Learning Outcomes based Curriculum Framework

(LOCF) for

MICROBIOLOGY

Undergraduate Programme

PANSKURA BANAMALI COLLEGE
(AUTONOMOUS COLLEGE: 2018-2019 to 2027-2028)
UNDER VIDYASAGAR UNIVERSITY
Largest Rural Based, NAAC Re-accredited 'A' Grade (2016-2021)
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1.Preamble

Microbiology is the study of all living organisms that are too small to be visible with the naked eye. This includes bacteria, archaea, viruses, fungi, prions, protozoa and algae. These microbes play an important roles in nutrient cycling, biodegradation , climate change, food spoilage, the cause and control of diseases and biotechnology. Thanks to their versatility, microbes can put to work in many ways , such as making life- saving drugs, the production of bio –fluels, removal of pollution and manufacturing of food and drink.

The Choice Based Credit System (CBCS) curriculum for Microbiology at the undergraduate level has now been developed into a new system called Learning Outcome Curriculum Framework (LOCF) under the recommendations and guidance of University Grants Commission (UGC). The LOCF approach first envisioned the programme learning outcomes of the B.Sc. (Hons) program in Microbiology as well as the learning outcomes of the courses being taught under this programme, keeping in view the graduate attributes of the subject. The curriculum was then developed in tune with the learning outcomes. It is envisaged that the students trained under this curriculum will have the required attributes of knowledge, skills, temperament and ethics related to the subject of Microbiology. Besides the contents of the curriculum, the teaching learning processes have also been designed to achieve these attributes. A variety of learning assessment tasks have been included in the curriculum. Besides assessing the knowledge/skills acquired by the students, these tasks would also help to supplement the teaching learning processes.

There are 14 core courses (CC1 - 14) which encompass all important aspects of the discipline of Microbiology and are all compulsory courses. The choice based Discipline Specific Elective (DSE) courses are designed to

solutions in the form of small project under the mentorship of their teachers. These are also designed to expose the students to leaders / innovators in the areas related to microbiology for inspiration. The Generic Elective Courses (GEC) are designed to impart comprehensive understanding of Microbiology to students from other disciplines. The Microbiology students will have the choice to select courses from other disciplines depending on their interest and passion besides Microbiology. The CC, DSE and GEC are all 6 credit (4 Credit Theory and 2 Credit Laboratory work) courses. A number of Skill based Elective Courses (SEC), 4 Credits each would give the students option to develop skills in areas which have direct relevance to employability in diagnostics, health, food and pharmaceutical industries, agriculture and environment-related job opportunities in Microbiology. The focus of the Ability Enhancement Compulsory Courses (AECC) which are 2 Credits each, is to develop communication skills and awareness about our environment.

2. Introduction:

In this modern era , it is very important for the students are equipped with knowledge, skills, mindsets and behaviors which may enable them to perform their duties in a manner so that they become important contributors to the development of the society. This will also help them to fully utilize their educational training for earning a decent living so that the overall standard of their families and surroundings improve leading to development of welfare human societies. To achieve this goal, it is imperative that their educational training is improved such that it incorporates the use of newer technologies, use of newer assessment tools for mid-course corrections to make sure that they become competitive individuals to shoulder newer social responsibilities and are capable of undertaking novel innovations in their areas of expertise. In the face of the developing knowledge society, they are well aware about the resources of self-development using on-line resources of learning which is going to be a major component of learning in the future. The learning should also be a continuous process so that the students are able to re-skill themselves so as to make themselves relevant to the changing needs of the society. In the face of this need, the educational curricula, teaching learning processes, training, assessment methods all need to be improved or even re-invented. The higher educational institutions (HEI) all over the globe are in the grip of this urgent task and India needs to keep pace with all these developments.

3. Learning Outcomes based approach to Curriculum Planning

Learning Outcome based approach to curriculum planning (LOCF) is almost a paradigm shift in the whole gamut of higher education such that it is based on first and foremost identifying the outcomes of the learning required for a particular subject of study, and then planning all components of higher education so as to achieve these outcomes. The learning outcomes are the focal point of the reference to which all planning and evaluation of the end learning is compared and further modifications are made to fully optimize the education of the individuals in a particular subject. For the subject of Microbiology the outcomes are defined in terms of the understanding and knowledge of the students in microbiology and the practical skills the students are required to have to be competitive microbiologist so that they are able to play their role as microbiologist wherever required in the society such as the diseases caused by the microbes, their diagnosis and remedies; the role of microbiologists in the biotechnology industry and how they may be able to fit the bill in the industry. The students are also trained in such a way that they develop critical thinking and problem solving as related to the microbiology. The curriculum developed and the teaching and the evaluation tasks are such that the students are able to apply their knowledge and training of microbiology to solve the problems of microbiology as these exist or appear from time to time in the society. The curriculum envisions that the student, once graduate as specialists in a discipline, have an important role to play in the newer developments and innovations in the future in the subject for advancement of the discipline.

4. Nature and extent of the B.Sc. Programme:

The undergraduate programme in Microbiology is the first level of college or university degree in the country as in several other parts of the world. After obtaining this degree, a microbiologist may enter into the job market or opt for undertaking further higher studies in the subject. After graduation the students may join industry, academia, public health and play their role as microbiologists in a useful manner contributing their role in the development of the welfare society. Thus the undergraduate level degree in microbiology must prepare the students for all these objectives. Thus the LOCF curriculum developed has a very wide range covering all aspects of Microbiology with reasonable depth of knowledge and skills so to as to diversify them in various specialties of the subject and play their role professionally as expected of them. It is also imperative that microbiologists are evaluated in a manner appropriate to assess their proper development as microbiologists. The current LOCF in Microbiology has been designed in keeping all these important points in mind.

5. Aims of Bachelor's degree programme in MICROBIOLOGY:

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.

6. Graduate Attributes in Microbiology:

B.Sc. degree in Microbiology is the first college/university level degree in the country as in several parts of the world. The students graduating in this degree must have through understanding of basic knowledge or understanding of the fundamentals of Microbiology as applicable to wide ranging contexts. They should have the appropriate skills of Microbiology so as to perform their duties as microbiologists. They must be able to analyze the problems related to microbiology and come up with most suitable solutions. As microbiology is an interdisciplinary subject the students might have to take inputs from other ares of expertise. So the students must develop the spirit of team work. Microbiology is a very dynamic subject and practitioners might have to face several newer problems. To this end, the microbiologists must be trained to be innovative to solve such newer problems. Several newer developments are taking place in microbiology. The students are trained to pick up leads and see the possibility of converting these into products through entrepreneurship. To this end, the students are made to interact with industry experts so that they may able to see the possibility of their transition into entrepreneurs. They are also made aware of the requirements of developing a Microbiology enterprise by having knowledge of patents, copyrights and various regulatory process to make their efforts a success.

Besides attaining the attributes related to the profession of Microbiology, the graduates in this discipline should also develop ethical awareness which is mandatory for practicing a scientific discipline including ethics of working in a laboratory work and ethics followed for scientific publishing of their research work in future. The students graduating in microbiology should also develop excellent communication skills both in the written as well as spoken language which are must for them to pursue higher studies from some of the best and internationally acclaimed universities and research institutions spread across the globe.

7. Qualification Descriptors:

The following may serve as the important qualification descriptors for a UG degree in Microbiology:

1. Knowledge of the diverse places where microbiology is involved.
2. Understanding of diverse Microbiological processes.
3. Basic skills such as culturing microbes, maintaining microbes, safety issues related to handling of microbes, Good Microbiological practices etc.
4. Moderately advanced skills in working with microbes such as pilot scale culturing, downstream processes, diagnostics etc.
5. Generation of new knowledge through small research projects
6. Ability to participate in team work through small microbiology projects.
7. Ability to present and articulate their knowledge of Microbiology.
8. Knowledge of recent developments in the area of Microbiology.
9. Analysis of data collected through study and small projects.
10. Ability to innovate so as to generate new knowledge.
11. Awareness how some microbiology leads may be developed into enterprise.
12. Awareness of requirements for fruition of a microbiology-related enterprise.

8. Programme Learning Outcomes of B.Sc. Hons Microbiology course

After successful completion of a Bachelor's degree in Microbiology, the students will be able to;		
PLO 1	Critical thinking, Analysis and Problem Solving	Think critically, identify, analyze the problems and then attempt to design solutions that meet with specified goals. Apply appropriate tools efficiently in learners, and daily activities of academics and communication. Analyze with solutions to environmental issues and commit the problems to sustainable development in the environment. Understand the human in term of bioethics
PLO 2	Understanding the need for sustainable solutions	Function significantly at various problem and situations. Communicate proficiently (written or oral) as a responsible member of modern biotechnologist. Understand the research methods and able to analyze, interpret and derive a real conclusion.
PLO 3	Development of practical skills	Equipped with practical skills and the ability to apply their theoretical concepts to design, perform experiments, analyze and interpret data and thus develop proficiency in laboratory management.
PLO 4	Developing an inclination towards research	Develop an aptitude towards research through the internship in various field which promote and infuse professional ethics and code of practice among learners, empowering them to work within team with a multidisciplinary perspective.

9. Course Structure

B.Sc. (Hons.) Microbiology

SEMESTER I		SEMESTER II	
C1	Introduction to microbiology and microbial diversity	C3	Biochemistry
C2	Bacteriology	C4	Virology
AECC1	EVS/English/MIL	AECC2	EVS/English/MIL
GE	GE1	GE	GE2

SEMESTER III		SEMESTER IV	
C5	Microbial physiology and metabolism	C8	Microbial Genetics
C6	Cell Biology	C9	Environmental Microbiology
C7	Molecular Biology	C10	Food and dairy Microbiology
SEC	SEC1	SEC	SEC2
GE	GE3	GE	GE4

SEMESTER V		SEMESTER VI	
C11	Industrial Microbiology	C13	Medical Microbiology
C12	Immunology	C14	Recombinant DNA Technology
DSE	DSE1	DSE	DSE3
DSE	DSE2	DSE	DSE4

GENERIC ELECTIVE SUBJECTS (GE) (any one per semester in semesters 1-4)

1. Introduction and scope of Microbiology
2. Bacteriology and Virology
3. Industrial and food Microbiology
4. Microbes in Environment
5. Microbial Metabolism
6. Genetic Engineering and Biotechnology
7. Medical Microbiology and Immunology
8. Microbial Genetics and Molecular biology

SKILL ENHANCEMENT COURSES (SEC) (any one per semester in semesters 3-4)

1. Microbial Quality control in Food and Pharmaceutical industries
2. Microbial diagnosisin Health clinics
3. Bioferilizers and Biopesticide
4. Food Fermentation Techniques
5. Management of human microbial disease
6. Microbial Analysis of Air and Water

DISCIPLINE CENTRIC SUBJECTS (DSE) (any two per semester in semesters 5-6)

1. Bioinformatics
2. Microbial Biotechnology
3. Advances in Microbiology
4. Plant Pathology
5. Biomathematics and Biostatistics
6. Inheritance Biology
7. Microbes in sustainable Agriculture and Development
8. Biosafety and Intelectual property rights
9. Instrumentations and Biotechniques
10. Project Work

10. Course Credit

Year	Semes--ter	Course Type	Course Code	Course Title	Credit	L-T-P	Marks		
							CA	ESE	TOTAL
1	**Semester-I**								
	I	Core-1		**CT1: Introduction to microbiology and microbial diversity**	6	4-0-0	15	60	75
				CP1: Introduction to microbiology and microbial diversity Lab		0-0-4			
		Core-2		**CT2: Bacteriology**	6	4-0-0	15	60	75
				CP2: Bacteriology -Lab					
		GE-1		**GE-1**	6	4/5	15	60	75
				GE- 1 LAB		2/1			
		AECC-1		**English/MIL**	2	1-1-0	10	40	50
	Semester -I: total				**20**		**275**		
	Semester -II								
	II	Core-3		**CT3: Biochemistry**	6	4-0-0	15	60	75
				CP3: Mammalian Physiology-Lab		0-0-4			
		Core-4		**CT4: Virology**	6	4-0-0	15	60	75
				CP4: Virology -Lab		0-0-4			
		GE-2		**GE- 2**	6	4/5	15	60	75
				GE-2 Lab		2/1			
		AECC-2		**ENVS**	4		20	80	100
	Semester-II : Total				**22**		**325**		

Year	Semes--ter	Course Type	Course Code	Course Title	Credit	L-T-P	Marks		
							CA	ESE	TOTAL
2	Semester-III								
	III	Core-5		**CT5: Microbial physiology and metabolism**	6	4-0-0	15	60	75
				CP5: Microbial physiology and metabolism -Lab		0-0-4			
		Core-6		**CT6: Cell Biology**	6	4-0-0	15	60	75
				CP6: Cell Biology -Lab		0-0-4			
		Core-7		**CT7: Molecular Biology**	6	4-0-0	15	60	75
				CP7: Molecular Biology -Lab		0-0-4			
		GE-3		**GE-3**	6	4/5	15	60	75
				GE- 3 -LAB		2/1			
		SEC-1		**SEC-1**	2	1-1-0/ 1-0-2	10	40	50
		Semester – III : total 26							**350**
	Semester-IV								
	IV	Core-8		**CT8: Microbial Genetics**	6	4-0-0	15	60	75
				CP8: Microbial Genetics Lab		0-0-4			
		Core-9		**CT9: Environmental Microbiology**	6	4-0-0	15	60	75
				CP9: Environmental Microbiology Lab		0-0-4			
		Core-10		**CT10: Food and dairy Microbiology**	6	4-0-0	15	60	75
				CP10: Food and dairy Microbiology -Lab		0-0-4			
		GE-4		**GE-4**	6	4/5	15	60	75
				GE-4- LAB		2/1			
		SEC-2		**SEC-2**	2	1-1-0/ 1-0-2	10	40	50
		Semester – IV : total 26							**350**

Year	Semes-ter	Course Type	Course Code	Course Title	Credit	L-T-P	Marks		
							CA	ESE	TOTAL
3	V	Semester-V							
		Core-11		CT11: Industrial Microbiology	6	4-0-0	15	60	75
				CP11: Industrial Microbiology -Lab		0-0-4			
		Core-12		CT12: Immunology	6	4-0-0	15	60	75
				CP12: Immunology - Lab		0-0-4			
		DSE-1		DSE-1	6	4-0-0	15	60	75
				DSE-1 -LAB		0-0-4			
		DSE-2		DSE-2	6	4-0-0	15	60	75
				DSE-2 -LAB		0-0-4			
		Semester –V : total 24							300
	VI	Semester-VI							
		Core-13		CT13: Medical Microbiology	6	4-0-0	15	60	75
				CP13: Medical Microbiology - Lab		0-0-4			
		Core-14		CT14: Recombinant DNA	6	4-0-0	15	60	75
				CP14: Recombinant DNA Technology		0-0-4			
		DSE-3		DSE-3	6	4-0-0	15	60	75
				DSE-3 –LAB		0-0-4			
		DSE-4			6	4-0-0	15	60	75
				DSE-4 -LAB		0-0-4			
		Semester – VI : total 24							300
Total in all semester:					142				1900

CC = Core Course, **AECC** = Ability Enhancement Compulsory Course, **GE** = Generic Elective, **SEC** = Skill Enhancement Course, **DSE** = Discipline Specific Elective, **CA**= Continuous Assessment, **ESE**= End Semester Examination, **CT** = Core Theory, **CP**=Core Practical, **L** = Lecture, **T** = Tutorial, P = Practical, **MI**L = Modern Indian Language, **ENV**S = Environmental Studies.

Each Paper Marks distribution:

- **Full marks of each paper except SEC & AECC: (Theory 40 + Practical 20 + Attendance 5 + Internal 10) = 75**
- **For SEC: (Theory 40 + Attendance 5 + Internal 5) = 50**
- **For AECC1: (Theory 40 + Assessment 10) = 50**
- **For AECC2: (Theory 70 + Project 30) = 100**

11. PATTERN OF QUESTION

The paper comprises five Units containing one question of 12marks from each unit.

All five questions are compulsory with internal choice within each question.

Each question will comprise

[a] 2 objective type questions (1 mark each),

[b] 2 short answer questions (2 marks each) and

[c] 6 conceptual type questions (6 marks each). Of these questions 30% Questions would be analytical questions (problem solving type).

Maximum up to 40% of the question paper's content may be repeated in next examination

12. Details of Course Structure of B.Sc. Microbiology Hons

Details of the Courses
CORE COURSES (CC)
CC1: Introduction to Microbiology and Microbial Diversity
C-2: Bacteriology
C-3: Biochemistry
C-4: Virology
C-5: Microbial Physiology and Metabolism
C-6: Cell Biology
C-7: Molecular Biology
C-8: Microbial Genetics
C-9: Environmental Microbiology
C-10: Food and Dairy Microbiology
C-11: Industrial Microbiology
C-12: Immunology
C-13: Medical Microbiology
C-14: Recombinant DNA Technology

ABILITY ENHANCEMENT COMPULSORY (AECC) COURSES
AECC1: Environmental Science
AECC2: Communication Skills (English/MIL)

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE)(Any four)
DSE 1: Bioinformatics
DSE 2: Microbial Biotechnology
DSE 3: Advances in Microbiology
DSE 4: Plant Pathology
DSE 5: Biomathematics and Biostatistics
DSE 6: Inheritance Biology

DSE 7: Microbes in Sustainable Agriculture and Development

DSE 8: Biosafety and Intellectual property Rights
DSE 9: Instrumentation and Biotechniques
DSE 10: Project work

GENERIC ELECTIVE COURSE (GEC): Any Four
GEC1: Introduction and Scope of Microbiology
GEC2: Bacteriology and Virology
GEC3: Microbial Metabolism
GEC4: Industrial and Food Microbiology
GEC5: Microbes in Environment
GEC6: Medical Microbiology and Immunology
GEC7: Genetic Engineering and Biotechnology
GEC8: Microbial Genetics and Molecular biology

SKILL ENHANCEMENT COURSE (SEC): Any Two
SEC1: Microbial Quality Control in Food & Pharmaceutical Industries
SEC2: Microbial Diagnostics and Public Health
SEC3: Biofertilizers and Biopesticides
SEC4: Food Fermentation Techniques
SEC5: Management of Human Microbial Diseases
SEC6: Microbiological Analysis of Air, Water & Soil

Course Learning Outcomes

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Contents of the Courses

CORE COURSES (CC)

CC1: INTRODUCTION TO MICROBIOLOGY AND MICROBIAL DIVERSITY		
Course learning outcomes: **Outcome 1**. Gives a brief knowledge of history of microbiology and microbiologists those who came consecutively with their discoveries and contributions in this field. **Outcome 2**. Provides an information about how to classify cellular microorganisms based on their general characteristics. **Outcome 3**. Establishes a very good understanding of fungi, algae, protozoa in terms of their general characters, reproduction, life cycle, habitat, thallus organization and importance. **Outcome 4**. Are able to perform basic microbiological laboratory experiments and tools.		
THEORY COURSE **(4 Credits)**		
Unit – 1:	**History of Development of Microbiology** Developmentofmicrobiologyasadiscipline,Spontaneousgeneration*vs*.biogenesis.Contributionsof AntonvonLeeuwenhoek,LouisPasteur,RobertKoch,JosephLister,AlexanderFleming Role of microorganisms in fermentation, Germ theory of disease, Development of various microbiological techniques and golden era of microbiology, Development of the field of soil microbiology: ContributionsofMartinusW.Beijerinck,SergeiN.Winogradsky,SelmanA.Waksman Establishment of fields of medical microbiology and	**15 Lectures**

	immunology through the work of Paul Ehrlich, Elie Metchnikoff, EdwardJenner.	
Unit – 2:	**Diversity of Microbial World** **A. Systems ofclassification** Binomial Nomenclature, Whittaker's five kingdom and Carl Woese's three kingdom classification systems and their utility. Difference between prokaryotic and eukaryotic microorganisms. **B. Generalcharacteristicsofdifferentgroups:** Acellularmicroorganisms(Viruses,Viroids,Prions) and Cellularmicroorganisms (Bacteria, Algae, Fungi and Protozoa) with emphasis on distribution and occurrence, morphology, mode of reproduction and economicimportance. ➢ **Algae** History of phycology with emphasis on contributions of Indian scientists; General characteristics of algaeincludingoccurrence,thallusorganization,algaecellultrastructure ,pigments,flagella,eyespot food reserves and vegetative, asexual and sexual reproduction. Different types of life cycles in algae with suitable examples: Haplobiontic, Haplontic, Diplontic, Diplobiontic and Diplohaplontic life cycles. Applications of algae in agriculture, industry, environment andfood. ➢ **Fungi** Historical developments in the field of Mycology including significant contributions of eminent mycologists. General characteristics of fungi including habitat, distribution, nutritional requirements, fungal cell ultra- structure, thallus organization and aggregation, fungal wall structure and synthesis, asexualreproduction,sexualreproduction,heterokaryosis,heterothallis mandparasexualmechanism. Economic importance of fungi with examples in agriculture, environment, Industry, medicine, food, biodeterioration andmycotoxins. ➢ **Protozoa** Generalcharacteristicswithspecialreferenceto*Amoeba,Paramecium, Plasmodium,Leishmaniaand Giardia*	**40 Lectures**
Unit – 3:	**AnoverviewofScopeofMicrobiology**	**5 Lectures**
C-1:INTRODUCTIONTOMICROBIOLOGYANDMICROBIALDIVERSITY (PRACTICALS) **SEMESTER –I** **TOTALHOURS:60** **CREDITS:2**		

1. Microbiology Good Laboratory Practices andBiosafety.
2. Tostudytheprincipleandapplicationsofimportantinstruments(biologicalsafetycabinets, autoclave,incubator,BODincubator,hotairoven,lightmicroscope,pHmeter)usedinthe microbiologylaboratory.
3. Preparation of culture media for bacterialcultivation.
4. Sterilization of medium using Autoclave and assessment forsterility
5. Sterilization of glassware using Hot Air Oven and assessment forsterility
6. Sterilizationofheatsensitivematerialbymembranefiltrationandassessmentforsterility
7. Demonstrationofthepresenceofmicroflorain theenvironmentbyexposingnutrientagar plates toair.
8. Study of *Rhizopus*, *Penicillium*, *Aspergillus*using temporarymounts
9. Study of *Spirogyra* and *Chlamydomonas, Volvox*using temporaryMounts
10. Studyofthefollowingprotozoansusingpermanentmounts/photographs:*Amoeba*, *Entamoeba*, *Parameciu*m and*Plasmodium*

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Reference Books

1. TortoraGJ,FunkeBRandCaseCL.(2008).Microbiology:AnIntroduction.9thedition.Pearson Education
2. MadiganMT,MartinkoJM,DunlapPVandClarkDP.(2014).BrockBiologyofMicroorganisms. 14th edition. Pearson InternationalEdition
3. CappucinoJandShermanN.(2010).Microbiology:ALaboratoryManual.9thedition.Pearson EducationLimited
4. WileyJM,SherwoodLMandWoolvertonCJ.(2013)Prescott'sMicrobiology.9th Edition. McGraw HillInternational.
5. AtlasRM.(1997).PrinciplesofMicrobiology.2ndedition.WM.T.BrownPublishers.
6. PelczarMJ,ChanECSandKriegNR.(1993).Microbiology.5thedition.McGraw Hill BookCompany.
7. StanierRY,IngrahamJL,WheelisML,andPainterPR.(2005).General Microbiology. 5th edition. McMillan.

