CHHATRAPATI SHAHU JI MAHARAJ UNIVERSITY, KANPUR

Proposed Titles for Theory and Practical Papers

Integrated Under Graduate – Post Graduate Programme

SUBJECT: MICROBIOLOGY

CHHATRAPATI SHAHU JI MAHARAJ UNIVERSITY, KANPUR

STRUCTURE OF SYLLABUS FOR THE

PROGRAM: B.Sc.-M.Sc. INTEGRATED, SUBJECT: MICROBIOLOGY

Syllabus Developed by			
Name of BoS Convenor / BoS Member	**Designation**	**Department**	**College/University**
Prof S K Awasthi	Dean, Faculty of Life Sciences	Life Sciences & Biotechnology	CSJM University Kanpur
Prof. Nand Lal	Professor, Head & Convenor	Life Sciences & Biotechnology	CSJM University Kanpur
Prof. Neelam Pathak	External Expert	Biochemistry	RMLAU, Ayodhaya
Prof. Ram Narain	External Expert	Biotechnology	VBS Purvanchal University, Jaunpur
Prof. B N Mishra	External Expert	Biotechnology	Instt. Of Engineering &Technology, Lucknow
Prof. Varsha Gupta	Professor	Life Sciences & Biotechnology	CSJM University Kanpur
Prof. Rolee Sharma	Professor	Life Sciences & Biotechnology	CSJM University Kanpur
Dr. Shilpa Deshpande Kaistha	Associate Professor	Life Sciences & Biotechnology	CSJM University Kanpur
Dr. Ekta Khare	Assistant Professor	Life Sciences & Biotechnology	CSJM University Kanpur

Semester wise titles of Papers in B.Sc.-M.Sc. Integrated Microbiology						
UG PAPERS						
I YEAR / I SEM						
COURSE CODE	**TYPE**	**COURSE TITLE**	**MIN CREDITS**	**CIA**	**ESE**	**MAX. MARKS**
L080101T	CORE	Introduction to Microbiology	4	25	75	100
L080102T	CORE	Bacteriology, Virology and Mycology	4	25	75	100
L080103T	CORE	Microbial Techniques	4	25	75	100
L080104P	PRACTICAL	Practical work	6	25	75	100
L080105V	Skill Development	Microbial Quality Control in Food and Pharmaceutical Industries	3	25	75	100
Z010101T	Co-curricular@	Food, Nutrition and Hygiene	2	25	75	100
L080201T	CORE	Cell Biology	4	25	75	100
L080202T	CORE	Biochemistry	4	25	75	100
L080203T	CORE	Microbial Physiology and Metabolism	4	25	75	100
L080204P	PRACTICAL	Practical work	6	25	75	100
L080205V	Skill Development	Entrepreneurship Development I	3	25	75	100
Z020201	Co-curricular@	First Aid and Health	2	25	75	100
	MINOR ELECTIVE FROM OTHER FACULTY (IN 1ST YR- I/II SEM)*		4	25	75	100
	TOTAL FOR YEAR I		**50**			**1100**
II YEAR / III SEM						
L080301T	CORE	Inheritance biology	4	25	75	100
L080302T	CORE	Fundamentals of Molecular Biology	4	25	75	100
L080303T	CORE	Instrumentation, Biotechniques and Biostatistics	4	25	75	100

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L080304P	PRACTICAL	Practical Work	6	25	75	100
L080305V	Skill Development	Microbial Diagnosis in Health Clinics and Disease Management	3	25	75	100
Z030301	Co-curricular@	Human Values and Environment Studies	2	25	75	100
		II YEAR / IV SEM				
L080401T	CORE	Microbial Genetics and Genomics	4	25	75	100
L080402T	CORE	Environmental Microbiology	4	25	75	100
L080403T	CORE	Microbial Technology	4	25	75	100
L080404P	PRACTICAL	Practical work	6	25	75	100
L080405V	Skill Development	Entrepreneurship Development II	3	25	75	100
Z040401	Co-curricular@	Physical Education and Yoga	2	25	75	100
	MINOR ELECTIVE FROM OTHER FACULTY (IN 2nd YR- III/IV SEM)*		4	25	75	100
	TOTAL FOR YEAR II		**50**			**1100**
		III YEAR / V SEM				
L080501T	CORE	Recombinant DNA Technology	4	25	75	100
L080502T	CORE	Applied Microbiology	4	25	75	100
L080503T	CORE	Agriculture Microbiology	4	25	75	100
L080504T	CORE	Computers and Bioinformatics	4	25	75	100
L080505P	PRACTICAL	Practical Work	6	25	75	100
Z050501	Co-curricular@	Analytic Ability and Digital Awareness	2	25	75	100
L080506R	PROJECT	Research Assignment I	4	25	75	100 (Qualifying)
		TOTAL	28			500
		III YEAR / VI SEM				
L080601T	CORE	Medical Microbiology and Immunology	4	25	75	100
L080602T	CORE	Food and Dairy Microbiology	4	25	75	100
L080603T	CORE	Industrial Microbiology	4	25	75	100
L080604T	CORE	Microbial Biotechnology	4	25	75	100
L080605P	PRACTICAL	Practical Work	6	25	75	100
Z060601	Co-curricular@	Communication Skills and Personality Development	2	25	75	100
L080606R	PROJECT	Research Assignment II	4	25	75	100 (Qualifying)
		TOTAL	28			500
		TOTAL FOR YEAR III	**56**			**1000**

PG PAPERS

IV YEAR / 7TH SEM

COURSE CODE	TYPE	COURSE TITLE	MIN CREDITS	CIA	ESE	MAX. MARKS
L080701T	CORE	Cellular Microbiology	4	25	75	100
L080702T	CORE	Mycology and Phycology	4	25	75	100
L080703T	CORE	Virology	4	25	75	100
L080704T	CORE	Extreme Microbiology	4	25	75	100

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L080705P	PRACTICAL	Practical Work	4	25	75	100
	PROJECT	Review writing and Presentation"		-	-	-
IV YEAR / 8TH SEM						
L080801T	CORE	Plant Pathology	4	25	75	100
L080802T	CORE	Advances in Microbiology	4	25	75	100
L080803T	CORE	Entrepreneurial Microbiology	4	25	75	100
L080804T	ELECTIVE	Plant Tissue Culture, Methods and Applications	4	25	75	100
L080805T		Bioremediation Technology				
L080806P	PRACTICAL	Practical Work	4	25	75	100
L080807R	PROJECT	Review writing and Presentation"	8	25	75	100
	MINOR ELECTIVE FROM OTHER FACULTY (IN 1V YR- 7TH /8TH SEM)*		4	25	75	100
	TOTAL (FOR YEAR IV)		**52**			**1200**
V YEAR / 9TH SEM						
L080901T	CORE	Analytical Techniques	4	25	75	100
L080902T	CORE	Advanced Molecular Biology	4	25	75	100
L080903T	ELECTIVE	Microbial Omic Technologies	4	25	75	100
L080904T		Bioethics, Biosafety and Intellectual Property Rights				
L080905T	ELECTIVE	Molecular Host-Microbe Interactions	4	25	75	100
L080906T		Marine Microbiology				
L080907P	PRACTICAL	Practical Work (Major Course)	4	25	75	100
	PROJECT	Research Project Dissertation"		-	-	-
	TOTAL		24			500
VST YEAR / 10TH SEM						
L081001T	CORE	Molecular Microbial Genetics	4	25	75	100
L081002T	CORE	Advanced Immunology and Immunotechniques	4	25	75	100
L081003T	ELECTIVE	Nanobiotechnology	4	25	75	100
L081004T		Pharmaceutical Microbiology				
L081005T	ELECTIVE	Animal Cell, tissue culture and transgenic technology	4	25	75	100
L081006T		Enzyme Technology				
L081007P	PRACTICAL	Practical Work	4	25	75	100
L081008R	PROJECT	Research Project Dissertation "	8	25	75	100
	TOTAL		24			600
	TOTAL (FOR YEAR V)		**48**			**1100**
GRAND TOTAL			**256**			**5500**

NOTE:

1. *A MINOR ELECTIVE FROM OTHER FACULTY SHALL BE CHOSEN IN 1st (EITHER 1st / 2nd SEMESTER), 2nd (EITHER 3rd / 4th SEMESTER) and 4th YEAR (EITHER 7th / 8th SEMESTER) AS PER AVAILABILITY.
2. @The co-curricular papers at UG level shall be qualifying papers of 100 marks.
3. The yearwise exit and lateral entry in the program shall be as per NEP-2020 guidelines.
4. "In both 4th and 5th years of B.Sc.-M.Sc. Integrated Microbiology program, there will be a Research Project or equivalently a research-oriented Dissertation as per guidelines issued earlier and will be of 4 credit (4 hr/week), in each semester. Student will submit Project

Hons. Alok P.

Report/ Dissertation at the end of 8th and 10th semesters that will be evaluated for 8 credit hours for a total of 100 marks.

5. Research project/assignment can be done in form of Internship/Survey/Field work/Research project/ Industrial training/ Review, and a report/dissertation shall be submitted that shall be evaluated via seminar/presentation and viva voice.
6. The student straight away will be awarded 25 marks if he publishes a research paper on the topic of Research Project or Dissertation.

