmental genetics- *Drosophila melanogaster Sachharomyces cerevisiae, Caenorhabditis elegans, Arabidopsis thaliana,* and *Xenopus laevis.*

UNIT III

Genomics, Bioinformatics and Proteomics

Genomes of bacteria, Drosophila and Humans; Human genome project; Evolution and Comparative Genomics. Introduction to Bioinformatics, Gene and protein databases; Sequence similarity and alignment; Gene feature identification. Gene Annotation and analysis of transcription and translation; Post-translational analysis- Protein interaction.

UNIT IV

Genomic Analysis- Dissection of Gene Function

Genetic analysis using mutations, forward genetics, genomics, reverse genetics, RNAi, functional genomics and system biology. Genetics of cancer, Oncogenes, Tumor suppressor genes, Mutator genes.

UNIT V

Population Genetics

Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, mutation, genetic drift.

Evolutionary Genetics

Genetic variation and Speciation. Genetic variation in natural population. Changes in the genetic structure of the populations

PRACTICALS

1. Genomic DNA isolation from E.coli (without plasmid).
2. Restriction enzyme digestion of genomic DNA from E.coli.
3. Isolation of plasmid DNA and genomic DNA together from E.coli. and restriction enzyme digestion.
4. Restriction enzyme digestion (EcoRI) of genomic and plasmid DNA (obtained from Expt.3).

5. Estimation of size of a DNA fragment after electrophoresis using DNA markers.
6. Construction of Restriction digestion maps from data provided.
7. Demonstration of DNA fingerprinting.

SUGGESTED READINGS

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2006). Principles of Genetics. VIII Edition John Wiley & Sons.
2. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. IX Edition. Benjamin Cummings.
4. Russell, P. J. (2009). iGenetics- A Molecular Approach. III Edition. Benjamin Cummings.
5. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
6. Pevsner, J. (2009). Bioinformatics and Functional Genomics. II Edition. John Wiley & Sons.
7. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. IX Edition. Introduction to Genetic Analysis.
8. Ghosh, Z. and Mallick,V. (2008). Bioinformatics-Principles and Applications. Oxford Univ. Press

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FIFTH SEMESTER
Course Code UMBE 502: PLANT PATHOLOGY

Course Objectives: The main objective of this course is to provide in-depth knowledge of plant diseases, the causes, symptoms, and the biochemical and genetical aspects of host-pathogen interactions. The student will become conversant with various means by which plants can defend themselves and plant diseases can be controlled or prevented. This will enable the student to initiate studies in search of novel and ecofriendly means of disease control which would improve the quality and quantity of crops.

Course Learning Outcomes: Upon successful completion of the course, the student

- Student will know about concept of disease, causal agents of plant diseases, identification methods and management of crop diseases.
- Student will know importance of sign and symptoms for detection of pathogens and disease, integrated methods of disease management, use of biological and chemicals in disease management.
- Students will know various laboratory methods of detection of plant pathogens and evaluation of biological and chemical agents against plant pathogens.
- Student will know plant viruses, important viral diseases of crops, sign and symptoms and management of viral diseases.
- Students will know biological method of plant growth, disease control and conventional and industrial production of bio control agents.
- Students will know principles and utilization of integrated pest management of field crop..

COURSE CONTENTS:

UNIT I

Introduction and History of plant pathology

Concept of plant disease- definitions of disease, disease cycle & pathogenicity, symptoms associated with microbial plant diseases, types of plant pathogens, economic losses and social impact of plant diseases. Significant landmarks in the field of plant pathology- Contributions of Anton De Bary, Millardet, Burrill, E. Smith, Adolph Mayer, Ivanowski, Diener, Stakman, H.H. Flor, Van Der Plank, molecular Koch's postulates. Contributions of eminent Indian plant pathologists.

UNIT II

Stages in development of a disease

Infection, invasion, colonization, dissemination of pathogens and perennation.

Plant disease epidemiology

Concepts of monocyclic, polycyclic and polyetic diseases, disease triangle & disease pyramid, forecasting of plant diseases and its relevance in Indian context.

UNIT III

Host Pathogen Interaction

A. MICROBIAL Pathogenicity

Virulence factors of pathogens: enzymes, toxins (host specific and non specific) growth regulators, virulence factors in viruses (replicase, coat protein, silencing suppressors) in disease development.

Effects of pathogens on host physiological processes (photosynthesis, respiration, cell membrane permeability, translocation of water and nutrients, plant growth and reproduction).