CC2: Bacteriology

Course learning outcomes:

Outcome 1. Gives a brief knowledge of cellular organization of bacteria.

Outcome 2. Developes skills on bacteriological techniques which includes pure culture isolation, cultivation, culture preservation.

Outcome 3. Are able to visualize microbial cells under microscopes.

Outcome 4. Provides information about pattern of growth, nutritional mode, taxonomy and some important archaeal and eubacterial bacterial groups.

THEORY COURSE

(4 Credits)

Unit – 1	**Cellorganization** 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,inclusionbodies,nucleo id,chromosomeandplasmids Endospore: Structure, formation, stages ofsporulation.	**14 Lectures**
Unit – 2	**Bacteriological techniques:**Pure culture isolation: Streaking, serial dilution and plating methods; cultivation, maintenance and preservation/stockingofpurecultures;cultivationofanaerobicbacteri a,andaccessingnon-culturable bacteria.	**5 Lectures**

Unit – 3	**Microscopy** BrightFieldMicroscope,DarkFieldMicroscope,PhaseContrastMicroscope,Fluoresence Microscope,Confocalmicroscopy,ScanningandTransmissionElectronMicroscope	**6 Lectures**
Unit – 4	**Growthandnutrition** Nutritional requirements in bacteria and nutritional categories; Culturemedia:componentsofmedia,naturalandsyntheticmedia,chemicallydefinedmedia, complexmedia,selective,differential,indicator,enrichedandenrichmentmedia *Physicalmethodsofmicrobialcontrol*:heat,lowtemperature,highpressure,filtration,desiccation, osmotic pressure,radiation *Chemical methods of microbial control*: disinfectants, types and mode of action	**8 Lectures**
Unit – 5	**ReproductioninBacteria** Asexual methods of reproduction, logarithmic representation of bacterial populations, phases of growth, calculation of generation time and specific growthrate	**3 Lectures**
Unit-6	**BacterialSystematics** Aimandprinciplesofclassification,systematicsandtaxonomy,conceptofspecies,taxa,strain; conventional,molecularandrecentapproachestopolyphasicbacterialtaxonomy,evolutionary chronometers, rRNA oligonucleotide sequencing, signature sequences, and protein sequences. Differences between eubacteria andarchaebacteria	**8 Lectures**
Unit-7	**Important archaeal and eubacterial groups** **Archaebacteria:**General characteristics, phylogenetic overview, genera belonging to Nanoarchaeota (Nanoarchaeum), Crenarchaeota (Sulfolobus, Thermoproteus) and Euryarchaeota [Methanogens (Methanobacterium, Methanocaldococcus), thermophiles (Thermococcus, Pyrococcus, Thermoplasma), and Halophiles (Halobacterium, Halococcus)] **Eubacteria:**Morphology, metabolism, ecological significance and economic importance of following groups: *Gram Negative:* Non proteobacteria: General characteristics with suitable examples Alpha proteobacteria: General characteristics with suitable examples Beta	**16 Lectures**

	proteobacteria: General characteristics with suitable examples Gamma proteobacteria: General characteristics with suitable examples Delta proteobacteria: General characteristics with suitable examples Epsilon proteobacteria: General characteristics with suitable examples Zeta proteobacteria: General characteristics with suitable examples *Gram Positive:* Low G+ C (Firmicutes): General characteristics with suitable examples High G+C (Actinobacteria): General characteristics with suitable examples Cyanobacteria: An Introduction	

C-2: BACTERIOLOGY (PRACTICAL)
SEMESTER –I

TOTALHOURS:60 **CREDITS:2**

1. Preparationofdifferentmedia:syntheticmediaBG-11,Complexmedia-Nutrient agar, McConkey agar, EMBagar.
2. Simplestaining
3. Negativestaining
4. Gram'sstaining
5. Acid fast staining-permanent slideonly.
6. Capsulestaining
7. Endosporestaining.
8. Isolation of pure cultures of bacteria by streakingmethod.
9. Preservation of bacterial cultures by varioustechniques.
10. Estimation of CFU count by spread plate method/pour platemethod.
11. Motility by hanging dropmethod.

Reference Books

1. Atlas RM. (1997). Principles of Microbiology. 2nd edition. WM.T.BrownPublishers.
2. BlackJG.(2008).Microbiology:PrinciplesandExplorations.7thedition.PrenticeHall
3. MadiganMT,andMartinkoJM.(2014).BrockBiologyofMicro-organisms.14th edition.ParkerJ. Prentice Hall International,Inc.
4. PelczarJrMJ,ChanECS,andKriegNR.(2004).Microbiology.5theditionTataMcGrawHill.
5. SrivastavaSandSrivastavaPS.(2003).UnderstandingBacteria.KluwerAcademicPublishers, Dordrecht
6. StanierRY,IngrahamJL,WheelisMLandPainterPR.(2005).GeneralMicrobiology.5thedition McMillan.
7. TortoraGJ,FunkeBR,andCaseCL.(2008).Microbiology:AnIntroduction.9th editionPearson Education.
8. WilleyJM,SherwoodLM,andWoolvertonCJ.(2013).Prescott'sMicrobiology.9th edition. McGraw Hill HigherEducation.
9. Cappucino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson EducationLimited

CC3: Biochemistry

Course learning outcomes:

Course learning outcomes : By the end of this course the students-

Outcome 1. Developed a very good understanding of various biomolecules which are required for development and functioning of a bacterial cell.

Outcome 2. Developed how the carbohydrates make the structural and functional components such as energy generation and as storage food molecules for the bacterial cells

Outcome 3. Well understood about multifarious function of proteins; are able to calculate enzyme activity and other quantitative and qualitative parameters of enzyme kinetics; also knowledge about lipids and nucleic acids.

Outcome 4. Student are able to make buffers, study enzyme kinetics and calculate Vmax, Km, Kcat values.

THEORY COURSE

(4 Credits)

Unit – 1:	**Bioenergetics** FirstandsecondlawsofThermodynamics.DefinitionsofGibb'sFreeEnergy,enthalpy,andEntropyand mathematical relationship among them, Standard free energy change and equilibrium constantCoupled reactions and additive nature of standard free energy change, Energy rich compounds:Phosphoenolpyruvate,1,3-Bisphosphoglycerate,Thioesters,ATP	**8 Lectures**
Unit – 2:	**Carbohydrates** Familiesofmonosaccharides:aldosesandketoses,trioses,tetroses,pentoses,andhexoses. Stereo isomerism of monosaccharides, epimers, Mutarotation and anomers of glucose. Furanose andpyranose forms of glucose and	**12**

	fructose, Haworth projection formulae for glucose; chair and boatformsofglucose,Sugarderivatives,glucosamine,galactosamine,muramicacid,N-acetylneuraminicacid, Disaccharides; concept of reducing and non-reducing sugars, occurrence and Haworthprojections of maltose, lactose, and sucrose, Polysaccharides, storage polysaccharides, starch andglycogen.StructuralPolysaccharides,cellulose,peptidoglycanandchitin	**Lectures**
Unit – 3:	**Lipids** Definition and major classes of storage and structural lipids. Storage lipids. Fatty acids structure andfunctions. Essential fatty acids. Triacylglycerols structure, functions and properties. SaponificationStructural lipids. Phosphoglycerides: Building blocks, General structure, functions and properties.Structure of phosphatidylethanolamine and phosphatidylcholine, Sphingolipids: building blocks,structureofsphingosine,ceramide.Specialmentionofsphingomyelins,cerebrosidesandgangliosidesLipid functions: cell signals, cofactors, prostaglandins, Introduction of lipid micelles, monolayers,bilayers	**12 Lectures**
Unit-4	**Proteins** Functions of proteins, Primary structures of proteins: Amino acids, the building blocks of proteins.General formula of amino acid and concept of zwitterion. Titration curve of amino acid and itsSignificance, Classification, biochemical structure and notation of standard protein amino acidsNinhydrinreaction.Natural modifications of amino acids in proteins hydrolysine, cystine andhydroxyproline,Nonproteinaminoacids:Gramicidin,beta-alanine,D-alanineandD-glutamicacidOligopeptides: Structure and functions of naturally occurring glutathione and insulin and syntheticaspartame,Secondarystructureofproteins:Peptideunitanditssalientfeatures.Thealphahelix,thebetapleatedsheetandtheiroccurrenceinproteins,Tertiaryandquaternarystructuresofproteins. Forcesholdingthepolypeptidetogether.Humanhaemoglobinstructure,Quaternarystructuresofproteins	**12 Lectures**
Unit-5	**Enzymes** Structureofenzyme:Apoenzymeandcofactors,prostheticgroup-TPP,coenzyme NAD,metal cofactors, Classification of enzymes, Mechanism of action of enzymes: active site,transitionstatecomplexandactivationenergy.Lockandkeyhypothesis,andInducedFithypothesis.Significanceofhyperbolic,doublereciprocalplotsofenzymeactivity,Km,andallostericmechanismDefinitions of	**12 Lectures**

	terms – enzyme unit, specific activity and turnover number, Multienzymecomplex :pyruvate dehydrogenase; isozyme: lactate dehydrogenase, Effect of pH and temperature on enzymeactivity.Enzymeinhibition:competitive-sulfadrugs;non-competitive-heavymetalsalts	
Unit-6	**Vitamins** Classificationandcharacteristicswithsuitableexamples,sourcesandimportance	**4 Lectures**
C-3:Biochemistry (PRACTICALS) SEMESTER –II **TOTALHOURS:60** **CREDITS:2**		

1. Propertiesofwater,ConceptofpHandbuffers,preparationofbuffersandNumericalproblemstoexplaintheconcepts
2. NumericalproblemsoncalculationsofStandardFreeEnergyChangeandEquilibriumconstant
3. StandardFreeEnergyChangeofcoupledreactions
4. Qualitative/Quantitativetestsforcarbohydrates,reducingsugars,nonreducingsugars
5. Qualitative/Quantitativetestsforlipidsandproteins
6. Studyofproteinsecondaryandtertiarystructureswiththehelpofmodels
7. Studyofenzymekinetics–calculationof V_{max},Km,Kcatvalues
8. Studyeffectoftemperature,pHandHeavymetalsonenzymeactivity

Estimationofanyonevitamin

Reference Books

1. Campbell,MK(2012)Biochemistry,7thed.,PublishedbyCengageLearning
2. Campbell,PNandSmithAD(2011)BiochemistryIllustrated,4thed.,PublishedbyChurchillLivingstone
3. TymoczkoJL,BergJMandStryerL(2012)Biochemistry:Ashortcourse,2nded.,W.H.Freeman
4. BergJM,TymoczkoJLandStryerL(2011)Biochemistry,W.H.FreemanandCompany
5. NelsonDLandCoxMM(2008)LehningerPrinciplesofBiochemistry,5thEdition.,W.H.FreemanandCompany,
6. WilleyMJ,Sherwood,LM&WoolvertonCJ(2013)Prescott,HarleyandKlein'sMicrobiologyby.9thEd.,McGrawHill
7. Voet,D.andVoetJ.G(2004)Biochemistry3rdedition,JohnWileyandSons,

CC4: Virology

Course learning outcomes:

Outcome 1.Described viruses and the chemical nature of viruses, different types of viruses infecting animals, plants and bacteria (bacteriophages)

Outcome 2. Understanding about the biology of bacteriophages.

Outcome 3. Gained knowledge of a variety of plant viruses and animal viruses.

Outcome 4. The ability to describe role of viruses in the causation of the cancer'

THEORY COURSE

(4 Credits)

Unit – 1	**NatureandPropertiesofViruses** Introduction:Discoveryofviruses,natureanddefinitionofviruses,generalproperties,conceptofviroids,virusoids,satellitevirusesandPrions.Theoriesofviralorigin StructureofViruses:Capsidsymmetry,envelopedandnon-envelopedvirusesIsolation,purificationandcultivationofviruses Viraltaxonomy:Classificationandnomenclatureofdifferentgroupsofviruses	**12 Lectures**
Unit – 2	**Bacteriophages** Diversity,classification,onestepmultiplicationcurve,lyticandlysogenicphages(lambdaphage)conceptofearlyandlateproteins,regulationoftranscriptioninlambdaphage	**10 Lectures**
Unit-3	**ViralTransmission,SalientfeaturesofviralnucleicacidsandReplication** Modesofviraltransmission:Persistent,non-persistent,verticalandhorizontal SalientfeaturesofviralNucleicacid:Unusualbases(TMV,T4phage),overlappinggenes(ϕX174,Hepatitis Bvirus),alternatesplicing(HIV),terminalredundancy(T4phage),terminalcohesiveends(lambdaphage),partialdoublestrandedgenomes(HepatitisB),longterminalrepeats(retrovirus),segmented(Influenzavirus),andnon-segmentedgenomes(picornavirus),cappingandtailing(TMV)Viral multiplication and replication strategies: Interaction of viruses with cellular receptors and	**20 Lectures**

	entryofviruses.ReplicationstrategiesofvirusesasperBaltimoreclassification(phiX174,Retroviridae,Vaccinia,Picorna),Assembly,maturationandreleaseofvirions	
Unit-4	**VirusesandCancer** Introductiontooncogenicviruses TypesofoncogenicDNAandRNAviruses:Conceptsofoncogenesandproto-oncogenes	**6 Lectures**
Unit-5	**Prevention& control ofviraldisease** Antiviralcompoundsandt heirmodeofactionInterfer onandtheirmodeofaction Generalprinciplesofviralvaccination	**8 Lectures**
Unit-6	**ApplicationsofVirology** UseofviralvectorsincloningandexpressionGenetherapyandPhagedisplay	**4 Lectures**

C-3:Virology
(PRACTICALS)
SEMESTER –II

TOTALHOURS:60 **CREDITS:2**

1. Studyofthestructureofimportantanimalviruses(rhabdo,influenza,paramyxohepatitisBandretroviruses)usingelectron micrographs
2. Studyofthestructureofimportantplantviruses(caulimo,Gemini,tobaccoringspot,cucumbermosaicandalpha-alphamosaicviruses)usingelectronmicrographs
3. Studyofthestructureofimportantbacterialviruses(ϕX174,T4,λ)usingelectronmicrograph.
4. Isolationandenumerationofbacteriophages(PFU)fromwater/sewagesampleusingdoubleagarlayer technique
5. Studyingisolationandpropagationofanimalvirusesbychickembryotechnique
6. Studyofcytopathiceffectsofvirusesusingphotographs
7. Performlocallesiontechniqueforassayingplantviruses.

1. Dimmock,NJ,Easton,AL,Leppard,KN(2007).IntroductiontoModernVirology.6thedition,BlackwellPublishingLtd.
2. CarterJandSaundersV(2007).Virology:PrinciplesandApplications.JohnWileyandSons.
3. FlintSJ,Enquist,LW,Krug,RM,Racaniello,VR,Skalka,AM(2004).PrinciplesofVirology,Molecularbiology,PathogenesisandControl.2ndedition.ASMpressWashingtonDC.
4. LevyJA,ConratHF,OwensRA.(2000).Virology.3rdedition.PrenticeHallpublication,NewJersey.
5. WagnerEK,HewlettMJ.(2004).BasicVirology.2ndedition.BlackwellPublishing.
6. Mathews.(2004).PlantVirology.HullR.AcademicPress,NewYork.
7. NayuduMV.(2008).PlantViruses.TataMcGrawHill,India.
8. BosL.(1999)Plantviruses-Atextbookofplantvirologyby.BackhuysPublishers.
9. VersteegJ.(1985).AColorAtlasofVirology.WolfeMedicalPublication.

CC5: Microbial Physiology and Metabolism

Course learning outcomes: By the conclusion of this course, the students are capable of -

Outcome 1. Describing the growth characteristics of the microorganisms capable of growing under unusual environmental condition of temperature, oxygen, and solute and water activity.

Outcome 2. Explained the growth characteristics of the microorganisms which require different nutrient for growth and the associated mechanisms of energy generation for their survival like autotrophs, heterotrophs, chemolithoautotrophs etc.

Outcome 3. Differentiating concepts of aerobic and anaerobic respiration and how these are manifested in the form of different metabolic pathways in microorganisms.

THEORY COURSE **(4 Credits)**		
Unit – 1:	**MicrobialGrowthandEffectofEnvironmentonMicrobialGrowth** Definitions of growth, measurement of microbial growth, Batch culture, Continuous culture,generationtimeandspecificgrowthrate,synchronousgrowth, diauxicgrowthcurve Microbialgrowthinresponsetoenvironment-Temperature(psychrophiles,mesophiles,thermophiles,extremophiles,thermodurics,psychrotrophs),pH(acidophiles,alkaliphiles),soluteandwateractivity(halophiles,xerophiles,osmophilic),Oxygen(aerobic,anaerobic,microaerophilic,facultativeaerobe,facultative anaerobe),barophilic. Microbialgrowthinresponsetonutritionandenergy–Autotroph/Phototroph,heterotrophy,Chemolithoautotroph, Chemolithoheterotroph, Chemoheterotroph, Chemolithotroph,photolithoautotroph,Photoorganoheterotroph.	**12 Lectures**
Unit – 2:	**NutrientuptakeandTransport** Passiveandfacilitateddiffusion Primaryandsecondaryactivetransport,conceptofunipo rt,symportandantiportGrouptranslocation Ironuptake	**10 Lectures**

Unit – 3:	**ChemoheterotrophicMetabolism-AerobicRespiration** Conceptofaerobicrespiration,anaerobicrespirationandfermentationSugardegradationpathways i.e.EMP,ED,PentosephosphatepathwayTCAcycle Electrontransportchain:componentsofrespiratorychain,comparisonofmitochondrialandbacterialETC,electrontransportphosphorylation,uncouplersandinhibitors	**16 Lectures**
Unit-4	**ChemoheterotrophicMetabolism-Anaerobicrespirationandfermentation** Anaerobicrespirationwithspecialreferencetodissimilatorynitratereduction(Denitrification;nitrate/nitriteandnitrate/ammoniarespiration;fermentativenitratereduction) Fermentation-AlcoholfermentationandPasteureffect;Lactatefermentation(homofermentativeandheterofermentativepathways),conceptoflinearandbranchedfermentationpathways	**6 Lectures**
Unit-5	**ChemolithotrophicandPhototrophicMetabolism.** Introductiontoaerobicandanaerobicchemolithotrophywithanexampleeach.Hydrogenoxidation(definitionandreaction)andmethanogenesis(definitionandreaction) Introductiontophototrophicmetabolism-groupsofphototrophicmicroorganisms,anoxygenic*vs.*oxygenicphotosynthesiswithreferencetophotosynthesisingreenbacteria,purplebacteriaandcyanobacteria	**10 Lectures**
Unit-6	**NitrogenMetabolism**-anoverview Introductiontobiologicalnitrogenfixation Ammoniaassimilation Assimilatorynitratereduction,dissimilatorynitratereduction,denitrification	**6 Lectures**
C-5:Microbial Physiology and Metabolism **(PRACTICALS)** **SEMESTER –III** **TOTALHOURS:60** **CREDITS:2**		

1. Studyandplotthegrowthcurveof*E.coli*byturbidometricandstandardplatecountmethods.
2. Calculationsofgenerationtimeandspecificgrowthrateofbacteriafromthegraphplottedwiththegiven data
3. Effectoftemperatureongrowthof*E.coli*
4. EffectofpHongrowthof*E.coli*
5. Effectofcarbonandnitrogensourcesongrowthof*E.coli*
6. Effectofsaltongrowthof*E.coli*
7. Demonstrationofalcoholicfermentation
8. Demonstrationofthethermaldeathtimeanddecimalreductiontimeof*E.coli.*

SUGGESTEDREADINGS

1. MadiganMT,andMartinkoJM(2014).BrockBiologyofMicroorganisms.14thedition.PrenticeHall InternationalInc.
2. MoatAGandFosterJW.(2002).MicrobialPhysiology.4thedition.JohnWiley&Sons
3. ReddySRandReddySM.(2005).MicrobialPhysiology.ScientificPublishersIndia
4. GottschalkG.(1986).BacterialMetabolism.2ndedition.SpringerVerlag
5. StanierRY,IngrahmJI,WheelisMLandPainterPR.(1987).GeneralMicrobiology.5thedition,Mc MillanPress.
7. WilleyJM,SherwoodLM,andWoolvertonCJ.(2013).Prescott'sMicrobiology.9thedition.Mc GrawHillHigherEducation.