Proposed Syllabus (According to NEP-2020) for Integrated B.Sc./ B.Sc.(H)/ M.Sc. in Microbiology (Degree)

Certificate Course in Microbial Techniques,
Diploma in Microbial Technology,
B.Sc. Microbiology, B.Sc. Microbiology (Hons.-With Research) and M.Sc. Microbiology

Program Objectives:	
1.	To provide the graduates with knowledge in microbiology and an overview of the processes that employ or deal with microbes that enables them to handle the safe and efficient use of microbiological applications with development of competence on par with global standards and helps the graduates for life-long learning.'
2.	To prepare graduates by imparting skills to use technological developments related to current and advanced areas involving molecular diagnostics, immunotechnology, mass cultivation of microbes, downstream processing and nanotechnology with scope for upskilling in all potential future technologies so as to contribute effectively for Research & Development leading to patenting and publishing.
3.	To train graduates to choose a decent career option either as Entrepreneur or having a high degree of employability; or pursue higher education - by empowering students with basic interpersonal skills, ability to handle critical situations allowing them to be good team members as well as training to excel in competitive examinations.
4.	To impart a strong sense of social responsibility with awareness of professional and societal ethical values and scope to develop leadership capabilities.
Programme Outcomes (POs)	
1.	**Microbiology Knowledge** Graduates will acquire microbiology specific knowledge including molecular biology, immunology and rDNA technology coupled with handson skills and leadership skills to take up higher studies, set up small scale industries, and develop confidence to take up challenging tasks of research in the field of Microbiology.
2.	**Critical Thinking** Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational, and personal) from different perspectives.
3.	**Effective Communication** Speak, read, write and listen clearly in person and through electronic media in English and in one Indian language, and make meaning of the world by connecting people, ideas, books, media and technology
4.	**Team Work** Competent enough to use microbiology knowledge and skills to analyze problems involving microbes, articulate these with peers/ team members/ other stake holders, and undertake remedial measures/ studies etc.
5.	**Effective Citizenship** Developed a broader perspective of the discipline of Microbiology to enable him to identify challenging societal problems and plan his professional career to develop innovative solutions for such problems. Students learn to integrate science with society for the overall development of the nation.
6.	**Environment and Sustainability** Understand the issues of environmental contexts and sustainable development.
7.	**Ethics** Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them.
8.	**Lifelong learning**

	Graduates will carry on to learn and adapt in a world of constantly evolving technology
Programme Specific Outcomes (PSOs)	
PSO1	**Microbiology skills** • Acquired knowledge and understanding of the microbiology concepts as applicable to diverse areas such as medical, industrial, environment, genetics, agriculture, food and others. • The ability to understand the basic concepts related to the relevant fields of microbiology will enable them to analyse and develop solutions to microbiology related problems.
PSO2	**Microbiology related employability skills** • The ability to use technological developments related to current and advanced areas involving molecular diagnostics, immunotechnolgy, mass cultivation of microbes, downstream processing and nanotechnology with scope for upskilling in all potential future technologies so as to contribute effectively for Research & Development leading to patenting and publishing. • The ability to use the acquired hands-on skills in microbiology, molecular biology, immunology, medical microbiology and screening for useful biomolecules within employment areas.
PSO3	**Successful Career and Entrepreneurship** • The ability to gainfully become an entrepreneur by using microorganisms to produce biofertilizers, mushrooms and pharmaceutically important biomolecules. • Knowledge as well as use of practical hands-on training to become employed in diagnostic, industrial, pharmaceutical, food and research and development laboratories.

Certificate Course in Microbial Techniques	
B. Sc. I Programme Specific Outcomes	
1.	Students will be able to acquire, articulate, retain, and apply specialized skills and knowledge relevant to microbiology.
2.	Students will acquire and demonstrate proficiency in good laboratory practices in a microbiological laboratory and be able to explain the theoretical basis and practical skills of the tools/technologies commonly used to study this field.
3.	Students will gain fundamental knowledge about the various scopes on biochemistry, metabolism, microbial physiology and environmental science, and their concepts.
4.	The certificate course will enable students to apply for technical positions in government and private labs/institutes.

Diploma in Microbial Technology	
B.Sc. II Programme Specific Outcomes	
1.	Students will develop familiarity and understanding of the microbiology concepts as relevant to various areas such as biochemistry
2.	Students will exhibit reasonable abilities in the utilization of instruments, advances and techniques common to microbiology, and apply the logical strategy and theory testing in the plan and execution of examinations
3.	Students will be adequately capable to utilize microbiology information and abilities to analyse problems involving microorganisms, articulate these with peers and undertake remedial measures.
4.	Students will be able to work in a variety of fields, including biological and medical science in higher education institutions, public health, environmental organizations, and the food, dairy, pharmaceutical, and biotechnology industries.

Degree in Bachelor of Science in Microbiology	
B.Sc. III Programme Specific Outcomes	
1.	Students of B.Sc. Microbiology Programme will learn to use scientific logic as they investigate a broad variety of contemporary subjects covering different areas of basic microbiology such as Bacteriology, Virology, Biochemistry, Microbial Physiology, Immunology, Cell Biology, Molecular Biology, Genetics, Immunology, and Microbial Genetics, as well as becoming aware of the importance of environmental microbiology.
2.	Students will learn about various biotechnological applications of microorganisms as well as industrially relevant substances developed by microorganisms. They'll learn about the special role microbes play in genetic modification technologies.
3.	Students will learn and develop good laboratory practices in a microbiological laboratory, as well as be able to explain the theoretical foundations and practical skills of the tools and technologies widely used in this area. Students can gain proficiency in the quantitative skills needed to analyze biological problems.
4.	Students will learn about experimental methods, hypothesis creation and testing, and experiment design and execution. Students can develop their critical thinking skills as well as their ability to read and interpret scientific literature. Via successful presentation of experimental findings as well as workshops, students can acquire good oral and written communication skills

Degree in Bachelor of Science in Microbiology (Honors – with Research)	
B.Sc. IV Programme Specific Outcomes	
1.	Students will learn about experimental methods, hypothesis creation and testing, and experiment design and execution. Students can develop their critical thinking skills as well as their ability to read and interpret scientific literature. Via successful presentation of experimental findings as well as workshops, students can acquire good oral and written communication skills
2.	He/she will be able to design and execute experiments related to Basic Microbiology, Immunology, Molecular Biology, Recombinant DNA Technology, and Microbial Genetics, and will be able to execute a short research project incorporating techniques of Basic and Advanced Microbiology under supervision.
3.	The student can become an entrepreneur by using microorganisms to produce biofertilizers, mushrooms and pharmaceutically important biomolecules as well as using practical hands-on training to become employed in diagnostic, industrial, pharmaceutical, food and research and development laboratories.
4.	After graduation the students may join industry, academia, and public health and play their role as microbiologists in a useful manner contributing their role in the development of the welfare society.

Degree in Masters of Science in Microbiology	
M.Sc. Programme Specific Outcomes	
1.	The student will be able to explain about various applications of Microbiology such as Environmental, Industrial, Food Microbiology, and Microbial Pathogenicity.
2.	At the time of completion of the programme the student will have developed extensive knowledge in various areas of Microbiology. Through the stimulus of scholarly progression and intellectual development the programme aims to equip students with excellence in education and skills, thus enabling the student to pursue a career of his/her choice.
3.	By cultivating talents and promoting all round personality development through multi-dimensional education a spirit of self-confidence and self-reliance will be infused in the student. The student will be instilled with values of professional ethics and be made ready to contribute to society as responsible individuals.
4.	The student will be equipped to take up a suitable position in academia or industry, and to pursue a career in research if so desired.

Proposed Syllabus (According to NEP-2020) for Integrated B.Sc./ B.Sc.(H)/ M.Sc. in Microbiology (Degree)

Certificate Course in Microbial Techniques,
Diploma in Microbial Technology,
B.Sc. Microbiology, B.Sc. Microbiology (Hons.- With Research) and M.Sc. Microbiology

Year	Semester	Major Course					Minor Elective (Other Faculty) (As per University Guidelines)	Vocational/ Skill Development Course	Co-Curricular Course (As per University Guide-lines)	Industrial Training/ Review/ Survey/ Research Project	Min. Credits (for the year)	Cumulative Minimum Credits) Required for award of Certificate/ Diploma/ Degree
		Course I	Course II	Course III	Course IV	Course V						
1	I	**L080101T** Introduction to Microbiology (4 credits) Marks: 100	**L080102T** Bacteriology, Virology and Mycology (4 credits) Marks: 100	**L080103T** Microbial Techniques (4 credits) Marks: 100	**L080104P** Practical Work (6 credits) Marks: 100	- -	**IDC101T** Atomic structure, bonding, general organic chemistry & aliphatic hydrocarbons	**L080105V** Microbial Quality Control in Food and Pharmaceutical Industries (3 credits) Makes: 100	**Z010101T** Food, Nutrition and Hygiene (2 Credits) Qualifying	-	50	**B.Sc. I Year or Certificate in Microbial Techniques (Total credits = 50; Marks= 1100)**
	II	**L080201T** Cell Biology (4 credits) Marks: 100	**L080202T** Biochemistry (4 credits) Marks: 100	**L080203T** Microbial Physiology and Metabolism (4 credits) Marks: 100	**L080204P** Practical Work (6 credits) Marks: 100	- -	*Or* Any other course 4 credits Marks: 100	**L080205V** Entrepreneur-ship Development I (3 credits) Makes: 100	**Z020201** First Aid and Health (2 Credits) Qualifying	-		
2	III	**L080301T** Inheritance biology (4 credits) Marks: 100	**L080302T** Fundamentals of Molecular Biology (4 credits) Marks: 100	**L080303T** Instrumentation, Biotechniques and Biostatistics (4 credits) Marks: 100	**L080304P** Practical Work (6 credits) Marks: 100	- -	Any course offered from other faculty 4 credits Marks: 100	**L080305V** Microbial Diagnosis in Health Clinics and Disease Management (3 credits) Marks: 100	**Z030301** Human Values and Environ-ment Studies (2 Credits) Qualifying	-	50	**B.Sc. II Year or Diploma in Microbial Technology (Total credits**