B. Genetics of Plant Diseases

Concept of resistance (R) gene and avirulence (avr) gene; gene for gene hypothesis, types of plant resistance: true resistance– horizontal & vertical, apparent resistance.

C. Defense Mechanisms in Plants

Concepts of constitutive defense mechanisms in plants, inducible structural defenses (histological-cork layer, abscission layer, tyloses, gums), inducible biochemical defenses [hypersensitive response (HR), systemic acquired resistance (SAR), phytoalexins, pathogenesis related (PR) proteins, plantibodies, phenolics, quinones, oxidative bursts].

UNIT IV Control of Plant Diseases

Principles & practices involved in the management of plant diseases by different methods, viz. **regulatory** - quarantine, crop certification, avoidance of pathogen, use of pathogen free propagative material

cultural - host eradication, crop rotation, sanitation, polyethylene traps and mulches

chemical - protectants and systemic fungicides, antibiotics, resistance of pathogens to chemicals**.**

biological - suppressive soils, antagonistic microbes-bacteria and fungi, trap plants genetic engineering of disease resistant plants- with plant derived genes and pathogen derived genes

UNIT V

Specific Plant diseases (Agrios, Singh)

Study of some important plant diseases giving emphasis on its etiological agent, symptoms, epidemiology and control

A. Important diseases caused by fungi (9 periods)

- White rust of crucifers - *Albugo candida*

- Downy mildew of onion - *Peronospora destructor*
- Late blight of potato - *Phytophthora infestans*
- Powdery mildew of wheat - *Erysiphe graminis*
- Ergot of rye - *Claviceps purpurea*
- Black stem rust of wheat - *Puccinia graminis tritici*
- Loose smut of wheat - *Ustilago nuda*

B. Important diseases caused by phytopathogenic bacteria (3 periods)

Angular leaf spot of cotton, bacterial leaf blight of rice, crown galls, bacterial cankers of citrus

C. Important diseases caused by phytoplasmas (1 period)

Aster yellow, citrus stubborn

D. Important diseases caused by viruses (2 periods)

Papaya ring spot, tomato yellow leaf curl, banana bunchy top, rice tungro

E. Important diseases caused by viroids (1 period)

Potato spindle tuber, coconut cadang cadang

PRACTICALS

1. Demonstration of Koch's postulates in fungal, bacterial and viral plant pathogens.
2. Study of important diseases of crop plants by cutting sections of infected plant material - *Albugo, Puccinia, Ustilago, Fusarium, Colletotrichum.*

SUGGESTED READINGS

1. Agrios GN. (2006). Plant Pathology. 5th edition. Academic press, San Diego,
2. Lucas JA. (1998). Plant Pathology and Plant Pathogens. 3rd edition. Blackwell Science, Oxford.
3. Mehrotra RS. (1994). Plant Pathology. Tata McGraw-Hill Limited.
4. Rangaswami G. (2005). Diseases of Crop Plants in India. 4th edition. Prentice Hall of India Pvt. Ltd., New Delhi.
5. Singh RS. (1998). Plant Diseases Management. 7th edition. Oxford & IBH, New Delhi.

SIXTH SEMESTER

(A) DISSERTATION	Credits	Maximum Marks
A. Valuation (i) Language & Presentation (ii) Review of Literature (iii) Methodology (iv) Analysis & interpretation of Result	**18**	**300**
B. Viva-Voce EXTERNAL		**50**
C. Viva-Voce INTERNAL		**50**
Total		**400**

(B) Comprehensive viva voce (virtual credits)	**4**	**50**

Course Objectives: The key objective of this paper is to introduce the students to concepts in identification of a research problem and developing a hypothesis. The course will enable students to learn how to carry out survey of literature, perform experiments, and analyse data. The student will learn how to write a scientific project report, and oral presentation of the results.

Course Learning Outcomes:

- Student is able to formulate a hypothesis to be tested.
- Student learns how to collect and read literature related to the hypothesis.
- Student is able to design experiments to test that hypothesis. Student is exposed to the use of a variety of instruments and is able to perform experiments such as making culture media for various microbes, isolating microorganisms from different sources, and identifying the isolated microorganism. Can examine the microorganism's capacity to produce compounds of industrial importance.
- Student learns about ethical issues in conducting research. Student learns how to examine the obtained data and interpret the results.
- Student learns how to discuss their results based on results obtained by other researchers on the same topic.
- Student learns the skill of writing a project report.
- Student learns about ethical issues related to publishing, plagiarism and self-plagiarism.