CC6: Cell Biology

Course learning outcomes:

Outcome 1. Able to distinguish prokaryotic and eukaryotic cells in terms of their structures and internal organization.

Outcome 2. Understood the structures of nucleus.

Outcome 3. Described the roles of ribosomes, endoplasmic reticulum, golgi apparatus, lysosomes in protein targeting, folding, processing, sorting and transporting.

Outcome 4. Able to understand cell signaling very well.

THEORY COURSE **(4 Credits)**		
Unit – 1:	**StructureandorganizationofCell** CellOrganization– Eukaryotic(Plantandanimalcells)andprokaryot icPlasmamembrane:Structureandtransportofs mallmolecules Cell Wall: Eukaryotic cell wall, Extra cellular matrix and cell matrix interactions, Cell-CellInteractions- adhesionjunctions,tightjunctions,gapjunctions,andplasmodesmata(o nlystructuralaspects) Mitochondria,chloroplastsandperoxisomes Cytoskeleton:Structureandorganizationofactinfilaments,associationof actinfilamentswithplasmamembrane,cellsurfaceprotrusions,intermedi atefilaments,microtubules	**12 Lectures**
Unit – 2:	**Nucleus** Nuclearenvelope,nuclearporecomplexa ndnuclearlaminaChromatin– Molecularorganization Nucleolus	**4 Lectures**
Unit – 3:	**ProteinSortingandTransport** Ribosomes,EndoplasmicReticulum– Structure,targetingandinsertionofproteinsintheER,proteinfolding,	**12 Lectures**

	processing and quality control in ER, smooth ER and lipid synthesis, export of proteins andlipids GolgiApparatus– Organization,proteinglycosylation,proteinsortingandexportfromGolgiApparatus Lysosomes	
Unit-4	**Cell Signalling** Signalling molecules and their receptors Function of cell surface receptors Pathways of intra-cellular receptors – Cyclic AMP pathway, cyclic GMP and MAP kinase pathway	**8 Lectures**
Unit-5	**Cell Cycle, Cell Death and Cell Renewal** Eukaryotic cell cycle and its regulation, Mitosis and Meiosis Development of cancer, causes and types Programmed cell death Stem cells Embryonic stem cell, induced pleuripotent stem cells	**12 Lectures**

C-6: Cell Biology
(PRACTICALS)
SEMESTER –III

TOTALHOURS:60 **CREDITS:2**

1. Studyarepresentativeplantandanimalcellbymicroscopy.
2. Studyofthestructureofcellorganellesthroughelectronmicrographs
3. CytochemicalstainingofDNA–Feulgen
4. DemonstrationofthepresenceofmitochondriainstriatedmusclecellsIcheekepithelialcellusingvitalstainJanusGreenB
5. StudyofpolyploidyinOnionroottipbycolchicinetreatment.
6. Identification and study of cancer cells by photomicrographs.
7. Study of different stages of Mitosis.
8. Study of different stages of Meiosis.

SUGGESTED READING

1. Hardin J, Bertoni G and Kleinsmith LJ. (2010). Becker's World of the Cell. 8th edition. Pearson.
2. Karp G. (2010) Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons. Inc.
3. De Robertis, EDP and De Robertis EMF. (2006). Cell and Molecular Biology. 8th edition. Lipincott Williams and Wilkins, Philadelphia.
4. Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. 5th Edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.

CC7: Molecular Biology

Course learning outcomes:

Outcome 1. Has acquired a fairly good understanding of salient features of genetic elements and DNA topology.

Outcome 2. Discussed a fundamental concept of central dogma.

Outcome 3. Able to understand the regulation of gene expression in prokaryotes and eukaryotes.

Outcome 4. Able to perform all experiments of Molecular biology.

THEORY COURSE (4 Credits)		
Unit – 1:	**StructuresofDNAandRNA/GeneticMaterial** DNA Structure: Miescher to Watson and Crick- historic perspective, DNAstructure,Salientfeaturesofdoublehelix,TypesofDNA,Typesofgeneticmaterial,denaturationandrenaturation,cotcurves.DNAtopology-linkingnumber, topoisomerases; Organization of DNA Prokaryotes,Viruses,Eukaryotes.RNAStructure,OrganelleDNA--mitochondriaandchloroplastDNA.	**12 Lectures**
Unit – 2:	**ReplicationofDNA(ProkaryotesandEukaryote** Bidirectionalandunidirectionalreplication,semi-conservative,semi-discontinuousreplicationMechanism of DNA replication: Enzymes and proteins involved in DNA replication – DNApolymerases,DNAligase,primase,telomerase–forreplicationoflinearends VariousmodelsofDNAreplicationincludingrollingcircle,D-loop(mitochondrial),Θ(theta)modeofreplicationandotheraccessoryprotein,Mismatchandexcisionrepair	**10 Lectures**
Unit – 3:	**TranscriptioninProkaryotesandEukaryotes** Transcription:Definition,differencefromreplication,promoter-conceptandstrengthofpromoterRNAPolymeraseandthetranscriptionunit	**8 Lectures**

	TranscriptioninEukaryotes:RNApolymerases,generalTranscriptionfactors	
Unit-4	**Post-TranscriptionalProcessing** Split genes, concept of introns and exons, RNA splicing, spliceosome machinery**,** concept ofalternativesplicing,Polyadenylationandcapping,ProcessingofrRNA,RNAinterference:siRNA,miRNAanditssignificance	**8 Lectures**
Unit-5	**Translation(ProkaryotesandEukaryotes)** Translationalmachinery,ChargingoftRNA,aminoacyltRNAsynthetases,Mechanismsofinitiation,elongationandterminationofpolypeptidesinbothprokaryotesandeukaryotes,Fidelityoftranslation,Inhibitorsofproteinsynthesisinprokaryotesandeukaryote	**10 Lectures**
Unit-6	**RegulationofgeneExpressioninProkaryotesandEukaryote.** Principles of transcriptional regulation, regulation at initiation with examples from *lac* and *trp*operons, Sporulation in *Bacillus,*Yeast mating type switching , Changes in Chromatin Structure -DNAmethylationandHistoneAcetylation mechanisms.	**12 Lectures**

C-5: Molecular Biology
(PRACTICALS)
SEMESTER –III

TOTALHOURS:60 **CREDITS:2**

1. Study of different types of DNA and RNA using micrographs and model / schematic representations
2. Study of semi-conservative replication of DNA through micrographs / schematic representations
3. Isolation of genomic DNA from E. coli
4. Estimation of salmon sperm / calf thymus DNA using colorimeter (diphenylamine reagent) or UV spectrophotometer (A260 measurement)
5. Estimation of RNA using colorimeter (orcinol reagent) or UV spectrophotometer (A260 measurement)
6. Resolution and visualization of DNA by Agarose Gel Electrophoresis.
7. Resolution and visualization of proteins by Polyacrylamide Gel Electrophoresis (SDS-PAGE).

SUGGESTEDREADINGS

1. WatsonJD,BakerTA,BellSP,GannA,LevineMandLosickR(2008)MolecularBiologyoftheGene,6thedition,ColdSpringHarbourLab.Press,PearsonPublication
2. BeckerWM,KleinsmithLJ,HardinJandBertoniGP(2009)TheWorldoftheCell,7thedition,PearsonBenjaminCummingsPublishing,SanFrancisco
3. DeRobertisEDPandDeRobertisEMF(2006)CellandMolecularBiology,8thedition.LippincottWilliamsandWilkins,Philadelphia
4. KarpG(2010)CellandMolecularBiology:ConceptsandExperiments,6thedition,JohnWiley&Sons.Inc.
5. SambrookJandRussellDW.(2001).MolecularCloning:ALaboratoryManual.4thEdition,ColdSpringHarbourLaboratory press.
6. KrebsJ,GoldsteinE,KilpatrickS(2013).Lewin'sEssentialGenes,3rdEd.,JonesandBartlettLearning
7. GardnerEJ,SimmonsMJ,SnustadDP(2008).PrinciplesofGenetics.8thEd.Wiley-India

CC8: Microbial Genetics

Course learning outcomes:

Outcome 1. Described genome organization of model organisms namely *E.coli* and *Saccharomyces,* and the molecular mechanisms that underlie mutations.

Outcome 2. Developed a fairly good knowledge about the three well known mechanisms by which genetic material is transferred among the microorganisms namely transformation, transduction and conjugation.

Outcome 3. Are able to describe different types of the extrachromosomal elements or the plasmids; the nature of the transposable elements in the prokaryotic and the eukaryotic cells.

Outcome 4. Hands on skills of isolation of plasmid DNA from bacterial cells and its visualization by performing agarose gel electrophoresis.

THEORY COURSE

(4 Credits)

Unit – 1:	**GenomeOrganizationandMutations** GenomeorganizatioN :*E.coli, Saccharomyces,Tetrahymena* Mutationsandmutagenesis:DefinitionandtypesofMutations;Physicalandchemicalmutagens;Molecular basis of mutations; Functional mutants (loss and gain of function mutants); Uses ofmutations Reversionandsuppression:Truerevertants;Intra-andinter-genicsuppression;Amestest;Mutatorgenes	**18 Lectures**
Unit – 2:	**Plasmids** Types of plasmids – F plasmid, R Plasmids, colicinogenic plasmids, Ti plasmids, linear plasmids,yeast-2µplasmid,Plasmidreplicationandpartitioning,Hostrange,plasmid-incompatibility,plasmidamplification,Regulationofcopynumber,curingofplasmids	**10 Lectures**

Unit – 3:	**MechanismsofGeneticExchange** Transformation-Discovery,mechanismofnaturalcompetence Conjugation- Discovery,mechanism,HfrandF'strains,Interruptedmatingtechniquea ndtimeofentrymapping Transduction- Generalizedtransduction,specializedtransduction,LFT&HFTlysates,M appingbyrecombinationandco-transductionofmarkers	**12 Lectures**
Unit-4	**4PhageGenetics** FeaturesofT4genetics,Geneticbasisoflytic*versus*lysogenicswitchofpha gelambda	**8 Lectures**
Unit-5	**Transposableelements** Prokaryotictransposableelements– InsertionSequences,compositeandnon- compositetransposons,ReplicativeandNonreplicativetransposition,Mu transposon Eukaryotictransposableelements- Yeast(Tyretrotransposon),Drosophila(Pelements),Maize(Ac/Ds) Usesoftransposonsandtransposition	**12 Lectures**

C-8: Microbial Genetics
(PRACTICALS)
SEMESTER –IV

TOTALHOURS:60 **CREDITS:2**

1. PreparationofMasterandReplicaPlates
2. Studytheeffectofchemical(HNO_2)andphysical(UV)mutagensonbacterialcells
3. Studysurvivalcurveofbacteriaafterexposuretoultraviolet(UV)light
4. IsolationofPlasmidDNAfrom*E.coli*
5. StudydifferentconformationsofplasmidDNAthroughAgaraosegelelectrophoresis.
6. DemonstrationofBacterialConjugation
7. Demonstrationofbacterialtransformationandtransduction
8. DemonstrationofAMEStest

SUGGESTEDREADING

1. KlugWS,CummingsMR,Spencer,C,Palladino,M(2011).ConceptsofGenetics,10thEd.,BenjaminCummings
2. KrebsJ,GoldsteinE,KilpatrickS(2013).Lewin'sEssentialGenes,3rdEd.,JonesandBartlettLearning
3. PierceBA(2011)Genetics:AConceptualApproach,4thEd.,MacmillanHigherEducationLearning
4. WatsonJD,BakerTA,BellSPetal.(2008)MolecularBiologyoftheGene,6thEd.,BenjaminCummings
5. GardnerEJ,SimmonsMJ,SnustadDP(2008).PrinciplesofGenetics.8thEd.Wiley-India
6. RussellPJ.(2009).*i*Genetics-AMolecularApproach.3rdEd,BenjaminCummings
7. SambrookJandRussellDW.(2001).MolecularCloning:ALaboratoryManual.4thEdition,ColdSpringHarbourLaboratory press.
8. MaloySR,CronanJEandFriefelderD(2004)MicrobialGenetics2ndEDITION.,JonesandBarlettPublishers

CC9: Environmental Microbiology

Course learning outcomes:

Outcome 1. Have developed a fairly good knowledge and understanding of different types of environments and habitats where microorganisms grow including the microbiomes of the human gut and animal gut.

Outcome 2. Are able to identify the important role microorganisms play in maintaining healthy environment by degradation of solid/liquid wastes; how these activities of microorganisms are used in sewage treatment plants, production of activated sludge and functioning of septic tanks

Outcome 3.Understood the significance of BOD/COD and various tests involving use of enumerating fecal *E.coli* for assessing quality of water.

Outcome 4. Have developed the practical skills for conducting experiments to assess the BOD/COD of wastewaters and their interpretation; practically assess the portability of drinking water by the use of standard microbiological tests.

THEORY COURSE (4 Credits)		
Unit – 1:	**MicroorganismsandtheirHabitats** Structureandfunctionofecosystems TerrestrialEnvironment:Soilprofileandsoilmicroflora AquaticEnvironment:Microfloraoffreshwa terandmarinehabitatsAtmosphere:Aeromi crofloraanddispersalofmicrobes Animal Environment: Microbes in/on human body (Microbiomics) & animal (ruminants) body.ExtremeHabitats:Extremophiles:Microbesthrivingathigh&lowt emperatures,pH,highhydrostatic&osmoticpressures,salinity,&lownu trientlevels. Microbialsuccessionindecompositionofplantorganicmatter	**14 Lectures**
	MicrobialInteractions Microbeinteractions:Mutualism,synergism,commensalism,competitio n,amensalism,parasitism,predation Microbe-Plantinteraction:Symbioticandnonsymbioticinteractions	

Unit – 2:	Microbe-animalinteraction:Microbesinruminants,nematophagusfungiandsymbioticluminescentbacteria	**12 Lectures**
Unit – 3:	**BiogeochemicalCycling** Carboncycle:Microbialdegradationofcellulose,hemicelluloses,ligninandchitin Nitrogencycle:Nitrogenfixation,ammonification,nitrification,denitrificationandnitratereductionPhosphoruscycle:Phosphateimmobilizationandsolubilisation Sulphurcycle:MicrobesinvolvedinsulphurcycleOtherelementalcycles:Ironandmanganese	**12 Lectures**
Unit-4	**WasteManagement** SolidWastemanagement:Sourcesandtypesofsolidwaste,Methodsofsolidwastedisposal(compostingandsanitarylandfill) Liquid waste management: Composition and strength of sewage (BOD and COD), Primary,secondary(oxidationponds,tricklingfilter,activatedsludgeprocessandseptictank)andtertiarysewagetreatment	**12 Lectures**
Unit-5	**MicrobialBioremediation** Principlesanddegradationofcommonpesticides,organic(hydrocarbons,oilspills)andinroganic(metals)matter,biosurfactants	**5 Lectures**
Unit-6	**WaterPotability** Treatmentandsafetyofdrinking(potable)water,methodstodetectpotabilityofwatersamples:(a)standardqualitativeprocedure:presumptivetest/MPNtest,confirmedandcompletedtestsforfaecalcoliforms(b)Membranefiltertechniqueand(c)Presence/absencetests	**5 Lectures**

C-9: Environmental Microbiology
(PRACTICALS)
SEMESTER –IV

TOTALHOURS:60 **CREDITS:2**

1. Analysisofsoil-pH,moisturecontent,waterholdingcapacity,percolation,capillaryaction.
2. Isolationofmicrobes(bacteria&fungi)fromsoil(28ºC&45ºC).
3. Isolationofmicrobes(bacteria&fungi)fromrhizosphereandrhizoplane.
4. Assessmentofmicrobiologicalqualityofwater.
5. DeterminationofBODofwastewatersample.
6. Studythepresenceofmicrobialactivitybydetecting(qualitatively)enzymes(dehydrogenase,amylase,urease)insoil.
7. Isolationof*Rhizobium*fromrootnodules.

SUGGESTEDREADINGS

1. AtlasRMandBarthaR.(2000).MicrobialEcology:Fundamentals&Applications.4thedition.Benjamin/CummingsSciencePublishing,USA
2. MadiganMT,MartinkoJMandParkerJ.(2014).BrockBiologyofMicroorganisms.14thedition.Pearson/BenjaminCummings
3. MaierRM,PepperILandGerbaCP.(2009).EnvironmentalMicrobiology.2ndedition,AcademicPress
4. Okafor,N(2011).EnvironmentalMicrobiologyofAquatic&Wastesystems.1stedition,Springer,NewYork
5. SinghA,Kuhad,RC&WardOP(2009).AdvancesinAppliedBioremediation.Volume17,Springer-Verlag,BerlinHedeilberg
6. Barton LL & Northup DE (2011). Microbial Ecology. 1st edition, Wiley Blackwell, USACampbellRE.(1983).MicrobialEcology.BlackwellScientificPublication,Oxford,England.
7. CoyneMS.(2001).SoilMicrobiology:AnExploratoryApproach.DelmarThomsonLearning.
8. LynchJM&HobbieJE.(1988).MicroorganismsinAction:Concepts&ApplicationinMicrobialEcology.BlackwellScientific Publication,U.K.
9. MartinA.(1977).AnIntroductiontoSoilMicrobiology.2nd edition.JohnWiley&SonsInc.NewYork&London.
10. StolpH.(1988).MicrobialEcology:OrganismsHabitatsActivities.CambridgeUniversityPress,Cambridge,England.
11. SubbaRaoNS.(1999).SoilMicrobiology.4thedition.Oxford&IBHPublishingCo.NewDelhi.
12. WilleyJM,SherwoodLM,andWoolvertonCJ.(2013).Prescott'sMicrobiology.9thedition.McGrawHill HigherEducation.

CC10: Food and Dairy Microbiology

Course learning outcomes:

Outcome 1.Developed a clear understanding of effect of intrinsic and extrinsic parameter on the microbial growth.

Outcome 2.Are able to describe the role of microorganisms in the production of food, its spoilage, including their role in homemade fermented foods.

Outcome 3.Are able to identify the role of microorganisms in the causation of the diseases and how to protect against food-borne pathogens.

Outcome 4. Developed experimental skills for testing the milk and different foods for the presence of microorganisms

THEORY COURSE (4 Credits)		
Unit – 1:	**Foodsasasubstrateformicroorganisms** Intrinsicandextrinsicfactorsthataffectgrowthandsurvivalofmicrobe sinfoods,naturalfloraandsourceofcontaminationoffoodsingeneral.	**8 Lectures**
Unit – 2:	**Microbialspoilageofvariousfoods** Principles,Spoilageofvegetables,fruits,meat,eggs,milkandbutter,bread ,cannedFoods	**10 Lectures**
Unit – 3:	**Principlesandmethodsoffoodpreservation** Principles, physical methods of food preservation: temperature (low, high, canning, drying),irradiation, hydrostatic pressure, high voltage pulse, microwave processing and aseptic packaging,chemicalmethodsoffoodpreservation:salt,sugar,organic acids,SO2,nitriteandnitrates,ethyleneoxide,antibioticsandbacterioc ins	**12 Lectures**

Unit-4	**Fermentedfoods** Dairy starter cultures, fermented dairy products: yogurt, acidophilus milk, kumiss, kefir, dahi andcheese,otherfermentedfoods:dosa,sauerkraut,soysauceandtampeh,Probiotics:Healthbenefits,typesofmicroorganismsused,probioticfoodsavailableinmarket.	**10 Lectures**
Unit-5	**Food borne diseases (causative agents, foods involved, symptoms and preventivemeasures)** Foodintoxications:*Staphylococcusaureus*,*Clostridiumbotulinum*andmycotoxins; Foodinfections:*Bacilluscereus*,*Vibrioparahaemolyticus*,*Escherichiacoli*,Salmonellosis,Shigellosis,*Yersiniaenterocolitica*,*Listeriamonocytogenes*and*Campylobacterjejuni*	**10 Lectures**
Unit-6	**Foodsanitationandcontrol** HACCP,Indicesoffoodsanitaryqualityandsanitizers	**5 Lectures**
Unit-7	Culturalandrapiddetectionmethodsoffoodbornepathogensinfoodsandintroductiontopredictivemicrobiology.	**5 Lectures**

C-10: Food and Dairy Microbiology
(PRACTICALS)
SEMESTER –IV

TOTALHOURS:60 **CREDITS:2**

1. MBRTofmilksamplesandtheirstandardplatecount.
2. Alkalinephosphatasetesttochecktheefficiencyofpasteurizationofmilk.
3. Isolationofanyfoodbornebacteriafromfoodproducts.
4. Isolationofspoilagemicroorganismsfromspoiledvegetables/fruits.
5. Isolationofspoilagemicroorganismsfrombread.
6. PreparationofYogurt/Dahi.