	IV	**L080401T** Microbial Genetics and Genomics (4 credits) Marks: 100	**L080402T** Environmental Microbiology (4 credits) Marks: 100	**L080403T** Microbial Technology (4 credits) Marks: 100	**L080404P** Practical Work (6 credits) Marks: 100	-		**L080405V** Entre-preneurship Development II (3 credits) Marks: 100	**Z040401** Physical Education and Yoga (2 Credits) Qualifying	-		= 100; Marks = 2200)
3	V	**L080501T** Recombinant DNA Technology (4 credits) Marks: 100	**L080502T** Applied Microbiology (4 credits) Marks: 100	**L080503T** Agriculture Microbiology (4 credits) Marks: 100	**L080504T** Computers and Bio-informatics (4 credits) Marks: 100	**L080505P** Practical Work (6 credits) Marks: 100	-	-	**Z050501** Analytic Ability and Digital Awareness (2 Credits) Qualifying	**L080506R** Research Assignment I (4 Credits) Qualifying	56	**B.Sc. in Micro-biology (Total credits = 156; Marks = 3200)**
	VI	**L080601T** Medical Microbiology and Immunology (4 credits) Marks: 100	**L080602T** Food and Dairy Microbiology (4 credits) Marks: 100	**L080603T** Industrial Microbiology (4 credits) Marks: 100	**L080604T** Microbial Bio-technology (4 credits) Marks: 100	**L080605P** Practical Work (6 credits) Marks: 100	-	-	**Z060601** Communic ation Skills and Personality Develop-ment (2 Credits) Qualifying	**L080606R** Research Assignment II (4 Credits) Qualifying		
4	VII	**L080701T** Cellular Microbiology (4 credits) Marks: 100	**L080702T** Mycology and Phycology (4 credits) Marks: 100	**L080703T** Virology (4 credits) Marks: 100	**L080704T** Extreme Micro-biology (4 credits) Marks: 100	**L080705P** Practical Work (4 credits) Marks: 100	Any course offered from other faculty 4 credits Marks: 100	-	-	Review writing and Presentation (4 credits) -	52	**B.Sc. Honors with Research in Microbiology (Total credits = 208; Marks =4400)**
	VIII	**L080801T** Plant Pathology (4 credits)	**L080802T** Advances in Microbiology (4 credits)	**L080803T** Entrepreneurial Microbiology (4 credits)	**L080804T** Plant Tissue Culture, Methods and Applications (4 credits) **L080805T** Bio-	**L080806P** Practical Work (4 credits)		-	-	**L080807R** Review writing and Presentation (4 credits)		

					remediation Technology (4 credits)							
		Marks: 100	Marks: 100	Marks: 100	Marks: 100	Marks: 100				Marks: 100		
5	IX	**L080901T** Analytical Techniques (4 credits)	**L080902T** Advanced Molecular Biology (4 credits)	**L080903T** Microbial Omic Technologies (4 credits) **L080904T** Bioethics, Biosafety and Intellectual Property Rights (IPR) (4 credits)	**L080905T** Molecular Host-Microbe Interactions (4 credits) **L080906T** Marine Micro-biology (4 credits)	**L080907P** Practical Work (4 credits)	-	-	-	Research Project Dissertation (4 credits)	48	**M.Sc. in Microbiology (Total credits = 256; Marks = 5500)**
		Marks: 100	Marks: 100	Marks: 100	Marks: 100	Marks: 100				-		
	X	**L081001T** Molecular Microbial Genetics (4 credits)	**L081002T** Advanced Immunology and Immuno-techniques (4 credits)	**L081003T** Nanobio-technology (4 credits) **L081004T** Pharmaceutical Microbiology (4 credits)	**L081005T** Animal Cell, tissue culture and transgenic technology (4 credits) **L081006T** Enzyme Technology (4 credits)	**L081007P** Practical Work (4 credits)	-	-	-	**L081008R** Research Project Dissertation (4 credits)		
		Marks: 100	Marks: 100	Marks: 100	Marks: 100	Marks: 100				Marks: 100		

* The practicals enlisted for the semesters can be changed. Virtual labs can be used to improve teaching and learning experiences.

**Student should be conducting research based activity for 4 credits (4 hours per week) in 7th, 8th, 9th and 10th semesters. Student will submit Project Report/ Dissertation at the end of 8th and 10th semesters that will be evaluated for 8 credit hours for a total of 100 marks.

SEMESTER –I

L080101T	MAJOR COURSE I INTRODUCTION TO MICROBIOLOGY	CREDITS: 4

Course Objectives

The primary objective of the course is to build a strong foundation of microbiology, from history to diversity of microorganisms.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**History of Development of Microbiology No. of Hours: 15** 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.Waksman Establishment of fields of medical microbiology and immunology through the work of Paul Ehrlich, Elie Metchnikoff, Edward Jenner	12
II	**Systems of Classification** Binomial nomenclature, Classification systems – Phenetic, Numerical Taxonomy, Phylogenetic; Major characteristics used in taxonomy-Classical and molecular characteristics; Major divisions of life-Domains and Kingdoms; Whittaker's five kingdom and Carl Woese's three kingdom classification systems and their utility. Bergey's manual and introduction to classification of bacteria. **Acellular microorganisms:** General properties and structure of animal viruses: Influenza, HIV; plant viruses: TMV; bacterial viruses: Lambda Phage and T4 bacteriophage; general features of Prions and Viroids. **Bacterial morphology** Ultrastructure of bacterial cell. Differences between archaebacterial and eubacterial cell. General features of Rickettsia, Chlamydia, Mollicutes, Actinomycetes and Cyanobacteria.	15
III	**Algae** History of phycology with emphasis on contributions of Indian scientists; General characteristics of algae including occurrence, thallus organization, algae cell ultra-structure, 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 and food.	10
IV	**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, asexual reproduction, sexual reproduction, heterokaryosis, heterothallism and parasexual mechanism. Economic importance of fungi with examples in agriculture, environment, Industry, medicine, food, biodeterioration and mycotoxins.	12

V	**Protozoa** General characteristics with special reference to Amoeba, Paramecium, Plasmodium, Leishmania and Giardia	6
VI	**An overview of Scope of Microbiology**	5

Course Outcomes: Upon successful completion students should be able to:

1. Students will gain knowledge about the different types of microorganisms and their significance.
2. Student will learn the importance of evaluation of various characteristics for classification of organisms.

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. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGraw Hill Book Company.
6. Stanier RY, Ingraham JL, Wheelis ML, Painter PR. (2005). General Microbiology. 5th edition. McMillan.

L080102T	MAJOR COURSE II BACTERIOLOGY, VIROLOGY AND MYCOLOGY	CREDITS: 4

Course Objectives:

The objective of this course is to develop detailed knowledge of bacteria, virus and fungal structural organization and propagation.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Bacterial Cell organization** Cell size, shape and arrangement, glycocalyx, capsule, flagella, endoflagella, fimbriae and pili. Cell-wall: Composition and detailed structure of Gram-positive and Gram-negative cell walls, Archaebacterial cell wall, Gram and acid fast staining mechanisms, lipopolysaccharide (LPS), sphaeroplasts, protoplasts, and L-forms. Effect of antibiotics and enzymes on the cell wall. Cell Membrane: Structure, function and chemical composition of bacterial and archaeal cell membranes. Cytoplasm: Ribosomes, mesosomes, inclusion bodies, nucleoid, chromosome and plasmids Endospore: Structure, formation, stages of sporulation.	12
II	**Important archaeal and eubacterial groups No. of Hours: 19** **Archaebacteria**: General characteristics, phylogenetic overview, genera belonging to Nanoarchaeota (*Nanoarchaeum*), Crenarchaeota	14