SUGGESTEDREADINGS

1. AdamsMRandMossMO.(1995).FoodMicrobiology.4thedition,NewAgeInternational(P)LimitedPublishers,New Delhi, India.
2. BanwartJM.(1987).BasicFoodMicrobiology.1stedition.CBSPublishersandDistributors,Delhi,India.
3. DavidsonPMandBrannenAL.(1993).AntimicrobialsinFoods.MarcelDekker,NewYork.
4. DillionVMandBoardRG.(1996).NaturalAntimicrobialSystemsandFoodPreservation.CABInternational,Wallingford, Oxon.
5. FrazierWCandWesthoffDC.(1992).FoodMicrobiology.3rdedition.TataMcGraw-HillPublishingCompany Ltd,NewDelhi,India.
6. GouldGW.(1995).NewMethodsofFoodPreservation.BlackieAcademicandProfessional,London.
7. JayJM,LoessnerMJandGoldenDA.(2005).ModernFoodMicrobiology.7th edition,CBSPublishersandDistributors,Delhi,India.
8. LundBM,BairdParkerAC,andGouldGW.(2000).TheMicrobiologicalSafetyandQualityofFoods.Vol.1-2,ASPENPublication,Gaithersberg,MD.
9. TortoraGJ,FunkeBR,andCaseCL.(2008).Microbiology:AnIntroduction.9th edition.PearsonEducation.

CC11: INDUSTRIAL MICROBIOLOGY

Course learning outcomes:

Outcome 1. Are capable of describing a large number of substrate that are used for the industrial fermentation processes.

Outcome 2. Have developed an understanding of different types of reactors or fermenters which are used for laboratory, pilot and industrial scale fermentations and their processes parameters.

Outcome 3. Have acquired a detailed knowledge of number of products which are produced by industrial fermentation processes.

THEORY COURSE (4 Credits)		
Unit – 1:	**Introductiontoindustrialmicrobiology** Briefhistoryanddevelopmentsinindustrialmicrobiology	**2 Lectures**
Unit – 2:	**Isolationofindustriallyimportantmicrobialstrainsandfermentation media** Sources of industrially important microbes and methods for their isolation, preservation andmaintenanceofindustrialstrains,strainimprovement,Crudeands yntheticmedia;molasses,corn-steepliquor,sulphitewasteliquor,whey,yeastextractandproteinhydr olysates	**10 Lectures**
Unit – 3:	**Types of fermentation processes, bio-reactors and measurement of fermentationparameters** Typesoffermentationprocesses-Solid-stateandliquid-state(stationaryandsubmerged)fermentations;batch,fed-batch(eg.baker'syeast)andcontinuousfermentations Components of a typical bio-reactor, Types of bioreactors-Laboratory, pilot- scale and	**12 Lectures**

	productionfermenters,constantlystirredtankandair-liftfermenters,Measurementandcontroloffermentationparameters-pH,temperature,dissolvedoxygen,foamingandaeration	
Unit-4	**Down-streamprocessing** Celldisruption,filtration,centrifugation,solventextraction,precipitation,lyophilizationandspraydrying	**6 Lectures**
Unit-5	**Microbial production of industrial products (micro-organisms involved, media,fermentationconditions,downstreamprocessinganduses)** Citricacid,ethanol, penicillin,glutamicacid,VitaminB12 Enzymes(amylase,protease,lipase)Wine,beer	**18 Lectures**
Unit-6	**Enzymeimmobilization** Methodsofimmobilization,advantagesandapplicationsofimmobilization,largescaleapplicationsofimmobilizedenzymes(glucoseisomeraseandpenicillinacylase)	**4 Lectures**

LAB Course
(Credit-2)

1. Studydifferentpartsoffermenter
2. Microbialfermentationsfortheproductionandestimation(qualitativeandquantitative)of:
   (a) Enzymes:AmylaseandProtease
   (b) Aminoacid:Glutamicacid
   (c) Organicacid:Citricacid
   (d) Alcohol:Ethanol
3. Avisittoanyeducationalinstitute/industrytoseeanindustrialfermenter,andotherdownstreamprocessing operations.

SUGGESTEDREADINGS

1. PatelA.H.(1996).IndustrialMicrobiology.1stedition,MacmillanIndiaLimited
2. OkaforN.(2007).ModernIndustrialMicrobiologyandBiotechnology.1stedition.BiosScientificPublishersLimited.USA
3. WaitesM.J.,MorganN.L.,RockeyJ.S.andHigtonG.(2001).IndustrialMicrobiology:AnIntroduction.1st edition.Wiley–Blackwell
4. GlazeA.N.andNikaidoH.(1995).MicrobialBiotechnology:FundamentalsofAppliedMicrobiology.1stediti on.W.H.FreemanandCompany
5. CasidaLE.(1991).IndustrialMicrobiology.1stedition.WileyEasternLimited.
6. CruegerWandCruegerA.(2000).Biotechnology:AtextbookofIndustrialMicrobiology.2ndedition.PanimaPublishingCo.NewDelhi.
7. StanburyPF,WhitakerAandHallSJ.(2006).PrinciplesofFermentationTechnology.2ndedition,ElsevierScienceLtd.

C-12: IMMUNOLOGY(THEORY)
SEMESTER–V

TOTALHOURS:60 **CREDITS:4**

Course learning outcomes:

Outcome 1. Understood the basic and general concepts of causation of disease by the pathogenic microorganisms and the various parameters of assessment of their severity including the broad categorization of the methods of diagnosis.

Outcome 2. Developed a thorough understanding of common bacterial, viral, fungal, parasitic diseases of human being including some very important diseases of the animals also.

Outcome 3. Conceptualized the protective role of the immune system of the host and developed an understanding of the basic components as well as the mechanisms underlying the immune system and its response to pathogenic microorganisms.

Outcome 4. Are able to conduct experiments for growing common bacteria in different microbiological media, antibiotic sensitivity determination and antigen antibody reaction (precipitation test in the agarose)

Unit1Introduction **No.ofHours:4**
ConceptofInnateandAdaptiveimmunity;Contributionsoffollowingscientiststothedevelopmentof field of immunology - Edward Jenner, Karl Landsteiner, Robert Koch, Paul Ehrlich, ElieMetchnikoff, Peter Medawar, MacFarlane Burnet, Neils K Jerne, Rodney Porter and SusumuTonegawa

Unit2ImmuneCellsandOrgans **No. of Hours: 7**Structure, Functions and Properties of: Immune Cells – Stem cell, T cell, B cell, NK cell,Macrophage,Neutrophil,Eosinophil,Basophil,Mastcell,Dendriticcell;andImmuneOrgans– BoneMarrow,Thymus,LymphNode,Spleen,GALT,MALT,CALT

Unit3Antigens **No.ofHours:4**
Characteristicsofanantigen(Foreignness,MolecularsizeandHeterogeneity);Haptens;Epitopes(T &Bcellepitopes);T-dependentandT-independentantigens;Adjuvants

Unit4Antibodies **No.ofHours:6**
Structure,Types,FunctionsandPropertiesofantibodies;Antigenicdeterminantsonantibodies(Isotypi c,allotypic,idiotypic);VDJrearrangements;MonoclonalandChimericantibodies

Unit5MajorHistocompatibilityComplex **No. of Hours: 5**OrganizationofMHClocus(Mice&Human);StructureandFunctionsofMHCI&IImolecules;An

tigenprocessingandpresentation(CytosolicandEndocyticpathways)

Unit6ComplementSystem **No.ofHours:4**
ComponentsoftheComplementsystem;Activationpathways(Classical,AlternativeandLectinpathways);BiologicalconsequencesofcomplementActivation

Unit7GenerationofImmuneResponse **No. of Hours: 10**PrimaryandSecondaryImmuneResponse;GenerationofHumoralImmuneResponse(PlasmaandMemory cells); Generation of Cell Mediated Immune Response (Self MHC restriction, T cellactivation, Co- stimulatory signals); Killing Mechanisms by CTL and NK cells, Introduction totolerance

Unit8ImmunologicalDisordersandTumorImmunity **No. of Hours: 10**Types of Autoimmunity and Hypersensitivity with examples; Immunodeficiencies - Animal models(NudeandSCIDmice),SCID,DiGeorgesyndrome,Chediak-Higashisyndrome,Leukocyteadhesiondeficiency,CGD;Typesoftumors,tumorAntigens,causesandtherapyforcancers.

Unit9ImmunologicalTechniques **No.ofHours:10**Principles of Precipitation, Agglutination, Immunodiffusion, Immunoelectrophoresis, ELISA,ELISPOT,Westernblotting,Immunofluoresence,Flowcytometry,Immunoelectronmicroscopy.

C-12:IMMUNOLOGY(PRACTICAL)SEMESTER–V

TOTALHOURS:60 **CREDITS:2**

1. Identification of human blood groups.
2. Perform Total Leukocyte Count of the given blood sample.
3. PerformDifferentialLeukocyteCountofthegivenbloodsample.
4. Separateserumfromthebloodsample(demonstration).
5. PerformimmunodiffusionbyOuchterlonymethod.
6. PerformDOTELISA.a
7. Performimmunoelectrophoresis.

SUGGESTEDREADINGS

1. AbbasAK,LichtmanAH,PillaiS.(2007).CellularandMolecularImmunology.6theditionSaundersPublication,Philadelphia.
2. DelvesP,MartinS,BurtonD,RoittIM.(2006).Roitt'sEssentialImmunology.11theditionWiley-BlackwellScientificPublication,Oxford.
3. GoldsbyRA,KindtTJ,OsborneBA.(2007).Kuby'sImmunology.6theditionW.H.FreemanandCompany,NewYork.
4. MurphyK,TraversP,WalportM.(2008).Janeway'sImmunobiology.7theditionGarlandSciencePublishers,NewYork.
5. PeakmanM,andVerganiD.(2009).BasicandClinicalImmunology.2ndeditionChurchillLivingstonePublishers, Edinberg.
6. RichardCandGeiffreyS.(2009).Immunology.6thedition.WileyBlackwellPublication.

C-13: MEDICAL MICROBIOLOGY (THEORY)SEMESTER–VI

TOTALHOURS:60 **CREDITS:4**

Unit1Normalmicrofloraofthehumanbodyandhostpathogeninteraction

No.ofHours:8

Normalmicrofloraofthehumanbody:Importanceofnormalmicroflora,normalmicrofloraofskin,throat,gastrointestinaltract,urogenitaltract

Host pathogen interaction: Definitions - Infection, Invasion, Pathogen, Pathogenicity, Virulence,Toxigenicity,Carriersandtheirtypes,Opportunisticinfections,Nosocomialinfections.Transmissionofinfection,PathophysiologiceffectsofLPS

Unit2Samplecollection,transportanddiagnosis **No. of Hours: 5**Collection,transportandculturingofclinicalsamples,principlesofdifferentdiagnostictests(ELISA,Immunofluorescence,Agglutinationbasedtests,Complementfixation,PCR,DNAprobes).

Unit3Bacterialdiseases **No.ofHours:15**

Listofdiseasesofvariousorgansystemsandtheircausativeagents.Thefollowingdiseasesindetailwithsymptoms,modeoftransmission,prophylaxisandcontrol

RespiratoryDiseases:*Streptococcuspyogenes*,*Haemophilusinfluenzae,Mycobacteriumtuberculosis*Gastrointestinal Diseases: *Escherichia coli*, *Salmonella typhi*, *Vibrio cholerae*, *Helicobacter pylori*Others: *Staphylococcus aureus, Bacillus anthracis, Clostridium tetani*, *Treponemapallidum,Clostridiumdifficie*

Unit4Viraldiseases **No.ofHours:14**

Listofdiseasesofvariousorgansystemsandtheircausativeagents.Thefollowingdiseasesindetailwithsymptoms,modeoftransmission,prophylaxisandcontrol

Polio,Herpes,Hepatitis,Rabies,Dengue,AIDS,Influenzawithbriefdescriptionofswineflu,Ebola,Chikungunya,JapaneseEncephalitis

Unit5Protozoandiseases **No.ofHours:5**

Listofdiseasesofvariousorgansystemsandtheircausativeagents.Thefollowingdiseasesindetailwithsymptoms,modeoftransmission,prophylaxisandcontrol

Malaria,Kala-azar

Unit6Fungaldiseases **No.ofHours:5**

Briefdescriptionofeachofthefollowingtypesofmycosesandonerepresentativediseasetobestudiedwithrespecttotransmission,symptomsandprevention

Cutaneousmycoses:Tineapedis(Athlete'sfoot)Systemic mycoses: HistoplasmosisOpportunisticmycoses:Candidiasis

Unit7Antimicrobialagents:Generalcharacteristicsandmodeofaction **No.ofHours:8**

Antibacterialagents:Fivemodesofactionwithoneexampleeach:Inhibitorofnucleicacidsynthesis;Inhibitor of cell wall synthesis; Inhibitor of cell membrane function; Inhibitor of protein synthesis;Inhibitorof metabolism

Antifungal agents: Mechanism of action of Amphotericin B,

GriseofulvinAntiviralagents:MechanismofactionofAmantadine,Acyclovir,AzidothymidineAntibioticresistance,MDR,XDR,MRSA,NDM-1

C-13:MEDICALMICROBIOLOGY(PRACTICAL)SEMESTER–VI

TOTALHOURS:60 **CREDITS:2**

1. Identifybacteria(anythreeof*E.coli,Salmonella,Pseudomonas,Staphylococcus,Bacillus*)usinglaboratory strains on the basis of cultural, morphological and biochemical characteristics: IMViC,TSI,nitratereduction,ureaseproductionandcatalasetests
2. Studyofcompositionanduseofimportantdifferentialmediaforidentificationofbacteria:EMBAgar,McConkey agar,Mannitolsaltagar,Deoxycholatecitrateagar,TCBS
3. Studyofbacterialfloraofskinbyswabmethod
4. PerformantibacterialsensitivitybyKirby-Bauermethod
5. Determinationofminimalinhibitoryconcentration(MIC)ofanantibiotic.
6. Studysymptomsofthediseaseswiththehelpofphotographs:Polio,anthrax,herpes,chickenpox,HPVwarts,AIDS(candidiasis),dermatomycoses(ringworms)
7. Studyofvariousstagesofmalarialparasiteinthe RBCsusingpermanentmounts.

SUGGESTEDREADING

1. AnanthanarayanR.andPanikerC.K.J.(2009)TextbookofMicrobiology.8thedition,UniversityPressPublication
2. BrooksG.F.,CarrollK.C.,ButelJ.S.,MorseS.A.andMietzner,T.A.(2013)Jawetz,MelnickandAdelberg'sMedicalMicrobiology.26thedition.McGrawHillPublication
3. GoeringR.,DockrellH.,ZuckermanM.andWakelinD.(2007)Mims'MedicalMicrobiology.4thedition.Elsevier
4. WilleyJM,SherwoodLM,andWoolvertonCJ.(2013)Prescott,HarleyandKlein'sMicrobiology.9thedition.McGrawHill HigherEducation
5. MadiganMT,MartinkoJM,DunlapPVandClarkDP.(2014).BrockBiologyofMicroorganisms.14thedition. PearsonInternationalEdition

C-14: RECOMBINANT DNA TECHNOLOGY (THEORY) SEMESTER–VI

TOTALHOURS:60 **CREDITS:4**

Course learning outcomes: By the conclusion of this course, the students-

Outcome 1. Has acquired a fairly good knowledge of the tools and the methods for genetic engineering.

Outcome 2. Has acquired a fairly good understanding of how these tools and methods are employed in the laboratory for manipulation of DNA so as to make it relevant for biotechnological uses.

Outcome 3. Students can perform isolation of DNA, amplification of any gene by PCR and its analysis by gel electrophoresis.

Unit1IntroductiontoGeneticEngineering **No.ofHours:2**
Milestonesingeneticengineeringandbiotechnology

Unit2MolecularCloning-ToolsandStrategies **No. of Hours: 20**CloningTools;Restrictionmodificationsystems:TypesI,IIandIII.Modeofaction,nomenclature,applicationsofType IIrestrictionenzymesingeneticengineering
DNAmodifyingenzymesandtheirapplications:
DNApolymerases.Terminaldeoxynucleotidyltransferase,kinasesandphosphatases,and DNAligases
Cloning Vectors: Definition and PropertiesPlasmid vectors:
pBR and pUC
seriesBacteriophagelambdaandM13basedvectorsCosmids,B
ACs,YACs
Useoflinkersandadaptors
Expressionvectors:*E.coli*lacandT7promoter-
basedvectors,yeastYIp,YEpandYCpvectors,BaculovirusbasedvectorsmammalianSV40-basedexpressionvectors

Unit3MethodsinMolecularCloning **No.ofHours:16**
TransformationofDNA:Chemicalmethod,Electroporation,
Genedelivery:Microinjection,electroporation,biolisticmethod(genegun),liposomeandviral-
mediateddelivery,*Agrobacterium*-mediateddelivery
DNA,RNAandProteinanalysis:Agarosegelelectrophoresis,Southern-andNorthern-
blottingtechniques,dotblot,DNAmicroarrayanalysis,SDS-PAGEandWesternblotting.

Unit4DNAAmplificationandDNAsequencing **No.ofHours:10**
PCR:BasicsofPCR,RT-PCR,Real-TimePCR
Sanger'smethodofDNASequencing:traditionalandautomatedsequencingPrimerwalkingandsho
tgunsequencing

Unit5ConstructionandScreeningofGenomicandcDNAlibraries **No. of Hours: 6**GenomicandcDNAlibraries:Preparationanduses,Screeningoflibraries:Colonyhybridizationandcolony PCR,Chromosomewalkingandchromosomejumping

Unit6ApplicationsofRecombinantDNATechnology
No.ofHours:6 Productsofreco
mbinantDNAtechnology:Productsofhumantherapeuticinterest-insulin,hGH,antisense molecules. Bt transgenic - cotton, brinjal, Gene therapy, recombinant vaccines, proteinengineeringandsitedirectedmutagensis

C-14:RECOMBINANTDNATECHNOLOGY(PRACTICAL)SEMESTER–VI

TOTALHOURS:60 **CREDITS:2**

1. PreparationofcompetentcellsfortransformationDemonstrationofBacterialTransformationandcalculationoftransformationefficiency.
2. DigestionofDNAusingrestrictionenzymesandanalysisbyagarosegelelectrophoresis
3. LigationofDNAfragments
4. CloningofDNAinsertandBluewhitescreeningofrecombinants.
5. Interpretationofsequencinggelelectropherograms
6. DesigningofprimersforDNAamplification
7. AmplificationofDNAbyPCR
8. DemonstrationofSouthernblotting

SUGGESTEDREADING

1. BrownTA.(2010).GeneCloningandDNAAnalysis.6thedition.BlackwellPublishing,Oxford,U.K.
2. ClarkDPandPazdernikNJ.(2009).Biotechnology:ApplyingtheGeneticRevolution.ElsevierAcademicPress,USA
3. PrimroseSBandTwymanRM.(2006).PrinciplesofGeneManipulationandGenomics,7thedition.BlackwellPublishing,Oxford,U.K.
4. SambrookJandRussellD.(2001).MolecularCloning-ALaboratoryManual.3rdedition.ColdSpringHarborLaboratory Press
5. WileyJM,SherwoodLMandWoolvertonCJ.(2008).Prescott,HarleyandKlein'sMicrobiology.McGrawHillHigherEducation
6. BrownTA.(2007).Genomes-3.GarlandSciencePublishers
7. PrimroseSBandTwymanRM.(2008).Genomics:Applicationsinhumanbiology.BlackwellPublishing,Oxford,U.K.

DSE-1:BIOINFORMATICS(THEORY)
SEMESTER–V/VI

TOTALHOURS:60 **CREDITS:4**

Course learning outcomes: By the conclusion of this course, the students have -

Outcome 1. Developed skills to use computers for analysis of biological data.

Outcome 2. Skill to use important biological databases, use tools to retrieve data, and compare the data of the biological macromolecules

Outcome 3. Developed basic skills for data retrieval, representation, analysis and interpretation.

Unit1IntroductiontoComputerFundamentals **No.ofHours:8**
RDBMS-Definitionofrelationaldatabase
Modeofdatatransfer(FTP,SFTP,SCP),advantageofencrypteddatatransfer

Unit2IntroductiontoBioinformaticsandBiologicalDatabases **No. of Hours: 14**Biological databases - nucleic acid, genome, protein sequence and structure, gene expressiondatabases,Databaseofmetabolicpathways,Modeofdatastorage-Fileformats-FASTA,GenbankandUniprot,Datasubmission&retrievalfromNCBI,EMBL,DDBJ,Uniprot,PDB

Unit3SequenceAlignments,PhylogenyandPhylogenetictrees **No.ofHours:16**
LocalandGlobalSequencealignment,pairwiseandmultiplesequencealignment.Scoringanalignment,scoringmatrices,PAM&BLOSUMseriesofmatrices
Typesofphylogenetictrees,Differentapproachesofphylogenetictreeconstruction-UPGMA,Neighbourjoining,MaximumParsomony,Maximumlikelihood

Unit4Genomeorganizationandanalysis **No.ofHours:10**
DiversityofGenomes:Viral,prokaryotic&eukaryoticgenomes
Genome,transcriptome,proteome,2-DgelelectrophoresisMaldiToffspectroscopyMajorfeaturesofcompletedgenomes:*E.coli,S.cerevisiae,Arabidopsis,*Human

Unit5ProteinStructurePredictions **No.ofHours:12**
Hierarchyofproteinstructure-primary,secondaryandtertiarystructures,modelingStructuralClasses,Motifs,FoldsandDomains
ProteinstructurepredictioninpresenceandabsenceofstructuretemplateEnergyminimizationsandevaluationbyRamachandranplot
Proteinstructureandrationaldrugdesign

DSE-1:BIOINFORMATICS(PRACTICAL)SEMESTER–V/VI
TOTALHOURS:60 **CREDITS:2**

1. Introductiontodifferentoperatingsystems-UNIX,LINUXandWindows
2. Introductiontobioinformaticsdatabases(anythree):NCBI/PDB/DDBJ,Uniprot,PDB
3. SequenceretrievalusingBLAST
4. Sequencealignment&phylogeneticanalysisusingclustalW&phylip
5. Picking out a given gene from genomes using Genscan or other softwares (promoter regionidentification,repeatingenome,ORFprediction).Genefindingtools(Glimmer,GENSCAN),Primerdesigning, Genscan/Genetool
6. Proteinstructureprediction:primarystructureanalysis,secondarystructurepredictionusingpsi-pred,homologymodelingusingSwissmodel.Molecularvisualizationusingjmol,Proteinstructuremodelevaluation(PROCHECK)
7. Predictionofdifferentfeaturesofafunctionalgene

SUGGESTEDREADING

1. SaxenaSanjay(2003)AFirstCourseinComputers,VikasPublishingHouse

2. PradeepandSinhaPreeti(2007)FoundationsofComputing,4thed.,BPBPublications
3. LeskM.A.(2008)IntroductiontoBioinformatics.OxfordPublication,3rdInternationalStudentEdition
4. RastogiS.C.,MendirattaN.andRastogiP.(2007)Bioinformatics:methodsandapplications,genomics,proteomic sanddrugdiscovery,2nded.PrenticeHallIndiaPublication
5. PrimroseandTwyman(2003)PrinciplesofGenomeAnalysis&Genomics.Blackwell

DSE-2: MICROBIAL BIOTECHNOLOGY (THEORY)SEMESTER– V/VI

TOTALHOURS:60 **CREDITS:4**

Course learning outcomes: By the conclusion of this course, the students-

Outcome 1. Has acquired a fairly good knowledge of the tools and the methods for genetic engineering.

Outcome 2. Has acquired a fairly good understanding of how these tools and methods are employed in the laboratory for manipulation of DNA so as to make it relevant for biotechnological uses.

Outcome 3. Students can perform isolation of DNA, amplification of any gene by PCR and its analysis by gel electrophoresis.

Unit1MicrobialBiotechnologyanditsApplications **No. of Hours: 10**Microbialbiotechnology:Scopeanditsapplicationsinhumantherapeutics,agriculture(Biofertilizers,PGPR,Mycorrhizae),environmental,andfoodtechnology
Useofprokaryoticandeukaryoticmicroorganismsinbiotechnologicalapplications Geneticallyengineeredmicrobesforindustrialapplication:Bacteriaandyeast

Unit2TherapeuticandIndustrialBiotechnology **No.ofHours:10**Recombinant microbial production processes in pharmaceutical industries - Streptokinase,recombinantvaccines(HepatitisB vaccine)
Microbialpolysaccharidesandpolyesters,Microbialproductionofbio-pesticides,bioplasticsMicrobial biosensors

Unit3ApplicationsofMicrobesinBiotransformations **No.ofHours:8**
Microbialbasedtransformationofsteroidsandsterols
Bio-catalyticprocessesandtheirindustrialapplications:Productionofhighfructosesyrupandproductionofcocoabuttersubstitute

Unit4MicrobialProductsandtheirRecovery **No.ofHours:10**Microbial product purification: filtration, ion exchange & affinity chromatography
techniquesImmobilizationmethodsandtheirapplication:Wholecellimmobilization

Unit5MicrobesforBio-energyandEnvironment **No.ofHours:12**Bio-

ethanolandbio-
dieselproduction:commercialproductionfromlignocellulosicwasteandalgalbiomass,Biogasproduction:Methaneand hydrogenproductionusingmicrobialculture.
Microorganismsinbioremediation:Degradationofxenobiotics,mineralrecovery,removalofheavymetalsfromaqueous effluents

Unit6RNAi **No.ofHours:6**
RNAianditsapplicationsinsilencinggenes,drugresistance,therapeuticsandhostpathogeninteractions

Unit7IntellectualPropertyRights **No.ofHours:4**
Patents,Copyrights,Trademarks

DSE-2: MICROBIAL BIOTECHNOLOGY(PRACTICAL)SEMESTER– V/VI

TOTALHOURS:60 **CREDITS:2**

1. Studyyeastcellimmobilizationincalciumalginategels
2. Studyenzymeimmobilizationbysodiumalginatemethod
3. Pigmentproductionfromfungi(*Trichoderma*/*Aspergillus*/*Penicillium*)
4. Isolationofxylanaseorlipaseproducingbacteria
5. StudyofalgalSingleCellProteins

SUGGESTEDREADING

1. Ratledge,CandKristiansen,B.(2001).BasicBiotechnology,2ndEdition,CambridgeUniversityPress.
2. Demain,A.LandDavies,J.E.(1999).ManualofIndustrialMicrobiologyandBiotechnology,2ndEdition,ASMPress.
3. Swartz,J.R.(2001).AdvancesinEscherichiacoliproductionoftherapeuticproteins.CurrentOpinioninBiotechnology,12,195–201.
4. Prescott,HarleyandKlein'sMicrobiologybyWilleyJM,SherwoodLM,WoolvertonCJ(2014),9thedition, McGrawHillPublishers.
5. GuptaPK(2009)ElementsofBiotechnology2nd edition,RastogiPublications,
6. GlazerANandNikaidoH(2007)MicrobialBiotechnology,2nd edition,CambridgeUniversityPress
7. GlickBR,PasternakJJ,andPattenCL(2010)MolecularBiotechnology4th edition,ASMPress,
8. StanburyPF,WhitakerA,HallSJ(1995)PrinciplesofFermentationTechnology2ndedition.,ElsevierScience
9. CruegerW,CruegerA(1990)Biotechnology:AtextBookofIndustrialMicrobiology2ndeditionSinauerassociates,Inc.

DSE-3: ADVANCES IN MICROBIOLOGY (THEORY)SEMESTER–V/VI

TOTALHOURS:60 **CREDITS:4**

Course learning outcomes: By the conclusion of this course, the students -

Outcome 1. Can explain salient characteristics of genomes of representative microorganisms.

Outcome 2. Have understood the concept and importance of metagenomics.

Outcome 3.Have developed an initial understanding of recent developments of host-microbe interactions, synthetic biology, viable but non-culturable forms of microorganism etc.

Outcome 4. Are able to extract DNA from bacteria / soil and perform PCR for 16s Ribosomal genes using universal primers and interpret the results.

Unit1EvolutionofMicrobialGenomes **No. of Hours: 15**Salient features of sequenced microbial genomes, core genome pool, flexible genome pool andconceptofpangenome,Horizontalgenetransfer(HGT),Evolutionofbacterialvirulence-Genomicislands,Pathogenicityislands(PAI)andtheircharacteristics

Unit2Metagenomics **No.ofHours:15**

Brief history and development of metagenomics, Understanding bacterial diversity usingmetagenomicsapproach,ProspectinggenesofbiotechnologicalimportanceusingmetagenomicsBasicknowledgeofviralmetagenome,metatranscriptomics,metaproteomicsandmetabolomics.

Unit3MolecularBasisofHost-MicrobeInteractions **No.ofHours:15**Epiphytic fitness and its mechanism in plant pathogens, Hypersensitive response (HR) to plantpathogensanditsmechanism,Typethreesecretionsystems(TTSS)ofplantandanimalpathogens,Biofilms:typesofmicroorganisms,molecularaspectsandsignificanceinenvironment,healthcare,virulenceandantimicrobial resistance

Unit4SystemsandSyntheticBiology

No.ofHours:15 Networkinginbiologicalsystems,Quorumsensinginbacteria,Co-ordinatedregulationofbacterialvirulence factors, Basics of synthesis of poliovirus in laboratory, Future implications of syntheticbiologywithrespecttobacteria andviruses

DSE-3: ADVANCESINMICROBIOLOGY(PRACTICAL)SEMESTER–V/VI

TOTALHOURS:60 **CREDITS:2**

1. ExtractionofmetagenomicDNAfromsoil
2. UnderstandtheimpedimentsinextractingmetagenomicDNAfromsoil
3. PCRamplificationofmetagenomicDNAusinguniversal16sribosomalgeneprimers
4. Casestudytounderstandhowthepoliovirusgenomewassynthesizedinthelaboratory
5. Casestudytounderstandhownetworkingofmetabolicpathwaysinbacteriatakesplace

SUGGESTEDREADING
1. FraserCM,ReadTDandNelsonKE.MicrobialGenomes,2004,HumanaPress
2. MillerRVandDayMJ.MicrobialEvolution-Geneestablishment,survivalandexchange,2004,ASMPress
3. BullAT.MicrobialDiversityandBioprospecting,2004,ASMPress
4. SangdunC.IntroductiontoSystemsBiology,2007,HumanaPress
5. KlippE,LiebermeisterW.SystemsBiology–ATextbook,2009,Wiley–VCHVerlag
6. Caetano-AnollesG.EvolutionaryGenomicsandSystemsBiology,2010,JohnWileyandSons
7. MadiganMT,MartinkJM,DunlapPVandClarkDP(2014)Brook'sBiologyofMicroorganisms,14thedition,Pearson-BejaminCummings
8. WilsonBA,SalyersAAWhittDDandWinklerME(2011)BacterialPathogenesis-AmolecularApproach,3rdedition,ASMPress,
9. BouarabK,BrissonandDaayfF(2009)MolecularPlant-MicrobeinteractionCABInternational
10. VoitEO(2012)AFirstCourseinSystemsBiology,Istedition,GarlandScience

DSE-4: PLANTPATHOLOGY(THEORY)
SEMESTER–V/VI

TOTALHOURS:60 **CREDITS:4**

Course learning outcomes: By the conclusion of this course, the students-

Outcome 1. Developed basic concepts of causation of diseases in plants by the different types of microorganisms namely bacterial, fungal and viral.

Outcome 2. Knowledge of important plant diseases, their etiology, salient characteristics and control measures

Outcome 3. Developed skills to analyze the diseased plant samples in the laboratory and are able to identify the salient features of the disease-causing microbe and the lesions produced on the plant parts.

Unit1IntroductionandHistoryofplantpathology **No. of Hours: 5**Conceptofplantdisease-definitionsofdisease,diseasecycle&pathogenicity,symptomsassociatedwith microbial plant diseases, types of plant pathogens, economic losses and social impact of plantdiseases. Significant landmarks in the field of plant pathology- Contributions of Anton DeBary,Millardet,Burrill,E.Smith,AdolphMayer,Ivanowski,Diener,Stakman,H.H.Flor,VanDerPlank,molecularKoch'spostulates.ContributionsofeminentIndianplantpathologists.

Unit2Stagesindevelopmentofadisease **No.ofHours:2**
Infection,invasion,colonization,disseminationofpathogensandperennation.

Unit3Plantdiseaseepidemiology **No.ofHours:5**Concepts of monocyclic, polycyclic and polyetic diseases, disease triangle & disease pyramid,forecastingofplantdiseasesanditsrelevanceinIndiancontext.

Unit4HostPathogenInteraction **No.ofHours:19**
A. MicrobialPathogenicity
Virulencefactorsofpathogens:enzymes,toxins(hostspecificandnonspecific)growthregulators,virulencefactorsinviruses(replicase,coatprotein,silencingsuppressors)indiseasedevelopment.Effects of pathogens on host physiological processes

(photosynthesis, respiration, cell membranepermeability,translocationofwaterandnutrients,plantgrowthandreproduction).

B. GeneticsofPlantDiseases

Conceptofresistance(R)geneandavirulence(avr)gene;geneforgenehypothesis,typesofplantresistance:trueresistance–horizontal&vertical,apparentresistance.

C. DefenseMechanismsinPlants

Concepts of constitutive defense mechanisms in plants, inducible structural defenses (histological-corklayer,abscissionlayer,tyloses,gums),induciblebiochemicaldefenses[hypersensitiveresponse(HR), systemic acquired resistance (SAR), phytoalexins, pathogenesis related (PR) proteins,plantibodies, phenolics,quinones,oxidativebursts].

Unit5ControlofPlantDiseases **No. of Hours: 10**Principles & practices involved in the management of plant diseases by different methods, *viz.*regulatory-quarantine,cropcertification,avoidanceofpathogen,useofpathogenfreepropagativematerial
cultural-hosteradication,croprotation,sanitation,polyethylenetrapsandmulches
chemical-protectantsandsystemicfungicides,antibiotics,resistanceofpathogenstochemicals.biological-suppressivesoils,antagonisticmicrobes-bacteriaandfungi,trapplants
geneticengineeringofdiseaseresistantplants-withplantderivedgenesandpathogenderivedgenes

Studyofsomeimportantplantdiseasesgivingemphasisonitsetiologicalagent,symptoms,epidemiologyandcontrol

A. Important diseases caused by
fungiWhiterustofcrucifers-*Albugocandida*
Downymildewofonion-*Peronosporadestructor*Late blight of potato - *Phytophthorainfestans*Powdery mildew of wheat - *Erysiphegraminis*Ergotofrye-*Clavicepspurpurea*
Blackstemrustofwheat-*Pucciniagraministritici*
Loosesmutofwheat-*Ustilagonuda*
Wiltoftomato-*Fusariumoxysporum*f.sp.*lycopersici*
Redrotofsugarcane-*Colletotrichumfalcatum*
Earlyblightofpotato-*Alternariasolani*

B. Importantdiseasescausedbyphytopathogenicbacteria:Angularleafspotofcotton,bacterialleafblightofrice,crowngalls, bacterialcankersofcitrus

C. Importantdiseasescausedbyphytoplasmas:Asteryellow,citrusstubborn

D. Importantdiseasescausedbyviruses:Papayaringspot,tomatoyellowleafcurl,bananabunchytop,ricetungro

E. Importantdiseasescausedbyviroids:Potatospindletuber,coconutcadangcadang

DSE-4: PLANTPATHOLOGY(PRACTICAL)SEMESTER–V/VI
TOTALHOURS:60 **CREDITS:2**

1. DemonstrationofKoch'spostulatesinfungal,bacterialandviralplantpathogens.
2. Studyofimportantdiseasesofcropplantsbycuttingsectionsofinfectedplantmaterial-*Albugo,Puccinia*,*Ustilago,Fusarium,Colletotrichum.*

SUGGESTEDREADINGS

1. AgriosGN.(2006).PlantPathology.5thedition.Academicpress,SanDiego,
2. LucasJA.(1998).PlantPathologyandPlantPathogens.3rdedition.BlackwellScience,Oxford.
3. MehrotraRS.(1994).PlantPathology.TataMcGraw-HillLimited.
4. RangaswamiG.(2005).DiseasesofCropPlantsinIndia.4thedition.PrenticeHallofIndiaPvt.Ltd.,NewDelhi.
5. SinghRS.(1998).PlantDiseasesManagement.7thedition.Oxford&IBH,NewDelhi.

DSE-5: BIOMATHEMATICS AND BIOSTATISTICS (PRACTICAL)
SEMESTER –V/VI

Course learning outcomes:

Outcome 1. Have developed basic knowledge of mathematics as applied to biological phenomenon.

Outcome 2. Skill to use important biological databases, use tools to retrieve data, and compare the data of the biological macromolecules

Outcome 3. Developed basic skills for data retrieval, representation, analysis and interpretation.

Unit 1 Biomathematics — No of Hours: 30

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. 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.
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. Differential Equations of first order, Linear Differential Equations.
Points in plane and space and coordinate form. Examples of matrices arising in Biological Sciences and Biological networks. Sum and Produce of matrices upto order 3.

Unit 2 Biostatistics — No of Hours: 30

Measures of central tendency, Measures of dispersion; skewness, kurtosis; Elementary Probability and basic laws; Discrete and Continuous Random variable, Mathematical Expectation; Curve Fitting; Correlation and Regression. Emphasis on examples from Biological Sciences;
Mean and Variance of Discrete and Continuous Distributions namely Binomial, Poisson, Geometric, Weibull, Logistic and Normal distribution. Fitting of Distributions;
Statistical methods: Scope of statistics: utility and misuse. Principles of statistical

analysis of biological data. Sampling parameters. Difference between sample and Population, Sampling Errors, Censoring, difference between parametric and non-parametric statistics;
Sampling Distributions, Standard Error, Testing of Hypothesis, Level of Significance and Degree of Freedom;
Large Sample Test based on Normal Distribution, Small sample test based on t-test, Z- test and F test; Confidence Interval; Distribution-free test - Chi-square test; Basic introduction to Multivariate statistics, etc.

BIOMATHEMATICS AND BIOSTATISTICS (PRACTICAL)
SEMESTER –V/V

DSE-5: **TOTAL HOURS: 60** **CREDITS: 2**

1. Word Problems based on Differential Equations
2. Mean, Median, Mode from grouped and ungrouped Data set
3. Standard Deviation and Coefficient of Variation
4. Skewness and Kurtosis
5. Curve fitting
6. Correlation
7. Regression
8. Finding area under the curve using normal probability
9. Testing of Hypothesis- Normal Distribution, t-test and Chi-Square-test
10. Confidence Interval

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.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
DSE-6: INHERITANCE BIOLOGY (THEORY)
SEMESTER –V/VI

TOTAL HOURS: 60 **CREDITS: 4**

Course learning outcomes: By the conclusion of this course, the students have -

Outcome 1. Good understanding of concepts of Mendelian genetics and structural organizations of chromosomes.

Outcome 2. Developed practical skills to do karyotyping and pedigree analysis.

Unit 1 Introduction to Genetics — No. of Hours: 5

Historical developments

Model organisms in genetic analyses and experimentation: *Escherichia coli*, *Saccharomyces cerevisiae, Neurospora crassa, Caenorhabditis elegans Drosophila melanogaster, Arabidopsis thaliana*

Unit 2 Mendelian Principles — No. of Hours: 13

Mendel's Laws: Dominance, segregation, independent assortment, deviation from Mendelian inheritance, Rediscovery of Mendel's principles, Chromosome theory of inheritance: Allele, multiplealleles, pseudoallele, complementation tests, Extensions of Mendelian genetics: Allelic interactions,concept of dominance, recessiveness, Incomplete dominance and co-dominance, Multiple alleles, Epistasis, penetrance and expressivity

Unit 3 Linkage and Crossing over **No. of Hours: 9**

Linkage and recombination of genes, Cytological basis of crossing over, Crossing over at four-strand stage, Molecular mechanism of crossing over, mapping

Unit 4 Extra-Chromosomal Inheritance **No. of Hours: 9**

Rules of extra nuclear inheritance, Organelle heredity - Chloroplast mutations in *Chlamydomonas*, mitochondrial, mutations in *Saccharomyces,* Maternal effects – Shell coiling in *Limnaea peregra* Infectious heredity - Kappa particles in *Paramecium*

Unit 5 Characteristics of Chromosomes **No. of Hours: 15** Structural organization of chromosomes - centromeres, telomeres and repetitive DNA, Packaging DNA molecules into chromosomes, Concept of euchromatin and heterochromatin, Normal and abnormal karyotypes of human chromosomes, Chromosome banding, Giant chromosomes: Polyteneand lampbrush chromosomes, Variations in chromosome structure: Deletion, duplication, inversionand translocation, Variation in chromosomal number and structural abnormalities -

Klinefelter syndrome, Turner syndrome, Down syndrome

Unit 6 Recombination — No. of Hours: 3

Homologous and non-homologous recombination, including transposition, site-specific recombination.

Unit 7 Human genetics — No. of Hours: 3

Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.

Unit 8 Quantitative genetics — No. of Hours: 3

Polygenic inheritance, heritability and its measurements, QTL mapping.