	(*Sulfolobus*, *Thermoproteus*) and Euryarchaeota [Methanogens (*Methanobacterium*), thermophiles (*Thermococcus*), and Halophiles (*Halobacterium*)]. **Eubacteria:** Morphology, metabolism, ecological significance and economic importance of following groups: ***Gram Negative:*** Non proteobacteria: General characteristics with reference to *Deinococcus, Chlamydia, Chlorobium* and *Spirochaetes* Alpha proteobacteria: General characteristics with reference to *Rhizobium, Ricketssia* and *Agrobacterium.* Beta proteobacteria: General characteristics with reference to *Neisseria, Burkholderia* and *Thiobacillus*. Gamma proteobacteria: General characteristics with reference to *Pseudomonas,* Purple Sulfur bacteriaand Enterobacteriaceae family. Delta proteobacteria: General characteristics with reference to Myxobacteria and *Bdellovibrio*. Epsilon proteobacteria: General characteristics with reference to *Helicobacter* and *Campylobacter*. Zeta proteobacteria: General characteristics with reference to *Mariprofundus ferrooxydans*. ***Gram Positive:*** Low G+C (Firmicutes): General characteristics with reference to *Lactobacillus, Bacillus, Clostridium, Mycoplasma, Staphylococcus, Streptococcus.* High G+C (Actinobacteria): General characteristics with reference to *Corynebacterium, Streptomyces, Propionibacterium, Frankia, Mycobacterium* and *Nocardia.* ***Cyanobacteria*:** General characterstics.	
III	**Reproduction in Bacteria** Asexual methods of reproduction, logarithmic representation of bacterial populations, phases of growth, calculation of generation time and specific growth rate.	4
IV	**Nature and Properties of Viruses** Introduction: Discovery of viruses, nature and definition of viruses, general properties, concept of viroids, virusoids, satellite viruses and Prions. Theories of viral origin. Structure of Viruses: Capsid symmetry, enveloped and non-enveloped viruses. Viral taxonomy: characteristics considered for the classification of viruses.	8
V	**Viral multiplication and replication strategies** Bacteriophage one step multiplication curve, lytic and lysogenic phages (lambda phage) Replication strategies of viruses as per Baltimore classification (phi X 174, Retroviridae, Vaccinia, Picorna), Assembly with example of Polio virus and T4 phage, maturation and release of virions.	12
VI	**Mycology** Classification of fungi – Ainsworth (1973). Distinguishing characters of the different classes of fungi with special reference to reproductive structures and life history of the genera mentioned in each group: Myxomycotina – Physarum Mastigomycotina – Albugo	10

	Zygomycotina – Rhizopus Ascomycotina – Saccharomyces Basidiomycotina – Agaricus Deuteromycotina – Fusarium Economic importance of Fungi	

Course Outcomes: Upon successful completion students should be able to:

1. Will be able to describe the morphological features, cell arrangement and structural components of bacterial cell in detail.
2. Can enlist the characteristics of archaea that differentiate it from eubacteria, and will have learnt key features of some model archaeal organisms.
3. Is able to describe tools for studying virus structure, process of virus attachment and entry, virus assembly and release.
4. Is able to describe steps in replication of genome of RNA viruses, retroviruses, and DNA viruses.
5. Will be able to identify the class of fungi on the bases of vegetative, spore structures and fruiting bodies.
6. Will understand the effect of fungi on human life.

SUGGESTED READINGS

1. Atlas RM. (1997). Principles of Microbiology. 2nd edition. WM.T.BrownPublishers.
2. Black JG. (2008). Microbiology: Principles and Explorations. 7th edition. PrenticeHall
3. Madigan MT, and Martinko JM. (2014). Brock Biology of Micro-organisms. 14th edition. Parker J. Prentice Hall International, Inc.
4. Pelczar Jr MJ, Chan ECS, and Krieg NR. (2004). Microbiology. 5th edition TataMcGraw Hill.
5. Srivastava S and Srivastava PS. (2003). Understanding Bacteria. Kluwer AcademicPublishers, Dordrecht.
6. Stanier RY, Ingraham JL, Wheelis ML and Painter PR. (2005). GeneralMicrobiology. 5th edition McMillan.
7. Cappucino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited.
8. Dimmock, NJ, Easton, AL, Leppard, KN (2007). Introduction to Modern Virology. 6th edition, Blackwell Publishing Ltd.
9. Carter J and Saunders V (2007). Virology: Principles and Applications. John Wiley and Sons.
10. Flint SJ, Enquist, LW, Krug, RM, Racaniello, VR, Skalka, AM (2004). Principles of Virology, Molecular biology, Pathogenesis and Control. 2nd edition. ASM pressWashington DC.
11. Levy JA, Conrat HF, Owens RA. (2000). Virology. 3rd edition. Prentice Hall publication, New Jersey.
12. Ainsworth G C, Sparrow K F, Sussman A S (eds), 1973. The Fungi: an advanced Treatise, Vol. 4a & 4b, a Taxonomic review with keys. Academic press, New York.

L080103T	MAJOR COURSE III MICROBIAL TECHNIQUES	CREDITS: 4

Course Objectives:

The objective of this course is to develop a strong ability of laboratory handing and cultivation of microorganisms.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Good microbiology laboratory practices** Rules and regulations to be followed in a microbiology laboratory, Laboratory quality control assessment (Internal quality control and external quality control), Laboratory waste disposal system: national and international guidelines for the disposal of waste. Basic concepts of bio-safety and its universal precautions	12
II	**Techniques in microbiology** Principles of microscopy, construction and application of Compound Microscope (monocular and binocular), Bright field Microscopy, Dark field Microscopy ,Phase Contrast Microscopy, Fluorescence Microscopy, Electron Microscopy- TEM and SEM Bacteriological Incubator & Incubator Shaker; Laminar flow	10
III	**Sterilization and control of microorganisms** Definitions of terms- sterilization and disinfection; Sterilization by Physical methods- Use of moist heat- heat under pressure, autoclave, boiling, pasteurization, fractional sterilization, tyndallization; Use of dry heat- hot air oven, incineration; Filtration- Seitz filter, membrane filter, HEPA filter; Radiation- Ionizing and non- ionizing; Chemical methods- Alcohols, aldehydes, phenols, halogens, metallic salts, ethylene oxide.	10
IV	**Isolation, cultivation and maintenance of microorganisms** Culture media and its types (components of media, natural and synthetic media, chemically defined media, complex media, selective, differential, indicator, enriched and enrichment media); Methods for enumeration & isolation of microorganisms using pour plate, spread plate technique, and streak plate; Isolation of anaerobic microorganisms; Maintenance and preservation of pure culture	12
V	**Stains and staining techniques** Staining techniques, principles, procedures and applications of Simple staining, negative staining; Differential staining- Gram's staining, acid fast staining, Leishman's staining, Giemsa's staining, Ziehl Neelsen staining; Structural staining- cell wall, capsule, endospore and flagella staining.	10
VI	**Culture preservation and collection** Biodiversity conservation – in nature, artificial. Conservation techniques, Culture collection centers – in India and abroad	6

Course Outcomes: Upon successful completion students should be able to:

1. Students will study different techniques used in microbiology.
2. Will understand, learn and gain skill of isolation, culturing and maintenance of pure culture.
3. Will understand the working of various microscopes and their applications.
4. Will gain knowledge of various (physical and chemical) methods of control of microorganisms and safety measures to be followed while handling microbes.
5. Will learn different methods of staining of microbes.

SUGGESTED READINGS

1. Cappuccino J.G. and Sherman N. (2014) Microbiology a laboratory manual. 10th Edn. Pearson.
2. Gile, T.J. and Scungio D. (2014) Complete guide to Laboratory safety, 4th Edn. HCPro a division of BLR.
3. Emmert E. (2013). Biosafety guidelines for handling microorganisms in the teaching laboratory: development and rationale. Journal of Microbiology & Biology Education 14: 78–83.
4. Bisen P.S., Varma K . : Handbook of Microbiology CBS Publishers and Distributors, Delhi.
5. Dubey R.C. and D.K. Maheshwary, A textbook of Microbiology S chand and Co. New Delhi.
6. Pelczar Michael J., Jr./E.C.S. Chan, Elements of Microbiology: McGraw, Hill International Book Company, New Delhi.
7. Pelczar Michael J ., Jr. E.C.S Chan, Noel R.Krieg : Microbiology : Concepts and applications-McGraw Hill Inc.
8. Pelczar Michael J., Reid R.D. and Chan E.C.S.: Microbiology, Tata McGraw hill publishing Co. Ltd., New Delhi.
9. Powar C.B.and Daginawala H.F.: General microbiology Vol I and II Himalaya publishing house Bombay.
10. Prescott L.M., Harley J.P., and Klein Donald A.: Microbiology, W.M.C., Brown publisher

L080104P	MAJOR COURSE IV	CREDITS : 6
	PRACTICAL WORK: EXPERIMENTS IN BASIC MICROBIOLOGY	

Course Objectives

The major objective of the course is to impart hands-on training in basic microbiological and chemical techniques.

	Content
1	Microbiology Good Laboratory Practices 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	Sterilization of medium using Autoclave and assessment for sterility.
4	Sterilization of glassware using Hot Air Oven and assessment for sterility.
5	Sterilization of heat sensitive material by membrane filtration and assessment for sterility.
6	Demonstration of the presence of microflora in the environment by exposing nutrient agar plates to air.
7	Study of *Rhizopus*, *Penicillium*, *Aspergillus, Saccharomyces* using temporary mounts.
8	Study of *Spirogyra* and *Chlamydomonas, Volvox* using temporary mounts
9	Study of the following protozoans using permanent mounts/photographs: *Amoeba*, *Entamoeba*, *Paramecium* and *Plasmodium*.
10	Preparation of different media: Synthetic Media, Complex media (Nutrient Agar, McConkey agar).
11	Simple staining
12	Negative staining
13	Gram's staining
14	Capsule staining
15	Spore staining
16	Isolation of pure cultures of bacteria by streaking method.