DSE-6: INHERITANCE BIOLOGY (PRACTICAL)
SEMESTER –V/VI

TOTAL HOURS: 60 **CREDITS: 2**

1. Mendelian deviations in dihybrid crosses
2. Studying Barr Body with the temporary mount of human cheek cells
3. Studying *Rhoeo* translocation with the help of photographs
4. Karyotyping with the help of photographs
5. Chi-Square Analysis
6. Study of polytene chromosomes using temporary mounts of salivary glands of *Chiromonas / Drosophila* larvae
7. Study of pedigree analysis
8. Analysis of a representative quantitative trait

SUGGESTED READING

1. Gardner EJ, Simmons MJ, Snustad DP (2008). Principles of Genetics. 8th Ed. Wiley-India
2. Snustad DP, Simmons MJ (2011). Principles of Genetics. 6th Ed. John Wiley and Sons Inc.
3. Weaver RF, Hedrick PW (1997). Genetics. 3rd Ed. McGraw-Hill Education
4. Klug WS, Cummings MR, Spencer CA, Palladino M (2012). Concepts of Genetics. 10th Ed. Benjamin Cummings
5. Griffith AJF, Wessler SR, Lewontin RC, Carroll SB. (2007). Introduction to Genetic Analysis. 9th Ed. W.H.Freeman and Co., New York
6. Hartl DL, Jones EW (2009). Genetics: Analysis of Genes and Genomes. 7th Ed, Jones and Bartlett Publishers
7. Russell PJ. (2009). *i* Genetics - A Molecular Approach. 3rd Ed, Benjamin Cummings

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
DSE-7: MICROBES IN SUSTAINABLE AGRICULTURE AND DEVELOPMENT (THEORY)
SEMESTER –V/VI

TOTAL HOURS: 60 **CREDITS: 4**

Course learning outcomes: By the conclusion of this course, the students-

Outcome 1. Has acquired a fairly good understanding of microbes in the soil.

Outcome 2. Has developed a fairly good understanding of the use of microbes in sustainable agriculture namely role in biogeochemical recycling, nitrogen fixing, organic matter degradation, use as bio fertilizers, as bio pesticides, production of biofuels

Outcome 3.Has developed skills for growing microorganisms in the laboratory for the production of different enzymes by different microorganisms.

Unit 1 Soil Microbiology No of Hours: 8

Soil as Microbial Habitat, Soil profile and properties, Soil formation, Diversity and distribution ofmicroorganisms in soil

Unit 2 Mineralization of Organic & Inorganic Matter in Soil **No of Hours: 8**

Mineralization of cellulose, hemicelluloses, lignocelluloses, lignin and humus, phosphate, nitrate, silica, potassium

Unit 3 Microbial Activity in Soil and Green House Gases No of Hours: 5

Carbon dioxide, methane, nitrous oxide, nitric oxide – production and control

Unit 4 Microbial Control of Soil Borne Plant Pathogens **No of Hours: 8**

Biocontrol mechanisms and ways, Microorganisms used as biocontrol agents against Microbial plant pathogens, Insects, Weeds

Unit 5 Biofertilization, Phytostimulation, Bioinsecticides **No of Hours: 15**

Plant growth promoting bateria, biofertilizers – symbiotic (*Bradyrhizobium, Rhizobium, Frankia*), Non Symbiotic (*Azospirillum, Azotobacter*, Mycorrhizae, MHBs, Phosphate solubilizers, algae), Novel combination of microbes as biofertilizers, PGPRs

Unit 6 Secondary Agriculture Biotechnology No of Hours: 10

Biotech feed, Silage, Biomanure, biogas, biofuels – advantages and processing parameters

Unit 7 GM crops — No of Hours: 6

Advantages, social and environmental aspects, Bt crops, golden rice, transgenic animals.

DSE-7: MICROBES IN SUSTAINABLE AGRICULTURE AND DEVELOPMENT (PRACTICAL)
SEMESTER –V/VI

TOTAL HOURS: 60 **CREDITS: 2**

1. Study soil profile
2. Study microflora of different types of soils
3. *Rhizobium* as soil inoculants characteristics and field application
4. *Azotobacter* as soil inoculants characteristics and field application
5. Design and functioning of a biogas plant
6. Isolation of cellulose degrading organisms

SUGGESTED READINGS

1. Agrios GN. (2006). Plant Pathology. 5th edition. Academic press, San Diego,

2. Singh RS. (1998). Plant Diseases Management. 7th edition. Oxford & IBH, New Delhi.
3. Glick BR, Pasternak JJ, and Patten CL (2010) Molecular Biotechnology 4th edition, ASM Press,
4. Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing, USA
5. Maier RM, Pepper IL and Gerba CP. (2009). Environmental Microbiology. 2nd edition, Academic Press
6. Barton LL & Northup DE (2011). Microbial Ecology. 1st edition, Wiley Blackwell, USA
7. Campbell RE. (1983). Microbial Ecology. Blackwell Scientific Publication, Oxford, England.
8. Coyne MS. (2001). Soil Microbiology: An Exploratory Approach. Delmar Thomson Learning.
9. Altman A (1998). Agriculture Biotechnology, Ist edition, Marcel decker Inc.
10. Mahendra K. Rai (2005). Hand Book of Microbial Biofertilizers, The Haworth Press, Inc. New York.
11. Reddy, S.M. et. al. (2002). Bioinoculants for Sustainable Agriculture and Forestry, Scientific Publishers.
12. Saleem F and Shakoori AR (2012) Development of Bioinsecticide, Lap Lambert Academic Publishing GmbH KG

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
DSE-8: BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS (THEORY)
SEMESTER –V/VI

TOTAL HOURS: 60 **CREDITS: 4**

Course learning outcomes: By the conclusion of this course, the students have -

Outcome 1. Full knowledge of working in a microbiology laboratory taking all safety measures, handing of live bacteria, disposal of infectious waste, care of the equipment requiring safety audit

Outcome 2. Developed knowledge of basic concepts related to IPR.

Outcome 3. Developed knowledge of patent filing, and some well-known/well-publicized case studies related to IPR

Unit 1 No of Hours: 8

Biosafety: Introduction; biosafety issues in biotechnology; Biological Safety Cabinets & their types;Primary Containment for Biohazards; Biosafety Levels of Specific Microorganisms

Unit 2 No of Hours: 12

Biosafety Guidelines: Biosafety guidelines and regulations (National and International); GMOs/LMOs- Concerns and Challenges; Role of Institutional Biosafety Committees (IBSC), RCGM,GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of International Agreements - Cartagena Protocol.

Unit 3 No of Hours: 4

AERB/RSD/RES guidelines for using radioisotopes in laboratories and precautions.

Unit 4 No of Hours: 12

Introduction to Intellectual Property: Patents, Types, Trademarks, Copyright & Related Rights, Industrial Design and Rights, Traditional Knowledge, Geographical Indications- importance of IPR –patentable and non patentables – patenting life – legal protection of biotechnological inventions – World Intellectual Property Rights Organization (WIPO).

Unit 5 No of Hours: 12

Grant of Patent and Patenting Authorities: Types of patent applications: Ordinary, PCT, Conventional,Divisional and Patent of Addition; An introduction to Patent Filing Procedures; Patent licensing and agreement; Patent infringement- meaning, scope, litigation, case studies, Rights and Duties of patentowner.

Unit 6 No of Hours: 12

Agreements and Treaties: GATT, TRIPS Agreements; Role of Madrid Agreement; Hague Agreement;WIPO Treaties; Budapest Treaty on international recognition of the deposit of microorganisms; UPOV & Brene conventions; Patent Co-operation Treaty (PCT); Indian Patent Act 1970 & recent amendments.

DSE-8: BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS (PRACTICAL)
SEMESTER –V/VI

TOTAL HOURS: 60 **CREDITS: 2**

1. Study of components and design of a BSL-III laboratory
2. Filing applications for approval from biosafety committee
3. Filing primary applications for patents
4. Study of steps of a patenting process
5. A case study

Suggested Reading

1. Bare Act, 2007.Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., New Delhi.
2. Kankanala C (2007). Genetic Patent Law & Strategy, 1st Edition, Manupatra Information Solution Pvt. Ltd. New Delhi.
3. Mittal, D.P. (1999). Indian Patents Law, Taxmann, Allied Services (p) Ltd.
4. Singh K K (2015). Biotechnology and Intelectual Property Rights: Legal and Social Impliocations, Springer India.
5. Goel D & Prashar S (2013). IPR, Biosafety and Bioethics. Pearson
6. Senthil Kumar Sadhasivam and Mohammed Jaabir, M. S. 2008. IPR, Biosafety and biotechnology Management. Jasen Publications, Tiruchirappalli, India.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
DSE-9: INSTRUMENTATION AND BIOTECHNIQUES (THEORY)
SEMESTER –V/VI

TOTAL HOURS: 60 **CREDITS: 4**

Course learning outcomes: By the conclusion of this course, the students have -

Outcome 1. Developed understanding of principals, and applications of different microscopic and spectrophotometric methods.

Outcome 2. Developed understanding of principals, and applications of different separation techniques especially chromatographic, electrophoretic and centrifugation techniques.

Outcome 3. Skills in handling and use of light microscope, spectrophotometer and centrifugation equipment to study/analyze various microbiological samples.

Unit 1 Microscopy — No. of Hours: 10

Brightfield and darkfield microscopy, Fluorescence Microscopy, Phase contrast Microscopy, Confocal Microscopy, Electron Microscopy (Scanning and Transmission Electron Microscopy) and Micrometry.

Unit 2 Chromatography — No. of Hours: 14

Principles and applications of paper chromatography (including Descending and 2-D), Thin layer chromatography. Column packing and fraction collection. Gel filtration chromatography, ion- exchange chromatography and affinity chromatography, GLC, HPLC.

Unit 3 Electrophoresis — No. of Hours: 14

Principle and applications of native polyacrylamide gel electrophoresis, SDS-polyacrylamide gel electrophoresis, 2D gel electrophoresis, Isoelectric focusing, Zymogram preparation and Agarose gelelectrophoresis.

Unit 4 Spectrophotometry — No. of Hours: 10

Principle and use of study of absorption spectra of biomolecules. Analysis of biomolecules using UVand visible range. Colorimetry and turbidometry.

Unit 5 Centrifugation No. of Hours: 12

Preparative and analytical centrifugation, fixed angle and swinging bucket rotors. RCF and sedimentation coefficient, differential centrifugation, density gradient centrifugation and ultracentrifugation.

DSE-9: INSTRUMENTATION AND BIOTECHNIQUES (PRACTICAL)
SEMESTER –V/VI

TOTAL HOURS: 60 **CREDITS: 2**

1. Study of fluorescent micrographs to visualize bacterial cells.
2. Ray diagrams of phase contrast microscopy and Electron microscopy.
3. Separation of mixtures by paper / thin layer chromatography.
4. Demonstration of column packing in any form of column chromatography.
5. Separation of protein mixtures by any form of chromatography.
6. Separation of protein mixtures by Polyacrylamide Gel Electrophoresis (PAGE).
7. Determination of λ_{max} for an unknown sample and calculation of extinction coefficient.
8. Separation of components of a given mixture using a laboratory scale centrifuge.
9. Understanding density gradient centrifugation with the help of pictures.

SUGGESTED READINGS

1. Wilson K and Walker J. (2010). Principles and Techniques of Biochemistry and Molecular Biology. 7th Ed., Cambridge University Press.
2. Nelson DL and Cox MM. (2008). Lehninger Principles of Biochemistry, 5th Ed., W.H. Freeman and Company.
3. Willey MJ, Sherwood LM & Woolverton C J. (2013). Prescott, Harley and Klein's Microbiology. 9thEd., McGraw Hill.
4. Karp G. (2010) Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons. Inc.
5. De Robertis EDP and De Robertis EMF. (2006). Cell and Molecular Biology. 8th edition. Lipincott Williams and Wilkins, Philadelphia.
6. Cooper G.M. and Hausman R.E. (2009). The Cell: A Molecular Approach. 5th Edition. ASM Press & Sunderland, Washington D.C., Sinauer Associates, MA.
7. Nigam A and Ayyagari A. 2007. Lab Manual in Biochemistry, Immunology and Biotechnology. Tata McGraw Hill.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
GE-1: INTRODUCTION AND SCOPE OF MICROBIOLOGY (THEORY)
SEMESTER –I

TOTAL HOURS: 60 **CREDITS: 4**

Course learning outcomes: By the conclusion of this course, the students-

Outcome 1. Has acquired a fairly good understanding of the Diversity of the microbes

Outcome 2. Has acquired a fairly good understanding of the activities/importance of microbes.

Outcome 3. Has acquired practical skills of handing microorganisms in the laboratory for study.

Unit 1 History of Development of Microbiology **No. of Hours: 12**

Development of microbiology as a discipline, Spontaneous generation *vs*. biogenesis. Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming

Role of microorganisms in fermentation, Germ theory of disease, Development of various microbiological techniques and golden era of microbiology, Development of the field of soil microbiology: Contributions of Martinus W. Beijerinck, Sergei N. Winogradsky, Selman A.WaksmanEstablishment of fields of medical microbiology and immunology through the work of Paul Ehrlich,Elie Metchnikoff, Edward Jenner

Unit 2 Diversity of Microorganisms **No. of Hours: 10**

Systems of classification : Binomial nomenclature, Whittaker's five kingdom and Carl Woese's three kingdom classification systems and their utility

General characteristics of different groups: Acellular microorganisms (Viruses, Viroids, Prions) andCellular microorganisms (Prokarya: Archaea and Bacteria, Eukarya : Algae, Fungi and Protozoa) giving definitions and citing examples

Protozoa : Methods of nutrition, locomotion & reproduction - Amoeba*, Paramecium* and *Plasmodium*

Unit 3 Microscopy No. of Hours: 7

Bright Field Microscope, Dark Field Microscope, Phase Contrast Microscope, FluoresenceMicroscope,Transmission Electron Microscope, Scanning Electron Microscope

Unit 4 Sterilization No. of Hours: 5

Moist Heat, Autoclave, Dry Heat, Hot Air Oven, Tyndallization, Filteration.

Unit 5 Microbes in Human Health & Environment **No. of Hours: 10**

Medical microbiology and immunology: List of important human diseases and their causative agents of various human systems. Definitions of immunity (active/passive), primary and secondary immune response, antigen, antibody and their types

Environmental microbiology: Definitions and examples of important microbial interactions – mutualism, commensalism, parasitism, Definitions and

microorganisms used as biopesticides, biofertilizers, in biodegradation, biodeterioration and bioremediation (*e.g.* hydrocarbons in oil spills)

Unit 6 Industrial Microbiology **No. of Hours: 8**

Definition of fermentation, primary and secondary metabolites, types of fermentations and fermenters and microbes producing important industrial products through fermentation.

Unit 7 Food and Dairy Microbiology **No. of Hours: 8**

Microorganisms as food (SCP), microorganisms in food fermentations (dairy and non dairy based fermented food products) and probiotics. Microorganisms in food spoilage and food borne infections.

GE-1: INTRODUCTION AND SCOPE OF MICROBIOLOGY (PRACTICALS)
SEMESTER –I

TOTAL HOURS: 60 **CREDITS: 2**

1. Microbiology Laboratory Management and Biosafety.
2. To study the principle and applications of important instruments (biological safety cabinets, autoclave, incubator, BOD incubator, hot air oven, light microscope, pH meter) used in the microbiology laboratory
3. Preparation of culture media for bacterial cultivation
4. Sterilization of medium using Autoclave and assessment for sterility
5. Sterilization of glassware using Hot Air Oven and assessment for sterility
6. Sterilization of heat sensitive material by filtration and assessment for sterility
7. Demonstration of presence of microflora in the environment by exposing nutrient agar plates to air.
8. Study of different shapes of bacteria using permanent slides
9. Study of *Rhizopus* and *Penicillium* using permanent mounts
10. Study of *Spirogyra* and *Chlamydomonas* using permanent Mounts
11. Study of the following protozoans using permanent mounts/photographs: *Amoeba*, *Entamoeba*, *Paramecium* and *Plasmodium*
12.

SUGGESTED READING

1. Tortora GJ, Funke BR and Case CL. (2008). Microbiology: An Introduction. 9th edition. Pearson Education

2. Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014). Brock Biology of Microorganisms. 14th edition. Pearson International Edition

3. Cappucino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited

4. Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott's Microbiology. 9th Edition. McGraw Hill International.

5. Atlas RM. (1997). Principles of Microbiology. 2nd edition. WM.T.Brown Publishers.

6. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGrawHill Book Company.

7. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5th edition. McMillan.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
GE-2: BACTERIOLOGY AND VIROLOGY (THEORY)
SEMESTER – II

TOTAL HOURS: 60 **CREDITS: 4**

Course learning outcomes: By the conclusion of this course, the students-

Outcome 1. Has acquired a fairly good understanding of the different types of bacteria and viruses.

Outcome 2. Has acquired a fairly good understanding of the structure and other salient characteristics of bacteria and viruses.

Outcome 3. Has acquired skills of visualizing bacteria by staining, using a microscope and culturing bacteria in microbiological media to describe the features of bacterial colonies.

Unit 1 Cell organization — No. of Hours: 10

Cell size, shape and arrangements, capsule, flagella and pili, Composition and detailed structure of gram- positive and gram- negative cell wall and archaeal cell wall, Structure, chemical compositionand functions of bacterial and archaeal cell membranes, Ribosomes, inclusions, nucleoid, plasmids, structure, formation and stages of sporulation

Unit 2 Bacterial growth and control — No. of Hours: 8

Culture media: Components of media, Synthetic or defined media, Complex media, enriched media, selective media, differential media, enrichment culture media

Pure culture isolation: Streaking, serial dilution and plating methods, cultivation, maintenance andstocking of pure cultures, cultivation of anaerobic bacteria

Growth: Binary fission, phases of growth

Unit 3 Bacterial Systematics and Taxonomy — No. of Hours: 12

Taxonomy, nomenclature, systematics, types of classifications

Morphology, ecological significance and economic importance of the following groups:Archaea: methanogens, thermophiles and halophiles

Eubacteria: Gram negative and Gram positiveGram negative:

Non-proteobacteria– *Deinococcus, Chlamydiae,* Spirochetes

Alpha proteobacteria- *Rickettsia, Rhizobium, Agrobacterium*

Gamma proteobacteria *–Escherichia,Shigella,Pseudomonas*

Gram positive: Low G+C: *Mycoplasma*, *Bacillus, Clostridium, Staphylococcus* High G+C: *Streptomyces, Frankia*

Unit 4 Introduction to Viruses — No. of Hours: 8

Properties of viruses; general nature and important featuresSubviral particles; viroids, prions and their

importance Isolation and cultivation of viruses

Unit 5 Structure, and multiplication of viruses — No. of Hours: 12

Morphological characters: Capsid symmetry and different shapes of viruses with examples Viral multiplication in the Cell: Lytic and lysogenic cycle
Description of important viruses: salient features of the viruses infecting different hosts - Bacteriophages (T4 & Lambda); Plant (TMV & Cauliflower Mosaic Virus), Human (HIV & Hepatitis viruses)

Unit 6 Role of Viruses in Disease and its prevention — No. of Hours: 10

Viruses as pathogens: Role of viruses in causing diseases
Prevention and control of viruses: Viral vaccines, interferons and antiviral compounds

GE-2: BACTERIOLOGY AND VIROLOGY (PRACTICAL)
SEMESTER – TOTAL HOURS: 60 CREDITS: 2

1. Preparation of different media: Nutrient agar, Nutrient broth
2. To perform simple staining and Gram's staining of the bacterial smear
3. To perform spore staining
4. Isolation of pure cultures of bacteria by streaking method
5. Enumeration of colony forming units (CFU) count by spread plate method/pour plate
7. Study the morphological structures of viruses (DNA and RNA) and their important characters using electron micrographs
8. Study of the methods of isolation and propagation of plant viruses
9. Study of cytopathic effects of viruses using photographs

SUGGESTED READING

1. Atlas RM. (1997). Principles of Microbiology. 2nd edition. WM.T.Brown Publishers
2. Madigan MT, Martinko JM, Dunlap PV and Clark DP (2014). Brock Biology of Micro-organisms. 14th edition. Pearson Education, Inc.
3. Stanier RY, Ingraham JL, Wheelis ML and Painter PR. (2005). General Microbiology. 5th edition. McMillan
4. Carter J and Saunders V(2007). Virology; principles and Applications. John Wiley and Sons
5. Flint SJ, Enquist, LW, Krug, RM, Racaniello, VR Skalka, AM (2004) Principles of Virology, Molecular Biology, Pathogenesis and Contro*l*.2nd edition.ASM Press
6. Shors Teri (2013) Understanding Viruses 2nd edition Jones and Bartlett Learning Burlington USA
7. Pelczar Jr MJ, Chan ECS, and Krieg NR. (2004). Microbiology. 5th edition Tata McGraw Hill.
8. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9th edition Pearson Education.
9. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.
10. Dimmock, NJ, Easton, AL, Leppard, KN (2007). Introduction to Modern Virology. 6th edition, Blackwell Publishing Ltd.
11. Cann AJ (2012) Principles of Molecular Virology, Academic Press Oxford UK

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
GE-3: MICROBIAL METABOLISM (THEORY)
SEMESTER – III

TOTAL HOURS: 60 **CREDITS: 4**

Course learning outcomes: By the conclusion of this course, the students-

Outcome 1. Has acquired a fairly good understanding of normal microflora of human body, common diseases caused by bacteria, viruses and other microbes.

Outcome 2. Understood the basic components of the immune system and how this system serve to protect the host against disease-causing microbes.

Outcome 3. Has acquired skills of handling microorganisms in the laboratory and study their characteristics.