17	Estimation of CFU count by spread plate method/pour plate method.
18	Demonstration of Motility by hanging drop method.
19	Isolation and enumeration of bacteriophages (PFU) from water/sewage sample using double agar layer technique.
20	Isolation of Fungi on potato dextrose agar media
21	Lactophenol cotton blue staining of fungi

Course Outcomes: Upon successful completion students should be able to:

1. Is able to use different sterilization procedures and learn handling of micropipette.
2. Is able to work in Biosafety Cabinet for culturing cells.
3. Is versed with identification and classification of given bacterial isolate by performing variety of cultural, biochemical tests.
4. Can use microscopy for cell imaging.

SUGGESTED READINGS

1. Weaver, D. and Tart, R. C., "A Laboratory Manual for General Microbiology" (1998). *Biology*. 46. https://cufind.campbell.edu/biology/46
2. Campbell, JL "A Manual of Scientific and Practical" Publ. BiblioBazaar.
3. Dr. R. C. Dubey and Dr. D. K. Maheshwari 'Practical Microbiology' S. Chand Publications.

L080105V	SKILL DEVELOPMENT COURSE MICROBIAL QUALITY CONTROL IN FOOD AND PHARMACEUTICAL INDUSTRIES	CREDITS: 3 (1T+2P)

Course Objectives

Various quality analysis parameters are provided in syllabus so that students can get opportunity to get hired in food and pharmacy.

Unit	Topics	Total No. of Hours
	THEORY	
I	**Microbiological Laboratory and Safe 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.	8
II	**HACCP for Food Safety and Microbial Standards No.** Hazard analysis of critical control point (HACCP) - Principles, flow diagrams, limitations Microbial Standards for Different Foods and Water – BIS standards for common foods and drinking water.	4
III	**Aeromicrobiology** Bioaerosols, Air borne microorganisms (bacteria, Viruses, fungi) and their impact on human health and environment, significance in food and pharma industries and operation theatres, allergens.	3
	PRACTICAL	
IV	**Microbiological analysis of water** Sample Collection, Treatment and safety of drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive test, MPN test, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests.	20
V	**Determining Microbes in Food / Pharmaceutical Samples**	20

	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.	
VI	**Pathogenic Microorganisms of importance in Food & Water** Enrichment culture technique, Detection of specific microorganisms - on XLD agar, Salmonella Shigella Agar, Manitol salt agar, EMB agar, McConkey Agar, Saboraud Agar. Ascertaining microbial quality of milk by MBRT, Rapid detection methods of microbiological quality of milk at milk collection centres (COB, 10 min Resazurin assay).	20
Course Outcomes: Upon successful completion students should be able to: 1. Analyse microbial quality of food. 2. Deal with the toxins and pathogens present in food and pharmacy.		

SUGGESTED READINGS

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.

SEMESTER –II

L080201T	MAJOR COURSE I CELL BIOLOGY	CREDITS: 4

Course Objective

To study the functioning of different organelles and mechanisms in eukaryotic and prokaryotic cells.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Structure of Cell** Plasma membrane: Structure and transport of small molecules. Cell Wall: Eukaryotic cell wall, Extracellular matrix and cell matrix interactions, Cell-Cell Interactions - adhesion junctions, tight junctions, gap junctions, and plasmodesmata (only structural aspects). Mitochondria, chloroplasts and peroxisomes.	12
II	**Nucleus** Nuclear envelope, nuclear pore complex and nuclear lamina. Chromatin – Molecular organization. Nucleolus.	6
III	**Cytoskeleton** Structure and organization of actin filaments, association of actin filaments with plasma membrane, cell surface protrusions, intermediate filaments, microtubules.	4
IV	**Protein Sorting and Transport** Endoplasmic Reticulum – Structure, targeting and insertion of proteins in the ER, protein folding, processing and quality control in ER, smooth ER and lipid synthesis, export of proteins and lipids Golgi Apparatus – Organization, protein glycosylation, protein sorting and export from Golgi Apparatus. Lysosomes.	12
V	**Cell Signalling** Signalling molecules and their receptors. Function of cell surface receptors. Pathways of intracellular receptors – Cyclic AMP pathway, cyclic GMP and MAP kinase pathway.	12
VI	**Cell Cycle, Cell Death and Cell Renewal** Eukaryotic cell cycle and its regulation, Mitosis and Meiosis. Development of cancer, causes, types, Diagnosis and therapy. Programmed cell death. Stem cells. Types: Embryonic stem cell, induced pluripotent stem cells.	14

Course Outcomes: Upon successful completion students should be able to:

1. Gain knowledge of functioning of different part of cells and understand differences between normal and diseased cells.
2. Learn about cell theory and techniques for fractionation of sub-cellular organelles.
3. Students will have an understanding of the composition of cytoskeleton and extracellular matrix.
4. Students will acquire knowledge of cell cycle, cell division and cell death mechanisms.

SUGGESTED READINGS

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

L080202T	MAJOR COURSE II BIOCHEMISTRY	CREDITS: 4

Course Objectives

To understand the properties of carbohydrates, proteins, lipids, cholesterol, DNA, RNA, glycoproteins and glycolipids and their importance in biological systems.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Bioenergetics** First and second laws of Thermodynamics. Definitions of Gibb's Free Energy, Enthalpy and Entropy, Standard free energy change, Coupled reactions, Energy rich compounds: Phosphoenolpyruvate, 1,3-Bisphosphoglycerate, Thioesters, ATP.	8
II	**Carbohydrates** Monosaccharides: aldoses and ketoses, trioses, tetroses, pentoses, and hexoses. Stereo-isomerism of monosaccharides, epimers, anomers of glucose. Furanose and pyranose forms of glucose and fructose, Sugar derivatives, glucosamine, galactosamine, muramic acid, N-acetyl neuraminic acid, Disaccharides; concept of reducing and non-reducing sugars, Polysaccharides, storage polysaccharides, starch and glycogen. Structural Polysaccharides, cellulose, peptidoglycan and chitin.	12
III	**Lipids** Definition and major classes of storage and structural lipids. Fatty acids structure and functions. Essential fatty acids. Triacyl glycerols structure, functions and properties. Phosphoglycerides: Building blocks, General structure, functions and properties. Structure of phosphatidylethanolamine and phosphatidylcholine, Sphingolipids. Special mention of sphingomyelins, cerebrosides and gangliosides. Lipid functions: cell signals, cofactors, Introduction of lipid micelles, monolayers and bilayers.	10
IV	**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 its significance, classification, biochemical structure and notation of standard protein amino acids. , Secondary structure of proteins: Peptide unit and its salient features. The alpha helix, the beta pleated sheet and their occurrence in proteins, Tertiary and Quaternary structures of proteins. Forces holding the polypeptide together. Human haemoglobin structure.	11
V	**Enzymes** Structure of enzyme: Apoenzyme and cofactors, coenzyme NAD, metal	11

	cofactors, Classification of enzymes, Mechanism of action of enzymes: active site, transition state complex and activation energy. Lock and key hypothesisand Induced Fit hypothesis. Significance of hyperbolic, double reciprocal plots of enzyme activity, Km, and allosteric mechanism Definitions of terms – enzyme unit, specific activity and turnover number, Multienzyme complex: pyruvate dehydrogenase; isozyme: lactate dehydrogenase, Effect of pH and temperature on enzyme activity. Enzyme inhibition: competitive- sulfa drugs; non-competitive.	
VI	**Nucleotide and Nucleic acids** Nucleic acid structure- ribose and deoxyribose sugar, nucleotide bases (purines, pyrimidines), types of DNA (A, B, Z and H) and structure (Watson-crick model), types of RNA (m-RNA, t-RNA, r-RNA) and structure	8

Course Outcomes: Upon successful completion students should be able to:

1. Will have understanding of the basic principles of thermodynamics applied to biological systems
2. Will be conversant with the structures of carbohydrates, lipids, proteins and nucleic acids.
3. Will comprehend the basic concepts of enzyme biochemistry including enzyme kinetics.
4. Will become aware of different variants of enzymes found in living cells.

SUGGESTED READINGS

1. Campbell, MK (2012) Biochemistry, 7th ed., Published by Cengage Learning.
2. Tymoczko JL, Berg JM and Stryer L (2012) Biochemistry: A short course, 2nd ed., W.H.Freeman.
3. Nelson DL and Cox MM (2008) Lehninger Principles of Biochemistry, 7th Edition., W.H. Freeman and Company.
4. VoetD. and Voet J.G (2004) Biochemistry 3rd edition, John Wiley
5. Berg JM, Tymoczko JL and Stryer L (2011) Biochemistry, W.H.Freeman and Company.