Unit 1 Microbial Growth and Effect of Environment on Microbial Growth **No. of Hours: 12**

Definitions of growth, Batch culture, Continuous culture, generation time and specific growth rate
Temperature and temperature ranges of growth
pH and pH ranges of growth
Effect of solute and water activity on growthEffect of oxygen concentration on growth Nutritional categories of microorganisms

Unit 2 Nutrient uptake and Transport No. of Hours: 10

Passive and facilitated diffusion
Primary and secondary active transport, concept of uniport, symport and antiportGroup translocation
Iron uptake

Unit 3 Chemoheterotrophic Metabolism - Aerobic Respiration No. of Hours: 16

Concept of aerobic respiration, anaerobic respiration and fermentation Sugar degradation pathways i.e. EMP, ED, Pentose phosphate pathwayTCA cycle
Electron transport chain: components of respiratory chain, comparison of mitochondrial and bacterialETC, electron transport phosphorylation, uncouplers and inhibitors

Unit 4 Chemoheterotrophic Metabolism- Anaerobic respiration and fermentation

No. of Hours: 6

Anaerobic respiration with special reference to dissimilatory nitrate reduction (Denitrification; nitrate

/nitrite and nitrate/ammonia respiration; fermentative nitrate reduction)
Fermentation - Alcohol fermentation and Pasteur effect; Lactate fermentation (homofermentative andheterofermentative pathways), concept of linear and branched fermentation pathways

Unit 5 Chemolithotrophic and Phototrophic Metabolism **No. of Hours: 10**
Introduction to aerobic and anaerobic chemolithotrophy with an example each. Hydrogen oxidation (definition and reaction) and methanogenesis (definition and reaction)
Introduction to phototrophic metabolism - groups of phototrophic microorganisms, anoxygenic *vs.* oxygenic photosynthesis with reference to photosynthesis in green bacteriaand cyanobacteria

Unit 6 Nitrogen Metabolism - an overview **No. of Hours: 6**
Introduction to biological nitrogen fixation
Ammonia assimilation
Assimilatory nitrate reduction

GE-3: MICROBIAL METABOLISM (PRACTICAL)

SEMESTER –III

TOTAL HOURS: 60 **CREDITS: 2**

1. Study and plot the growth curve of *E. coli* by tubidiometric and standard plate count methods.
2. Calculations of generation time and specific growth rate of bacteria from the graph plotted with the given data
3. Effect of temperature on growth of *E. coli*
4. Effect of pH on growth of *E. coli*
5. Effect of Nitrogen and Carbon sources on *E. Coli*
6. Effect of salt on growth of *E. coli*
7. Demonstration of alcoholic fermentation
8. Demonstration of the thermal death time and decimal reduction time of *E. coli.*

SUGGESTED READINGS

1. Madigan MT, and Martinko JM (2014). Brock Biology of Microorganisms. 14th edition. Prentice Hall International Inc.
2. Moat AG and Foster JW. (2002). Microbial Physiology. 4th edition. John Wiley & Sons
3. Reddy SR and Reddy SM. (2005). Microbial Physiology. Scientific Publishers India
4. Gottschalk G. (1986). Bacterial Metabolism. 2nd edition. Springer Verlag
5. Stanier RY, Ingrahm JI, Wheelis ML and Painter PR. (1987). General Microbiology. 5th edition, McMillan Press.
6. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
GE-4: INDUSTRIAL AND FOOD MICROBIOLOGY (THEORY)
SEMESTER – IV

TOTAL HOURS: 60 **CREDITS: 4**

Course learning outcomes: By the conclusion of this course, the students-

Outcome 1. Has acquired a fairly good knowledge of how microbes are used in the fermentative production of organic acids, alcohols, enzymes, antibiotics and various foods in the industry.

Outcome 2. Has acquired knowledge of various physical parameters which affect production of industrial products by the microorganisms and the safety aspects of the production and use of these products.

Outcome 3. Has developed laboratory skills in producing alcohol and enzymes by fermentative process using bacteria/yeast; Laboratory skills of testing microbial load in milk.

Unit 1 Introduction to Industrial microbiology — No. of Hours: 10

Brief history and developments in industrial microbiology
Types of fermentation processes - solid state, liquid state, batch, fed-batch and continuousTypes of fermenters – laboratory, pilot-scale and production fermenters
Components of a typical continuously stirred tank bioreactor

Unit 2 Isolation of Industrial Strains and Fermentation Medium — No. of Hours: 8

Primary and secondary screening
Preservation and maintenance of industrial strains
Ingredients used in fermentation medium - molasses, corn steep liquor, whey & Yeast extract

Unit 3 Microbial fermentation processes — No. of Hours: 12

Downstream processing - filtration, centrifugation, cell disruption, solvent extraction.Microbial production of industrial products - citric acid, ethanol and penicillin.
Industrial production and uses of the enzymes - amylases, proteases, lipases and cellulases

Unit 4 Food as a substrate for microbial growth — No. of Hours: 9

Intrinsic and extrinsic parameters that affect microbial

growth in foodMicrobial spoilage of food - milk, egg, bread and canned foods

Unit 5 Principles and methods of food preservation and food sanitation No. of Hours: 9

Physical methods - high temperature, low temperature, irradiation, aseptic packaging Chemical methods - salt, sugar, benzoates, citric acid, ethylene oxide, nitrate and nitriteFood sanitation and control – HACCP

Unit 6 Dairy products, probiotics and Food-borne Diseases No. of Hours: 12

Fermented dairy products - yogurt, acidophilus milk, kefir, dahi and cheeseProbiotics definition, examples and benefits
Food intoxication by *Clostridium botulinum* and *Staphylococcus aureus*
Food infection by *Salmonella* and *E.coli*

GE-4: INDUSTRIAL AND FOOD MICROBIOLOGY (PRACTICAL)
SEMESTER – IV

TOTAL HOURS: 60 **CREDITS: 2**

1. Microbial fermentation for the production and estimation of amylase
2. Microbial fermentation for the production and estimation of citric acid
3. Microbial fermentation for the production and estimation of ethanol
4. Determination of the microbiological quality of milk sample by MBRT
5. Isolation of fungi from spoilt bread/fruits/vegetables
6. Preparation of Yogurt/Dahi

READING
SUGGETED

1. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd Edition. Panima Publishing Company, New Delhi
2. Patel AH. (1996). Industrial Microbiology .1st Edition. MacMillan India Limited Publishing Company Ltd. New Delhi, India
3. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An introduction.9th Edition. Pearson Education
4. Willey JM, Sherwood LM AND Woolverton CJ (2013), Prescott, Harley and Klein's Microbiology.9th Edition. McGraw Hill Higher education
5. Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley Eastern Limited.
6. Stanbury PF, Whitaker A and Hall SJ. (2006). Principles of Fermentation Technology. 2nd edition, Elsevier Science Ltd.
7. Adams MR and Moss MO. (1995). Food Microbiology. 4th edition, New Age International (P) Limited Publishers, New Delhi, India.
8. Banwart JM. (1987). Basic Food Microbiology. 1st edition. CBS Publishers and Distributors, Delhi, India.
9. Frazier WC and Westhoff DC. (1992). Food Microbiology. 3rd edition. Tata McGraw-Hill Publishing Company Ltd, New Delhi, India.
10. Jay JM, Loessner MJ and Golden DA. (2005). Modern Food Microbiology. 7th edition, CBS Publishers and Distributors, Delhi, India.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
GE-5: MICROBES IN ENVIRONMENT (THEORY)
SEMESTER – IV

TOTAL HOURS: 60 **CREDITS: 4**

Course learning outcomes: By the conclusion of this course, the students-
Outcome 1. Has acquired a fairly good understanding of microbes in the soil.
Outcome 2. Has developed a fairly good understanding of the use of microbes in sustainable agriculture namely role in biogeochemical recycling, nitrogen fixing, organic matter degradation, use as bio fertilizers, as bio pesticides, production of biofuels

Outcome 3 .Has developed skills for growing microorganisms in the laboratory for the production of different enzymes by different microorganisms.

Unit 1 Microorganisms and their Habitats — No. of Hours: 14

Structure and function of ecosystems
Terrestrial Environment: Soil profile and soil microflora
Aquatic Environment: Microflora of fresh water and marine habitatsAtmosphere: Aeromicroflora and dispersal of microbes
Animal Environment: Microbes in/on human body (Microbiomics) & animal (ruminants) body. Extreme Habitats: Extremophiles: Microbes thriving at high & low temperatures, pH, high hydrostatic & osmotic pressures, salinity, & low nutrient levels.

Unit 2 Microbial Interactions — No. of Hours: 12

Microbe interactions: Mutualism, synergism, commensalism, competition, amensalism, parasitism,predation
Microbe-Plant interaction: Symbiotic and non symbiotic interactions
Microbe-animal interaction: Microbes in ruminants, nematophagus fungi and symbiotic luminescentbacteria

Unit 3 Biogeochemical Cycling — No. of Hours: 12

Carbon cycle: Microbial degradation of cellulose, hemicelluloses, lignin and chitin
Nitrogen cycle: Nitrogen fixation, ammonification, nitrification, denitrification and nitrate reductionPhosphorus cycle: Phosphate immobilization and solubilisation
Sulphur cycle: Microbes involved in sulphur cycleOther elemental cycles:
Iron and manganese

Unit 4 Waste Management — No. of Hours: 12

Solid Waste management: Sources and types of solid waste, Methods of solid waste disposal(composting and sanitary landfill)

Liquid waste management: Composition and strength of sewage (BOD and COD), Primary, secondary (oxidation ponds, trickling filter, activated sludge process and septic tank) and tertiarysewage treatment

Unit 5 Microbial Bioremediation — No. of Hours: 5

Principles and degradation of common pesticides, hydrocarbons (oil spills).

Unit 6 Water Potability — No. of Hours: 5

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 faecalcoliforms (b) Membrane filter technique and (c) Presence/absence tests

GE-5: MICROBES IN ENVIRONMENT (PRACTICAL)
SEMESTER –IV

TOTAL HOURS: 60 **CREDITS: 2**

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. Assessment of microbiological quality of water.
5. Determination of BOD of waste water sample.
6. Study the presence of microbial activity by detecting (qualitatively) enzymes (dehydrogenase, amylase, urease) in soil.
7. Isolation of *Rhizobium* from root nodules.

SUGGESTED READINGS

1. Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing, USA
2. Madigan MT, Martinko JM and Parker J. (2014). Brock Biology of Microorganisms. 14th edition. Pearson/ Benjamin Cummings
3. Maier RM, Pepper IL and Gerba CP. (2009). Environmental Microbiology. 2nd edition, Academic Press
4. Okafor, N (2011). Environmental Microbiology of Aquatic & Waste systems. 1st edition, Springer, New York
5. Singh A, Kuhad, RC & Ward OP (2009). Advances in Applied Bioremediation. Volume 17, Springer-Verlag, Berlin Hedeilberg
6. Barton LL & Northup DE (2011). Microbial Ecology. 1st edition, Wiley Blackwell, USA
Campbell RE. (1983). Microbial Ecology. Blackwell Scientific Publication, Oxford, England.
7. Coyne MS. (2001). Soil Microbiology: An Exploratory Approach. Delmar Thomson Learning.
8. Lynch JM & Hobbie JE. (1988). Microorganisms in Action: Concepts & Application in Microbial Ecology. Blackwell Scientific Publication, U.K.
9. Martin A. (1977). An Introduction to Soil Microbiology. 2nd edition. John Wiley & Sons Inc. New York & London.
10. Stolp H. (1988). Microbial Ecology: Organisms Habitats Activities. Cambridge University Press, Cambridge, England.
11. Subba Rao NS. (1999). Soil Microbiology. 4th edition. Oxford & IBH Publishing Co. New Delhi.
12. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
GE-6: MEDICAL MICROBIOLOGY AND IMMUNOLOGY (THEORY)
SEMESTER – IV

TOTAL HOURS: 60 **CREDITS: 4**

Course learning outcomes: By the conclusion of this course, the students

Outcome 1.Have acquired knowledge how microbes serve as a source for a large number of enzymes

Outcome 2. How these enzymes are produced in the laboratory, how their production is increased by different conditions and how the enzymes are purified.

Outcome 3. Practical skill for production and purification of enzymes; factors affecting microbial enzyme production; immobilization of enzymes.

Unit 1 Normal microflora of the human body and host pathogen interaction

No. of Hours: 8

Normal microflora of the human body: Importance of normal microflora, normal microflora of skin,throat, gastrointestinal tract, urogenital tract

Host pathogen interaction: Definitions - Infection, Invasion, Pathogen, Pathogenicity, Virulence, Toxigenicity, Carriers and their types, Opportunistic infections, Nosocomial infections. Transmissionof infection,

Unit 2 Sample collection, transport and diagnosis No. of Hours: 5

Collection, transport and culturing of clinical samples and their identification characteristics.

Unit 3 Bacterial diseases No. of Hours: 3

List of diseases of various organ systems and their causative agents.

Unit 4 Viral diseases No. of Hours: 3

List of diseases of various organ systems and their causative agents.

Unit 5 Protozoan diseases No. of Hours: 2

List of diseases of various organ systems and their causative agents.

Unit 6 Fungal diseases No. of Hours: 2

Brief description of various types of mycoses.

Unit 7 Antimicrobial agents: General characteristics and mode of action **No. of Hours: 7**

Antibacterial agents: Five modes of action with one example each: Inhibitor of nucleic acid synthesis; Inhibitor of cell wall synthesis; Inhibitor of cell membrane function; Inhibitor of protein synthesis; Inhibitor of metabolism

Antifungal agents: Mechanism of action of Amphotericin B, Griseofulvin Antiviral agents: Mechanism of action of Amantadine, Acyclovir, Azidothymidine

Unit 8 Immune Cells and Organs **No. of Hours: 7** 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 – BoneMarrow, Thymus, Lymph Node, Spleen

Unit 9 Antigens and Antibodies **No. of Hours: 7**
Characteristics of an antigen (Foreignness, Molecular size and Heterogeneity); Haptens; Epitopes (T & B cell epitopes), Adjuvants, Structure, Types and Functions of antibodies.

Unit 10 Generation of Immune Response **No. of Hours: 6**
Primary and Secondary Immune Response; Generation of Humoral Immune Response (Plasma and Memory cells); Generation of Cell Mediated Immune Response

Unit 11 Immunological Disorders and Tumor Immunity No. of Hours: 5

Types of Autoimmunity and Hypersensitivity with examples; Immunodeficiencies - Animal models(Nude and SCID mice).

Unit 12 Immunological Techniques **No. of Hours: 5**Principles of Precipitation, Agglutination, Immunodiffusion, Immunoelectrophoresis, ELISA, ELISPOT.

GE-6: MEDICAL MICROBIOLOGY AND IMMUNOLOGY (PRACTICAL)
SEMESTER –V

TOTAL HOURS: 60 **CREDITS: 2**

1. Identify bacteria on the basis of cultural, morphological and biochemical characteristics: IMViC, TSI, nitrate reduction, urease production and catalase tests
2. Study of composition and use of important differential media for identification of bacteria: EMB Agar, McConkey agar, Mannitol salt agar, Deoxycholate citrate agar, TCBS
3. Study of bacterial flora of skin by swab method
4. Perform antibacterial sensitivity by Kirby-Bauer method
5. Identification of human blood groups.
6. To perform Total Leukocyte Count of the given blood sample.
7. To perform Differential Leukocyte Count of the given blood sample.
8. To separate serum from the blood sample (demonstration).
9. To perform immunodiffusion by Ouchterlony method.

SUGGESTED READING

1. Ananthanarayan R. and Paniker C.K.J. (2009) Textbook of Microbiology. 8th edition, University Press Publication
2. Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's Medical Microbiology. 26th edition. McGraw Hill Publication
3. Goering R., Dockrell H., Zuckerman M. and Wakelin D. (2007) Mims' Medical Microbiology. 4th edition. Elsevier
4. Willey JM, Sherwood LM, and Woolverton CJ. (2013) Prescott, Harley and Klein's Microbiology. 9th edition. McGraw Hill Higher Education
5. Abbas AK, Lichtman AH, Pillai S. (2007). Cellular and Molecular Immunology. 6th edition Saunders Publication, Philadelphia.
6. Delves P, Martin S, Burton D, Roitt IM. (2006). Roitt's Essential Immunology.11th edition Wiley-Blackwell Scientific Publication, Oxford.
7. Goldsby RA, Kindt TJ, Osborne BA. (2007). Kuby's Immunology. 6th edition W.H. Freeman and Company, New York.

8. Richard C and Geiffrey S. (2009). Immunology. 6th edition. Wiley Blackwell Publication.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
GE-7: GENETIC ENGINEERING AND BIOTECHNOLOGY (THEORY)
SEMESTER –VI

TOTAL HOURS: 60 **CREDITS: 4**

Course learning outcomes: By the conclusion of this course, the students-

Outcome 1. Has acquired knowledge of gene, their expression and regulation of expression.

Outcome 2. Has acquired a fairly good understanding mechanisms of genetic exchange, mutations and their implications.

Outcome 3. Has developed practical skill for isolation of bacteria/plasmid DNA and its visualization in gel after separation by electrophoresis.

Unit 1 Introduction to genetic engineering — No. of Hours: 16

Milestones in genetic engineering and biotechnology

Restriction modification systems: Mode of action, applications of Type II restriction enzymes ingenetic engineering

DNA modifying enzymes and their applications: DNA polymerases. Terminal deoxynucleotidyltransferase, kinases and phosphatases, and DNA ligases

Cloning: Use of linkers and adaptors

Transformation of DNA: Chemical method, Electroporation

Methods of DNA, RNA and Protein analysis: Agarose gel electrophoresis, Southern - and Northern -blotting techniques, dot blot, DNA microarray analysis, SDS-PAGE and Western blotting.

Unit 2 Vectors — No. of Hours: 16

Cloning Vectors: Definition and Properties Plasmid vectors: pBR and pUC series Bacteriophage lambda and M13 based vectorsCosmids, BACs, YACs

Expression vectors: *E.coli* lac and T7 promoter-based vectors, yeast YIp, YEp and YCp vectors,Baculovirus based vectors, mammalian SV40-based expression vectors

Unit 3 DNA Amplification and DNA sequencing — No. of Hours: 10

PCR: Basics of PCR, RT-PCR, Real-Time PCR

Genomic and cDNA libraries: Preparation and uses, Genome sequencing Sanger's method of DNA Sequencing: traditional and automated sequencing

Unit 4 Application of Genetic Engineering and Biotechnology — No. of Hours: 14

Gene delivery: Microinjection, electroporation, biolistic method (gene gun), liposome and viral-mediated delivery, *Agrobacterium* - mediated delivery

Products of recombinant DNA technology: Products of human therapeutic interest - insulin, hGH, antisense molecules. Bt transgenic - cotton, brinjal, flavo savo tomato, Gene therapy, recombinantvaccine, protein engineering

Unit 5 Intellectual Property Rights — No. of Hours: 4

Patents, Copyrights, Trademarks

GE-7: GENETIC ENGINEERING AND BIOTECHNOLOGY (PRACTICAL)
SEMESTER –VI

TOTAL HOURS: 60 **CREDITS: 2**

1. Isolation of Plasmid DNA from *E.coli*
2. Digestion of DNA using restriction enzymes and analysis by agarose gel electrophoresis
3. Ligation of DNA fragments
4. Interpretation of sequencing gel electropherograms
5. Designing of primers for DNA amplification
6. Amplification of DNA by PCR
7. Demonstration of Southern blotting

SUGGESTED READING

1. Brown TA. (2010). Gene Cloning and DNA Analysis. 6th edition. Blackwell Publishing, Oxford, U.K.
2. Clark DP and Pasternik NJ. (2009). Biotechnology: Applying the Genetic Revolution. Elsevier Academic Press, USA
3. Primrose SB and Twyman RM. (2006). Principles of Gene Manipulation and Genomics, 7th edition. Blackwell Publishing, Oxford, U.K.
4. Sambrook J and Russell D. (2001). Molecular Cloning-A Laboratory Manual. 3rd edition. Cold Spring Harbor Laboratory Press
5. Wiley JM, Sherwood LM and Woolverton CJ. (2013). Prescott, Harley and Klein's Microbiology. 8th edition, McGraw Hill Higher Education
6. Brown TA. (2007). Genomes-3. Garland Science Publishers
7. Primrose SB and Twyman RM. (2008). Genomics: Applications in human biology. Blackwell Publishing, Oxford, U.K.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
GE-8: MICROBIAL GENETICS AND MOLECULAR BIOLOGY (THEORY)
SEMESTER – IV

TOTAL HOURS: 60 **CREDITS: 4**

Course learning outcomes: By the conclusion of this course, the students-

Outcome 1. Has acquired a fairly good knowledge of the tools and the methods for genetic engineering.

Outcome 2. Has acquired a fairly good understanding of how these tools and methods are employed in the laboratory for manipulation of DNA so as to make it relevant for biotechnological uses.

Outcome 3. Students can perform isolation of DNA, amplification of any gene by PCR and its analysis by gel electrophoresis.

Unit 1 Structures of DNA and RNA / Genetic Material **No. of Hours: 10**

DNA structure, Salient features of double helix, Types of DNA, denaturation and renaturation, topoisomerases; Organization of DNA Prokaryotes,Viruses, Eukaryotes. RNA Structure

Unit 2 Replication of DNA No. of Hours: 6

Bidirectional and unidirectional replication, semi- conservative, semi- discontinuous replicationMechanism of DNA replication: Enzymes and proteins involved in DNA replication –DNA polymerases, DNA ligase, primase, telomerase – for replication of linear ends

Unit 3 Transcription No. of Hours: 6

Transcription: Definition, promoter - concept and strength of promoter. Transcriptional Machineryand Mechanism of transcription.