L080203T	MAJOR COURSE III MICROBIAL PHYSIOLOGY AND METABOLISM	CREDITS: 4

Course Objectives

The major objective of this paper is to develop clear understanding of various aspects of microbial physiology along with diverse metabolic pathways existing in bacteria to better understand courses taught later such as biotechnology-based courses.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Microbial Growth and Effect of Environment on Microbial Growth** Definitions of growth, measurement of microbial growth, Batch culture, Continuous culture, generation time and specific growth rate, synchronous growth, diauxic growth curve Microbial growth in response to environment, Microbial growth in response to nutrition and energy – Autotroph/ Phototroph, heterotrophy	12
II	**Nutrient uptake and Transport** Passive and facilitated diffusion Primary and secondary active transport, concept of uniport, symport and antiport, Group translocation, Iron uptake	10

	Thermodynamics of transport system	
III	**Chemoheterotrophic Metabolism - Aerobic Respiration** Concept of aerobic respiration, anaerobic respiration and fermentation Sugar degradation pathways i.e. EMP, ED, Pentose phosphate pathway, TCA cycle Electron transport chain: components of respiratory chain, comparison of mitochondrial and bacterial ETC, electron transport phosphorylation	16
IV	**Chemoheterotrophic Metabolism - Anaerobic respiration and fermentation** Anaerobic respiration with special reference to dissimilatory nitrate reduction (Denitrification) Fermentation - Alcohol fermentation and Pasteur effect; Lactate fermentation (homofermentative and heterofermentative pathways), concept of linear and branched fermentation pathways	8
V	**Chemolithotrophic and Phototrophic Metabolism** Introduction to aerobic and anaerobic chemolithotrophy with an example each. Hydrogen, nitrogen, sulfur 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 bacteria, purple bacteria and cyanobacteria	10
VI	**Nitrogen Metabolism** - an overview Introduction to biological nitrogen fixation Ammonia assimilation Assimilatory nitrate reduction	4

Course Outcomes: Upon successful completion students should be able to:

1. Will be acquainted with methods of measuring microbial growth, calculating growth kinetic parameters with understanding of steady state and continuous growth.
2. Will have gained an in-depth knowledge of primary, secondary and group translocation transport systems existing in bacteria, simultaneously learning membrane transport proteins and kinetics of solute transport.
3. Will have learnt central metabolic pathways for carbon metabolism in bacteria. This allows students to apply the acquired knowledge in engineering metabolic pathways for developing industrially useful strains.
4. Will have gathered understanding of inorganic and organic nitrogen assimilation and its regulation.
5. Is conversant with intracellular signaling in bacteria in response to various nutritional and physiological stresses.

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. Stanier RY, Ingrahm JI, Wheelis ML and Painter PR. (1987). General Microbiology. 5th edition, McMillan Press.
5. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.

L080204P	MAJOR COURSE IV	CREDITS: 6

	PRACTICAL WORK: EXPERIMENTS ON CELL BIOLOGY, BIOCHEMISTRY AND MICROBIAL PHYSIOLOGY	

Course Objectives

The major objective of the course is to impart hands-on training in biochemical and physiological characterization of microorganisms. Student will be trained in basic enzyme assays and be taught to present the results with statistical verification.

	Content
1	Handling of micropipettes and checking their accuracy.
2	Qualitative tests for carbohydrates, reducing sugars, non reducing sugars.
3	Qualitative tests for lipids and proteins.
4	Study of protein secondary and tertiary structures with the help of models.
5	Study of enzyme kinetics – calculation of *V*max, Km, Kcat values.
6	Study and plot the growth curve of *E. coli* by tubidometric method.
7	Calculations of generation time and specific growth rate of bacteria from the graph plotted with the given data.
8	Effect of temperature on growth of *E. coli*.
9	Effect of pH on growth of *E. coli*.
10	Effect of salt concentration on growth of *E. coli*.
11	Demonstration of alcoholic fermentation.
12	Demonstration of the thermal death time and decimal reduction time of *E. coli*.
13	Catalase activity
14	Oxidase activity
15	Amylase activity
16	Study a representative plant and animal cell by microscopy.
17	Cytochemical staining of DNA – Feulgen.
18	Study of different stages of Mitosis.

Course Outcomes: Upon successful completion students should be able to:

1. Can make qualitative and quantitative detection of different types of molecules.
2. Understand the effect of various physiological conditions on growth
3. Understands the techniques of enzyme assay.

SUGGESTED READINGS

1. Weaver, D. and Tart, R. C., "A Laboratory Manual for General Microbiology" (1998). *Biology*. 46. https://cufind.campbell.edu/biology/46
2. Campbell, JL "A Manual of Scientific and Practical" Publ. BiblioBazaar.
3. Dr. R. C. Dubey and Dr. D. K. Maheshwari 'Practical Microbiology' S. Chand Publications

L080205V	SKILL DEVELOPMENT COURSE ENTREPRENEURSHIP DEVELOPMENT I	CREDITS: 3 (1T+2P)

Course Objectives

1. To understand entrepreneurship concept and provide students with an understanding of entrepreneurship at the individual, firm and societal level of inquiry.
2. To understand concepts of entrepreneurial behavior and wider societal issues and enable them to relate such concepts to practice.
3. To simulate an understanding of the behaviors of an entrepreneur placed within the dynamic of business.
4. To enable students to be aware of the importance of entrepreneurship in the economy.

5. To help student understand the nature of entrepreneurship and entrepreneurial roles and responsibilities.
6. To understand the meaning, importance and scope of creativity and innovation in entrepreneurial pursuits

Unit	Topics	Total No. of hrs.
	THEORY	
I	**Essence of Entrepreneurship** Meaning & Definition of Entrepreneurship, Entrepreneur & Enterprise – Differences between Entrepreneurship, Entrepreneur & Enterprise – Types of Entrepreneurs - Functions of Entrepreneur – Role of Entrepreneur for Economic Development, Emergence & Development of Entrepreneurship, Economic, Sociological, Psychological & Ethical Perspective of Entrepreneurship.	7
II	**Creativity and Innovation** Definition Creativity Process- Innovation- Principles **All About Start-ups:**Startups, Startup Ecosystem, Startup Lifecycle, Startup Unicorns, Startup Policies, Startup boot camps, Prototyping, Minimum Viable Products, Business Models, Venture Capital, Angel Investment.	8
	PRACTICAL	
I	**Case reports** Why Innovate? Sources and Types of Innovation- Case Studies, Simulations.	10
II	**Manifestations of Entrepreneurship** Family business entrepreneurship; Social Entrepreneurship; Corporate Entrepreneurship, Intrapreneurship, Public sector entrepreneurship; Rural Entrepreneurship, Cultural Entrepreneurship, Indigenous Entrepreneurship	15
III	**Entrepreneurship in the Indian Context** Entrepreneurship ecosystem in India; cases of Indian entrepreneurs; institutions facilitating entrepreneurship in India; small enterprise support system by the Indian government; Entrepreneurship Development Process- Start-up, Sustenance, Growth and Maturity.	15
IV	**Case Reports on Biotechnology Industry** Translational biotechnology industry overview (include the commercialization pathways for drug, medical device, diagnostic companies)	20

Course Outcomes: Upon successful completion students should be able to:

1. Learn & understand conceptual framework of entrepreneurship and its interdisciplinary nature.
2. Connect the conceptual understanding with the practice of entrepreneurship through a series of examples of "real-life" entrepreneurs.
3. Develop an understanding of the entrepreneurial ecosystem in India.

SUGGESTEDREADINGS

1. Kuratko, D.F., & Rao, T.V. (2017). Entrepreneurship: A South-Asian Perspective. New Delhi: Cengage Learning.
2. Hisrich, R.D., Manimala, M.J., Peters, M.P., & Shepherd D.A. (2014). *Entrepreneurship.* New Delhi: McGraw Hill Education.
3. Kuratko, D.F., & Hodgetts, R.M. (2007). *Entrepreneurship: Theory, Process & Practice.* India: Thomson Learning.

SEMESTER –III

L080301T	MAJOR COURSE I INHERITANCE BIOLOGY	CREDITS: 4

Course Objectives

The student will be able to develop and demonstrate an understanding of the structure and function of genes, patterns of inheritance and clinical manifestations of genetic diseases; chromosomes, chromosomal abnormalities.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Historical developments** Model organisms in genetic analyses and experimentation: *Escherichia coli*, *Saccharomyces cerevisiae, Neurospora crassa, Caenorhabditis elegans, Drosophila melanogaster, Arabidopsis thaliana.*	5
II	**Mendelian Principles** Mendel's Laws: Dominance, segregation, independent assortment, deviation from Mendelian inheritance, Chromosome theory of inheritance: Allele, multiple alleles, pseudoallele, complementation tests, Extensions of Mendelian genetics: Allelic interactions, concept of dominance, recessiveness, Incomplete dominance and co-dominance,Multiple alleles, Epistasis, penetrance and expressivity.	13
III	**Characteristics of Chromosomes** Structural organization of chromosomes - centromeres, telomeres and repetitive DNA, Packaging DNA molecules into chromosomes, Concept of euchromatin and heterochromatin, Chromosome banding, Giant chromosomes: Polytene and lampbrush chromosomes, Variations in chromosome structure: Deletion, duplication, inversion and translocation, Variation in chromosomal number and structural abnormalities - Klinefelter, Turner, Down syndrome.	15
IV	**Linkage, Crossing over and Recombination** Linkage and recombination of genes, Cytological basis of crossing over, Crossing over at four-strand stage, Molecular mechanism of crossing over, mapping. Homologous and non-homologous recombination, including transposition, site-specific recombination.	12
V	**Extra-Chromosomal Inheritance** Introduction and 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*. Epigenetics.	9
VI	**Human genetics and Quantitative genetics** Pedigree analysis, LOD score for linkage testing, karyotypes, genetic disorders. Polygenic inheritance, heritability and its measurements, QTL mapping.	6

Course Outcomes: Upon successful completion students should be able to:

1. Understand that genes are the units of inheritance for individual characteristic and also may contribute to susceptibility to certain diseases.
2. Analyze phenotypic data and deduce possible modes of inheritance (e.g. dominant, recessive, autosomal, X-linked, cytoplasmic) from family histories.

SUGGESTED READINGS

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.

L080302T	MAJOR COURSE II FUNDAMENTALS OF MOLECULAR BIOLOGY	CREDITS: 4

Course Objectives

The students will gain knowledge about the structure, shape and significance of DNA, RNA. Synthesis of RNA and proteins along with its control. Role of genes as basic units of expression.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Gene organization and regulation of gene expression** DNA Structure: Miescher to Watson and Crick- historic perspective, DNA structure, Salient features of double helix, Types of DNA, Gene organization in prokaryotes and eukaryotes, polycistronic genes, split genes promoters, enhancers. Types of genetic material. Organization of DNA in Prokaryotes, Viruses, Eukaryotes. RNA Structure	10
II	**Regulation of gene expression** Principles of transcriptional regulation, regulation at initiation with examples from *lac* and *trp* operons.	5
III	**DNA Replication and DNA polymerases** Replication of genetic material in prokaryotes and eukaryotes. A brief description of initiation at replication origins, and its cell cycle regulation. Structure and function of prokaryotic and eukaryotic. DNA polymerases	15
IV	**Transcription and mRNA processing** RNA structure and types of RNA, Mechanism of transcription in prokaryotes and eukaryotes: transcription factors, structure of prokaryotic and eukaryotic RNA polymerases, initiation, elongation and termination. RNA processing: processing of mRNA (Splicing, capping and polyadenylation)	14
V	**Prokaryotic and eukaryotic translation** Genetic code, Ribosome structure and assembly, tRNA, aminoacyl tRNA synthetases, Mechanism of initiation, elongation and termination of polypeptides.	8
VI	**Post-translational processes** Translational proof-reading, translational inhibitors, Post- translational modification of proteins, Protein trafficking	8

Course Outcomes: Upon successful completion students should be able to:

1. Understand the chemical components of DNA and various forms of DNA.
2. Know about the organization of prokaryotic and eukaryotic genome.
3. Develop a fairly good knowledge on the flow of information from DNA to Protein.
4. Summarize and compare the various cellular mechanisms involved in the control of prokaryotic and eukaryotic transcription.
5. Understand about protein synthesis and inhibition factors of protein synthesis.

SUGGESTED READINGS

1. Freifelder D (2012). Molecular Biology, 5th edition. Narosa Publishing House, India
2. Berg JM, Tymoczko JL, Gatto GJ and Stryer L (2015) Biochemistry, 8th Edition, WH Freeman & Co., New York.
3. Allison A. Lizabeth (2012) Fundamental Molecular Biology, 2nd Edition. J Willey and Sons, Hoboken,New Jersey.
4. Freifelder D and Malacinski GM (2005) Essentials of Molecular Biology, 4th Edition, John and Bartlett Publishing, UK
5. Krebs JE., Kilpatrick ST and Goldstein ES. (2013). Lewin' GENES XI, Jones & Bartlett Learning. Burlington, MA.

L080303T	MAJOR COURSE III INSTRUMENTATION, BIOTECHNIQUES AND BIOSTATISTICS	CREDITS: 4

Course Objectives

The major objective of the course is to provide knowledge about bio-techniques and the validation of data through implementation of biostatistics.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Potentiometry** Water, pH, normality, molarity, molality, buffers, pH meter principle, design and working of pH meter.	8
II	**Centrifugation** Preparative and analytical centrifugation, fixed angle and swinging bucket rotors. RCF and sedimentation coefficient, differential centrifugation, density gradient centrifugation and ultracentrifugation.	10
III	**Chromatography** 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.	14
IV	**Electrophoresis** Principle and applications of native polyacrylamide gel electrophoresis, SDS- polyacrylamide gel electrophoresis, 2D gel electrophoresis Isoelectric focusing, Zymogram preparation and Agarose gel electrophoresis.	12
V	**Spectrophotometry** Principle and use of study of absorption spectra of biomolecules. Analysis of biomolecules using UV and visible range. Colorimetry and turbidometry.	10

VI	**Introduction to biostatistics** Mean, median, mode, standard deviation, standard error, probability distribution, chi-square test, t- test, f- test, analysis of Variance, LD50, ED50, PD50.	6

Course Outcomes: Upon successful completion students should be able to:

1. Learn about the principle, working and applications of commonly used instruments in microbiology.
2. Get knowledge of applications of different separation techniques such as electrophoresis, centrifugation, chromatography, etc.
3. Students will be able to handle, calibrate and use the instruments.
4. To formulate Basic understanding of Biostatistics.
5. To create and grasp the information on kinds of biological data, collection of data and statistical analysis.

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. Nigam A and Ayyagari A. 2007. Lab Manual in Biochemistry, Immunology and Biotechnology. Tata McGraw Hill.

L080304P	MAJOR COURSE IV	CREDITS: 6
	PRACTICAL WORK: EXPERIMENTS ON MOLECULAR BIOLOGY, INSTRUMENTATION AND INHERITANCE BIOLOGY	

Course Objectives

The major objective of the course is to impart hands-on training in basic instrumentation and molecular techniques. Students will be trained with various techniques carried out in industries like fermentation, food and dairy.

	Content
1	Isolation of genomic DNA from *E. coli*.
2	Estimation of DNA using colorimeter (diphenylamine reagent) and UV spectrophotometer (A_{260} measurement).
3	Estimation of RNA using colorimeter (orcinol reagent) and UV spectrophotometer
4	(A_{260} measurement).
5	Properties of water, Concept of pH and buffers, preparation of buffers and Numerical problems to explain the concepts.
6	Separation of mixtures by paper chromatography.
7	Separation of mixtures by thin layer chromatography.
8	To demonstrate column packing in any form of column chromatography.

9	Separation of protein mixtures by Polyacrylamide Gel Electrophoresis (PAGE).
10	Determination of λ_{max} for an unknown sample and calculation of extinction coefficient.
11	Separation of components of a given mixture using a laboratory scale centrifuge.
12	Understanding density gradient centrifugation with the help of pictures.
13	Mendelian deviations in dihybrid crosses.

Course Outcomes: Upon successful completion students should be able to:

1. Use various techniques like:
   - chromatography,
   - centrifugation,
   - qualitative and quantitative analysis of biochemical biomolecules.

SUGGESTED READINGS

1. Weaver, D. and Tart, R. C., "A Laboratory Manual for General Microbiology" (1998). *Biology*. 46. https://cufind.campbell.edu/biology/46
2. Campbell, JL "A Manual of Scientific and Practical" Publ. BiblioBazaar.
3. Dr. R. C. Dubey and Dr. D. K. Maheshwari 'Practical Microbiology' S. Chand Publications
4. Molecular Cloning: A Laboratory Manual, Volume 1, Joseph Sambrook, David William Russell Cold Spring Harbor Laboratory Press.
5. Molecular Cloning, Volume 2, Joseph Sambrook, Cold Spring Harbor Laboratory Press

L080305V	SKILL DEVELOPMENT COURSE MICROBIAL DIAGNOSIS IN HEALTH CLINICS AND DISEASE MANAGEMENT	CREDITS: 3 (1T+2P)

Course Objectives

This course covers the basics of management of human diseases, therapeutic and prophylaxis.

Unit	Topics	Total No. of Hours
	THEORY	
I	**Importance of diagnosis of diseases** Bacterial, Viral, Fungal and Protozoan diseases of various human body systems, clinical samples for diagnosis of infectious disease.	3
II	**Therapeutics and Prevention of Microbial diseases** Treatment using antibiotics: Mechanism of action of antibiotics belonging to different classes: beta lactam antibiotics (penicillin, cephalosporins), quinolones, polypeptides and aminoglycosides. Concept of DOTS, emergence of antibiotic resistance, current issues of MDR/XDR strains. Treatment using antiviral agents: Mechanism of action of Amantadine, Acyclovir, Azidothymidine. Concept of HAART General preventive measures, Importance of personal hygiene, environmental sanitation and methods to 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.	12
	PRACTICAL	
I	**Collection of Clinical Samples**	10

	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.	
II	**Microscopic examination and culture methods.** 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.	20
III	**Serological and Molecular methods** Serological Methods - Agglutination, ELISA, immunofluorescence, Nucleic acid based methods - PCR, Nucleic acid probes.	10
IV	**Rapid Detection of Pathogens and Testing for Antibiotic Sensitivity** Typhoid, Dengue and HIV, Swine flu. 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.	20

Course Outcomes: Upon successful completion students should be able to:

1. Get knowledge of various health aspects, so that can work in hospitals, pharmacy and health care industries.
2. Demonstrate use of research tools and analytic methods to critically analyze, monitor, and assess the health status of populations and current public health related issues.
3. Work in hospitals, pharmacy and health care industries.