Unit 4 Translation No. of Hours: 6

Genetic code, Translational machinery, Charging of tRNA, aminoacyl tRNA synthetases,Mechanisms of initiation, elongation and termination of polypeptides.

Unit 5 Regulation of gene Expression **No. of Hours: 5**

Principles of transcriptional regulation, regulation at initiation with examples from *lac* and *trp* operons

Unit 6 Mutations No. of Hours: 9

Mutations and mutagenesis: Definition and types of Mutations; Physical and chemical mutagens; Uses of mutations, DNA repair mechanisms

Unit 7 Mechanisms of Genetic Exchange — No. of Hours: 10

Transformation - Discovery, mechanism of natural competence Conjugation - Discovery, mechanism, Hfr and F' strains Transduction - Generalized transduction, specialized transduction

Unit 8 Plasmids and Transposable Elements — No. of Hours: 8

Property and function of plasmids, Types of plasmids. Prokaryotic transposable elements – Insertion Sequences, composite and non-composite transposons, Replicative and Non replicative transposition,Uses of transposons and transposition.

GE-8: MICROBIAL GENETICS AND MOLECULAR BIOLOGY (PRACTICAL)
SEMESTER – IV

TOTAL HOURS: 60 **CREDITS: 2**

1. Study of different types of DNA and RNA using micrographs and model / schematic representations
2. Study of semi-conservative replication of DNA through micrographs / schematic representations
3. Estimation of salmon sperm / calf thymus DNA using colorimeter (diphenylamine reagent) or UV spectrophotometer (A_{260} measurement)
4. Resolution and visualization of DNA by Agarose Gel Electrophoresis.
5. Resolution and visualization of proteins by Polyacrylamide Gel Electrophoresis (SDS-PAGE).
6. Study the effect of chemical (HNO_2) and physical (UV) mutagens on bacterial cells
7. Study survival curve of bacteria after exposure to ultraviolet (UV) light
8. Demonstration of Bacterial Transformation and calculation of transformation efficiency.

SUGGESTED READINGS

1. Watson JD, Baker TA, Bell SP, Gann A, Levine M and Losick R (2008) Molecular Biology of the Gene, 6th edition, Cold Spring Harbour Lab. Press, Pearson Publication
2. Becker WM, Kleinsmith LJ, Hardin J and Bertoni GP (2009) The World of the Cell, 7th edition, Pearson Benjamin Cummings Publishing, San Francisco
3. De Robertis EDP and De Robertis EMF (2006) Cell and Molecular Biology, 8th edition. Lippincott Williams and Wilkins, Philadelphia
4. Karp G (2010) Cell and Molecular Biology: Concepts and Experiments, 6th edition, John Wiley & Sons. Inc.
5. Sambrook J and Russell DW. (2001). Molecular Cloning: A Laboratory Manual. 4th Edition, Cold Spring Harbour Laboratory press.
6. Krebs J, Goldstein E, Kilpatrick S (2013). Lewin's Essential Genes, 3rd Ed., Jones and Bartlett Learning
7. Gardner EJ, Simmons MJ, Snustad DP (2008). Principles of Genetics. 8th Ed. Wiley-India
8. Klug WS, Cummings MR, Spencer, C, Palladino, M (2011). Concepts of Genetics, 10th Ed., Benjamin Cummings
9. Maloy SR, Cronan JE and Friefelder D(2004) Microbial Genetics 2nd EDITION., Jones and Barlett Publishers
10. Russell PJ. (2009). *i* Genetics- A Molecular Approach. 3rd Ed, Benjamin Cummings

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
SE-1: Microbial Quality Control in Food and Pharmaceutical Industries
SEMESTER – IV

TOTAL HOURS: 30 **CREDITS: 2**

Course learning outcomes: By the conclusion of this course, the students-
Learning Outcome 1. Have developed a very good understanding of practical aspects of microbiological safety, various detection methodologies and use of different microbiological media in food industries.

Learning Outcome 2. Have developed a very good understanding of practical aspects of microbiological safety, various detection methodologies and toxicological testing of products in the pharmaceutical industries.

Unit 1 Microbiological Laboratory and Safe Practices No. of Hours: 8

Good laboratory practices - Good laboratory practices, Good microbiological practices Biosafety cabinets – Working of biosafety cabinets, using protective clothing, specification for BSL-1, BSL-2, BSL-3. Discarding biohazardous waste – Methodology of Disinfection, Autoclaving & Incineration

Unit 2 Determining Microbes in Food / Pharmaceutical Samples No. of Hours: 10

Culture and microscopic methods - Standard plate count, Most probable numbers, Direct microscopic counts, Biochemical and immunological methods: Limulus lysate test for endotoxin, gel diffusion, sterility testing for pharmaceutical products
Molecular methods - Nucleic acid probes, PCR based detection, biosensors.

Unit 3 Pathogenic Microorganisms of Importance in Food & Water No. of Hours: 8

Enrichment culture technique, Detection of specific microorganisms - on XLD agar, SalmonellaShigella Agar, Manitol salt agar, EMB agar, McConkey Agar, Saboraud Agar
Ascertaining microbial quality of milk by MBRT, Rapid detection methods of microbiological qualityof milk at milk collection centres (COB, 10 min Resazurin assay)

Unit 4 HACCP for Food Safety and Microbial Standards No. of Hours: 4

Hazard analysis of critical control point (HACCP) - Principles, flow diagrams, limitations Microbial Standards for Different Foods and Water – BIS standards for common foods and drinkingwater

SUGGESTED READING

1. Harrigan WF (1998) Laboratory Methods in Food Microbiology, 3rd ed. Academic Press
2. Garg N, Garg KL and Mukerji KG (2010) Laboratory Manual of Food Microbiology I K International Publishing House Pvt. Ltd.
3. Jay JM, Loessner MJ, Golden DA (2005) Modern Food Microbiology, 7th edition. Springer
4. Baird RM, Hodges NA and Denyer SP (2005) Handbook of Microbiological Quality control in Pharmaceutical and Medical Devices, Taylor and Francis Inc.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
SE-2: MICROBIAL DIAGNOSIS IN HEALTH CLINICS
SEMESTER – IV

TOTAL HOURS: 30 **CREDITS: 2**

Course learning outcomes: By the conclusion of this course, the students-

Outcome 1. Have developed a very good understanding of practical aspects of collection of different clinical samples, their transport, culture and examination by staining, and molecular and immunological diagnostic methods for diagnosis of microbial diseases.

Outcome 2. Have developed a very good understanding of practical aspects of antibiotic sensitivity testing, water and food testing skills using kits available in the market

Unit 1 Importance of Diagnosis of Diseases — No of Hours: 5

Bacterial, Viral, Fungal and Protozoan Diseases of various human body systems, Disease associatedclinical samples for diagnosis.

Unit 2 Collection of Clinical Samples **No of Hours: 5**

How to collect clinical samples (oral cavity, throat, skin, Blood, CSF, urine and faeces) and precautions required. Method of transport of clinical samples to laboratory and storage.

Unit 3 Direct Microscopic Examination and Culture. **No of Hours: 5**

Examination of sample by staining - Gram stain, Ziehl-Neelson staining for tuberculosis, Giemsa-stained thin blood film for malaria

Preparation and use of culture media - Blood agar, Chocolate agar, Lowenstein-Jensen medium, MacConkey agar, Distinct colony properties of various bacterial pathogens.

Unit 4: Serological and Molecular Methods **No of Hours: 5**

Serological Methods - Agglutination, ELISA, immunofluorescence, Nucleic acid based methods - PCR, Nucleic acid probes

Unit 5: Kits for Rapid Detection of Pathogens — No of Hours: 5

Typhoid, Dengue and HIV, Swine flu

Unit 6: Testing for Antibiotic Sensitivity in Bacteria **No of Hours: 5**

Importance, Determination of resistance/sensitivity of bacteria using disc diffusion method, Determination of minimal inhibitory concentration (MIC) of an antibiotic by serial double dilution method

SUGGESTED READING

1. Ananthanarayan R and Paniker CKJ (2009)Textbook of Microbiology, 8th edition, Universities Press Private Ltd.
2. Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's Medical Microbiology. 26th edition. McGraw Hill Publication
3. Randhawa, VS, Mehta G and Sharma KB (2009) Practicals and Viva in Medical Microbiology 2nd edition, Elsevier India Pvt Ltd
4. Tille P (2013) Bailey's and Scott's Diagnostic Microbiology, 13th edition, Mosby
5. Collee JG, Fraser, AG, Marmion, BP, Simmons A (2007) Mackie and Mccartney Practical Medical Microbiology, 14th edition, Elsevier.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
SE-3: BIOFERTILIZERS AND BIOPESTICIDES
SEMESTER – IV

TOTAL HOURS: 30 **CREDITS: 2**

Course learning outcomes: By the conclusion of this course, the students
Outcome 1. Have developed a very good understanding of practical aspects of production of biofertilizers.
Outcome 2. Have developed a very good understanding of practical aspects of the production of biopesticides/bioinsecticides.

Unit 1 Biofertilizers — No of Hours: 10

General account of the microbes used as biofertilizers for various crop plants and their advantagesover chemical fertilizers.
Symbiotic N2 fixers: *Rhizobium* - Isolation, characteristics, types, inoculum production and fieldapplication, legume/pulses plants
Frankia - Isolation, characteristics, Alder, Casurina plants, non-leguminous crop symbiosis. Cyanobacteria, *Azolla* - Isolation, characterization, mass multiplication, Role in rice cultivation, Cropresponse, field application.

Unit 2 Non - Symbiotic Nitrogen Fixers **No of Hours: 4**
Free living *Azospirillum*, *Azotobacter* - free isolation, characteristics, mass inoculums, production and field application.

Unit 3 Phosphate Solubilizers — No of Hours: 4

Phosphate solubilizing microbes - Isolation, characterization, mass inoculum production, fieldapplication

Unit 4 Mycorrhizal Biofertilizers **No of Hours: 5**
Importance of mycorrizal inoculum, types of mycorrhizae and associated plants, Mass inoculum production of VAM, field applications of Ectomycorrhizae and VAM.

Unit 5 Bioinsecticides — No of Hours: 7

General account of microbes used as bioinsecticides and their advantages over synthetic pesticides,
Bacillus thuringiensis, production, Field applications, Viruses – cultivation and field applications.

Suggested Readings

1. Kannaiyan, S. (2003). Bioetchnology of Biofertilizers, CHIPS, Texas.
2. Mahendra K. Rai (2005). Hand book of Microbial biofertilizers, The Haworth Press, Inc. New York.
3. Reddy, S.M. et. al. (2002). Bioinoculants for sustainable agriculture and forestry, Scientific

Publishers.
4. Subba Rao N.S (1995) Soil microorganisms and plant growth Oxford and IBH publishing co. Pvt. Ltd. NewDelhi.
5. Saleem F and Shakoori AR (2012) Development of Bioinsecticide, Lap Lambert Academic Publishing GmbH KG
6. Aggarwal SK (2005) Advanced Environmental Biotechnology, APH publication.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
SE-4: FOOD FERMENTATION TECHNIQUES
SEMESTER – IV

TOTAL HOURS: 30 **CREDITS: 2**

Course learning outcomes: By the conclusion of this course, the students-

Outcome 1. Have developed a very good understanding of practical aspects commercially produced food and fermentative products.

Outcome 2. Have developed a very good understanding of practical use of microbiology for better production of home based food and fermentation products for day to day use

Unit 1 Fermented Foods — No of Hours: 4

Definition, types, advantages and health benefits

Unit 2 Milk Based Fermented Foods — No of Hours: 8

Dahi, Yogurt, Buttermilk (Chach) and cheese: Preparation of inoculums, types of microorganisms and production process

Unit 3 Grain Based Fermented Foods — No of Hours: 6

Soy sauce, Bread, Idli and Dosa: Microorganisms and production process

Unit 4 Vegetable Based Fermented Foods — No of Hours: 4

Pickels, Saeurkraut: Microorganisms and production process

Unit 5 Fermented Meat and Fish — No of Hours: 4

Types, microorganisms involved, fermentation process

Unit 6 Probiotic Foods — No of Hours: 4

Definition, types, microorganisms and health benefits

Suggested Readings

1. Hui YH, Meunier-Goddik L, Josephsen J, Nip WK, Stanfield PS (2004) Handbook of food and fermentation technology, CRC Press
2. Holzapfel W (2014) Advances in Fermented Foods and Beverages, Woodhead Publishing.
3. Yadav JS, Grover, S and Batish VK (1993) A comprehensive dairy microbiology, Metropolitan
4. Jay JM, Loessner MJ, Golden DA (2005) Modern Food Microbiology, 7th edition. Springer

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
SE-5: MANAGEMENT OF HUMAN MICROBIAL DISEASES
SEMESTER – IV

TOTAL HOURS: 30 **CREDITS: 2**

Course learning outcomes: By the conclusion of this course, the students-

Outcome 1. Have developed a very good understanding of practical aspects diagnosis of common human infections.

Outcome 2. Have developed a very good understanding of preventive measures for human infections by the use of antibiotics and vaccines.

Unit 1 Human Diseases — No of Hours: 4

Infectious and non infectious diseases, microbial and non microbial diseases, Deficiency diseases,occupational diseases, Incubation period, mortality rate, nosocomial infections

Unit 2 Microbial diseases — No of Hours: 12

Respiratory microbial diseases, gastrointestinal microbial diseases, Nervous system diseases, skin diseases, eye diseases, urinary tract diseases, Sexually transmitted diseases: Types, route of infection, clinical systems and general prevention methods, study of recent outbreaks of human diseases (SARS/Swine flu/Ebola) – causes, spread and control, Mosquito borne disease – Types and prevention.

Unit 3 Therapeutics of Microbial diseases — No of Hours: 8

Treatment using antibiotics: beta lactam antibiotics (penicillin, cephalosporins), quinolones, polypeptides and aminoglycosides.

Judicious use of antibiotics, importance of completing antibiotic regimen, Concept of DOTS,emergence of antibiotic resistance, current issues of MDR/XDR microbial strains.

Treatment using antiviral agents: Amantadine, Acyclovir, Azidothymidine. Concept of HAART.

Unit 4 Prevention of Microbial Diseases — No of Hours: 6

General preventive measures, Importance of personal hygiene, environmental sanitation and methodsto prevent the spread of infectious agents transmitted by direct contact, food, water and insect vectors. **Vaccines:** Importance, types, vaccines available against microbial diseases, vaccination schedule(compulsory and preventive) in the Indian context.

Suggested Readings

1. Ananthanarayan R. and Paniker C.K.J. (2009) Textbook of Microbiology. 8th edition, University Press Publication
2. Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's Medical Microbiology. 26th edition. McGraw Hill Publication
3. Goering R., Dockrell H., Zuckerman M. and Wakelin D. (2007) Mims' Medical Microbiology. 4th edition. Elsevier
4. Willey JM, Sherwood LM, and Woolverton CJ. (2013) Prescott, Harley and Klein's Microbiology. 9th edition. McGraw Hill Higher Education
5. Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014). Brock Biology of Microorganisms. 14th edition. Pearson International Edition

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
SE-6: MICROBIOLOGICAL ANALYSIS OF AIR AND WATER
SEMESTER – III/IV

TOTAL HOURS: 30 CREDITS: 2

Course learning outcomes:

Outcome 1.Developed a clear understanding of effect of intrinsic and extrinsic parameter on the microbial growth.

Outcome 2.Are able to describe the role of microorganisms in the production of food, its spoilage, including their role in homemade fermented foods.

Outcome 3.Are able to identify the role of microorganisms in the causation of the diseases and how to protect against food-borne pathogens.

Outcome 4. Developed experimental skills for testing the milk and different foods for the presence of microorganisms

Unit 1 Aeromicrobiology **No of Hours: 4**

Bioaerosols, Air borne microorganisms (bacteria, Viruses, fungi) and their impact on human healthand environment, significance in food and pharma industries and operation theatres, allergens

Unit 2 Air Sample Collection and Analysis **No of Hours: 7**
Bioaerosol sampling, air samplers, methods of analysis, CFU, culture media for bacteria and fungi, Identification characteristics

Unit 3 Control Measures **No of Hours: 4**
Fate of bioaerosols, inactivation mechanisms – UV light, HEPA filters, desiccation, Incineration

Unit 4 Water Microbiology **No of Hours: 4**
Water borne pathogens, water borne diseases

Unit 5 Microbiological Analysis of Water **No of Hours: 7**
Sample Collection, Treatment and safety of drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive/MPN tests, confirmed and completedtests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests

Unit 6 Control Measures **No of Hours: 4**
Precipitation, chemical disinfection, filtration, high temperature, UV light

Suggested Reading

1. da Silva N, Taniwaki MH, Junqueira VC, Silveira N, Nascimento MS, Gomes RAR (2012) Microbiological Examination Methods of Food and WaterA Laboratory Manual, CRC Press
2. Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing, USA
3. Maier RM, Pepper IL and Gerba CP. (2009). Environmental Microbiology. 2nd edition, Academic Press
4. Hurst CJ, Crawford RL, Garland JL, Lipson DA (2007) Manual of Environmental Microbiology, 3rd edition, ASM press

13. Teaching learning processes:

The teaching learning processes incorporate a variety of modes and a regular use of ICT. These are listed below:

1. **Classroom Teaching** for topics which are intensely information-based. This a very regular feature of all the courses in Microbiology

2. **Power Point slides** for topics which involve information related to intricate biological pathways such as metabolic pathways in bacteria and other microorganisms.

   Use of Power Point presentations are also made whenever the lectures are to be summarized in a crisp and pointwise manner to highlight salient / important conclusions from the topics.

3. **Classroom Discussions** are a regular feature while teaching. The students are drawn into impromptu discussions by the teacher during the process of teaching.

4. **Video Displaying**, both real-time and animations, are used for topics which require 3D dimensional viewing of the biological mechanisms to drive the point home. These have proved to be very helpful while teaching concepts of molecular biology like DNA replication, transcription and translation. These are also used to convey complexities of antigen-antibody interactions and generation of antibody diversity during the teaching of Immunology.

5. **Laboratory Practical** are an integral part of every course included in UG programme in

   Microbiology. The is also a daily affair for UG students of Microbiology.

6. **Problem Solving** is encouraged during the laboratory work.

7. **Group Activity** as well as discussions with the laboratory supervisor/ among the students themselves/ Mentor is also encouraged during laboratory work.

8. **Project Work** is included in the programme where students work individually or in groups to design experiments to solve/answer a problem suggested by the Mentor or identified by the students in consultation with the Mentor. The students are mentored regularly during the duration the project is in progress.

9. **Presentations by the Students** are regularly done. The students are mentored in presentation of data, interpretation of data and articulation with the students/teachers/Research Scholars during their presentation.

10. **Visit to Industries/Laboratories** related to Microbiology like fermentation, food, diagnostics etc. are organized to acquaint the students with real-life working environments of the professional microbiologists with a view to broaden their perspective of the subject of Microbiology.

14. Assessment Tasks:

It is important that the students of UG Microbiology program achieve the desired results in terms of the learning outcomes to be professionally sound and competitive in a global society. Achieving the desired learning outcomes is also imperative in terms of job employment leading to a happy and prosperous individual further leading to a happy and prosperous family and thereby a happy and prosperous society or nation. The assessments tasks are pivotal to get an authentic feedback for the teaching learning process and for mid-course corrections and further improvements in future. The assessment tasks are carried out at various stages of the duration of the UG Microbiology programme like Mid-term assessments, End-term assessments, Semester examinations, Regular assessments, viva-voce etc. The assessment tasks are listed below:

1. **Multiple Choice Questions (MCQ)** are one of the predominant form of assessment tasks. This task is used during all kinds of term and semester examinations.

2. **Short-AnswerQuestions** during term and semester examinations are used to assess the ability of the student to convey his thoughts in a coherent way where prioritization of the information in terms of their significance is tested.
3. **Surprise Quizzes** are regularly used during continuous assessment while the teaching learning process is continuing which prepares the student to quickly recall information or quickly analyze a problem and come up with proper solutions.
4. **Visual/Pictorial Quizzes** are used to sharpen the comprehension of the students after looking at all the components of a system.
6. **Problem Solving** question are generally given during the laboratory work.
7. **Data Interpretation** is also another assessment task which is used to develop analytical skills of the students. This assessment is used during laboratory work as well as during conduction of project work.
8. **Analytical Skills** are assessed during work related to several experiments like enzyme kinetics, growth of bacteria and bacteriophages, mutation frequencies.
9. **Paper/ Project presentations** are used to assess the articulation skills of the student.

   These are carried out both during the duration of the teaching learning processes as well as during end-Semester examinations.
10. **Report Writing** is used to assess the keenness of the students for details related to microbiology while visiting laboratories / industries as students invariably are required to submit a report after such visits.
11. **Assignment Writing** are used to assess the writing abilities of the students during mid- term vacations.
12. **Viva-voce** during the laboratory working hours and during laboratory examination are used to assess the over-all knowledge and intelligence of the students.