SUGGESTED READINGS

1. Ananthanarayan R and Paniker CKJ (2009)Text book 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.
6. Goering R., Dockrell H., Zuckerman M. and Wakelin D. (2007) Mims' Medical Microbiology. 4th edition. Elsevier.
7. Willey JM, Sherwood LM, and Woolverton CJ. (2013) Prescott, Harley and Klein's Microbiology. 9th edition. McGraw Hill Higher Education.
8. Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014). Brock Biology of Microorganisms. 14th edition. Pearson International Edition.

SEMESTER –IV

L080401T	MAJOR COURSE I MICROBIAL GENETICS AND GENOMICS	CREDITS: 4

Course Objectives

The objective of this course is to understand how microorganisms can be used as tools to understand various biological phenomena. The student will become familiar with methods of transfer of genetic material in bacteria, and will understand the biology of lytic and lysogenic phages.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Prokaryotic Genomes** Physical organization of bacterial genomes (Structure of the bacterial nucleoid, Replication and partitioning of the bacterial genome and Genome of Archaea).	8
II	**Plasmid** Types of plasmids (F Plasmid: a Conjugate plasmid', Mobilization of Non-conjugative plasmid, R plasmid, Col plasmid Copy number and incompatibility), Episomes.	8
III	**Mutations and mutagenesis** Definition and types of Mutations; Physical and chemical mutagens; Reversion verses suppression mutation; Uses of mutations, DNA repair mechanisms.	12
IV	**Gene transfer mechanisms** Transformation, conjugation and transduction- mechanism and application. Molecular basis of recombination, Insertion Sequences & Transposons	12
V	**Bacteriophages** Stages in the Lytic Life Cycle of a typical phage T4 &T7, Lysogenic phages lambda and P1 Life cycle, replication, transcription and regulation of gene expression.	10
VI	**Bacteriophage Genetics** Benzer's fine structure of gene in bacteriophage T4: Plaque Formation and Phage Mutants, Genetic recombition in the lytic cycle, (concept of recon, muton, cistron).	10

Course Outcomes: Upon successful completion students should be able to:

1. Explain how plasmid copy number is regulated, can differentiate between Hfr strains and strains carrying F plasmid.
2. Compare and contrast generalized versus specialized transduction.
3. List the events in the lytic and lysogenic phases of lambda phage life cycle and the regulatory factors and events involved.

SUGGESTED READINGS

1. Cronan J. and Freifelder D., Microbial Genetics; Second Edition
2. Khalifa AE; Fundamentals of Microbial Genetics; Lamber Academic Pub.
3. Sundara R.S. Microbial Genetics; Amol Publications Pvt Ltd
4. Modern Microbial Genetics, Second Edition; Editor(s):Uldis N. Streips, Ronald E. Yasbin; Wiley-Liss, Inc.

L080402T	MAJOR COURSE II ENVIRONMENTAL MICROBIOLOGY	CREDITS: 4

Course Objectives

The major objective of this paper is to impart knowledge about structure, composition and functioning of microbial communities of diverse environment and their role in biogeochemical cycling and waste treatment.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Microorganisms and their Habitats** Structure and function of ecosystems. Terrestrial Environment: Soil profile and soil microflora. Aquatic Environment: Microflora of fresh water and marine habitats. Atmosphere: Aeromicroflora and dispersal of microbes. Extreme Habitats: Extremophiles: Microbes thriving at high & low temperatures, pH, high hydrostatic & osmotic pressures, salinity, & low nutrient levels. Microbial succession in decomposition of plant organic matter.	14
II	**Microbial Interactions** Microbe interactions: Mutualism, synergism, commensalism, competition, amensalism, parasitism, predation. Microbe-Plant interaction: Symbiotic and non symbiotic interactions. Microbe-animal interaction: termite gut microflora, nematophagus fungi and symbiotic luminescent bacteria.	12
III	**Biogeochemical Cycling** Carbon cycle: Microbial degradation of cellulose, hemicelluloses, lignin Nitrogen cycle: Nitrogen fixation, ammonification, nitrification, denitrification and nitrate reduction. Phosphorus cycle: Phosphate immobilization and solubilisation. Sulphur cycle: Microbes involved in sulphur cycle. Other elemental cycles: Iron and manganese.	12
IV	**Waste Management** 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 tertiary sewage treatment.	12
V	**Microbial Bioremediation** Principles and degradation of common pesticides, organic (hydrocarbons, oil spills) and inorganic (metals) matter	5
VI	**Water Potability** Treatment and safety of drinking (potable) water, methods to detect potability of water samples: (a)standard qualitative procedure: presumptive test/MPN test, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests	5

Course Outcomes: Upon successful completion students should be able to:

1. Understand the developments in the field of environmental microbiology with special emphasis on the role of microbes in mitigating environment pollution.
2. Understand about the diversity, adaptations and biotechnological applications of microbes of extreme environment.
3. Apply knowledge in designing microbe-based processes for remediation of waste, and for pulp, textile, biofuel and animal feed production industries.

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. Subba Rao NS. (1999). Soil Microbiology. 4th edition. Oxford & IBH Publishing Co. New Delhi.
4. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.
5. Okafor, N (2011). Environmental Microbiology of Aquatic & Waste systems. 1st edition, Springer

L080403T	MAJOR COURSE III MICROBIAL TECHNOLOGY	CREDITS: 4

Course Objectives

The course aims to impart understanding of various microbial applications for the small scale and industrial production of various products. The knowledge of recombinant technology, bioreactors, optimization strategies and IPR, patents, trademarks, copyrights will help to develop and get maximum beneficial from production processes.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Fermentation technology** Microbial growth kinetics in batch, continuous & fed-batch fermentation process. Solid state & submerged fermentation: their advantages & disadvantages. Immobilization of microbial enzymes, whole cells and their industrial applications. Biosensors and biochips.	10
II	**Renewable bioenergy using microorganisms** Methane production by anaerobic digestion of waste organic materials, Bioethanol and biohydrogen production by using microorganisms,	8
III	**Microbial Treatment of Waste and Metal Extraction** Industrial waste water treatment, Bioleaching, Biohydrometallurgy	5
IV	**Microbial Engineering** Use of microbes and microbial enzymes in the improvement of nutritive quality of feed; Engineering traits in plants related to stress resistance and nutritional quality improvement; Bt gene technology; frost protection by microbes. Nanoparticle synthesis using micro-organisms.	15
V	**Pharmaceutical Microbiology** Mode of action of antibiotics, antifungal and antiviral drugs; antitumor substances. GMP & GLP in pharmaceuticals; Sterilization of pharmaceutical products. Quality assurance and quality management in pharmaceuticals ISO, WHO and US certification. Safety in microbiology laboratory.	12
VI	**Bioethics and intellectual Property** Intellectual Property Rights (IPR), Patents, Trademarks, Copyrights, Secrets; Patenting of microbiological materials and GMOs; patenting of genes and DNA sequences; Quality control through WHO, Ethics & Safety of GMO.	10

Course Outcomes: Upon successful completion students should be able to:

1. Learns about the design, types of fermenters and various critical components of bioreactors

2. Will have gained insight on industrially important microbes, recent developments in fermentation processes and various optimization strategies at fermenter level.
3. Understands the concept of sterilization methods and principles of batch and continuous processes.
4. Understands different types of regulatory approvals required for drug development and difference between biologics, biosimilars and biobetters.
5. Understands the relevance of IPR, patent, copyright and trademarks. Quality control analysis through WHO.

SUGGESTED READINGS

1. Stanbury PF, Whitekar A. and Hall (2006). Principles of Fermentation Technology. Pergaman. McNeul and Harvey.
2. Bhosh, Fiecht er and Blakebrough (2005). Advances in Biochemical Engineering. Springer Verlag Publications.
3. Waste Water Engineering - Treatment, Disposal and Re-use by Metcalf and Eddy, Inc.,TataMacGraw Hill, New Delhi.
4. Pharmaceutical Microbiology – Edt. by W.B.Hugo& A. D. Russell Sixth edition. Blackwell scientific Publications.
5. Bernd Rehm (2006). Microbial Bionanotechnology: Biological Self-assembly Systems and Biopolymer-based Nanostructures. Horizon Scientific Press.
6. TA Brown. Gene cloning and DNA analysis. Blackwell Publ.

L080404P	MAJOR COURSE IV	CREDITS: 6
	PRACTICAL WORK: EXPERIMENTS IN MICROBIAL GENETICS, ENVIRONMENTAL MICROBIOLOGY AND MICROBIAL TECHNOLOGY	

Course Objectives

To provide experimental learning of various mechanisms of gene transfer in bacteria and bacteriophages, and to comprehend the role of microorganisms in environment/ ecosystem. Develop the ability to utilize microorganisms for microbial development processes.

	Content
1	Preparation of Master and Replica Plates.
2	Study the effect of chemical (HNO_2) and physical (UV) mutagens on bacterial cells
3	Study survival curve of bacteria after exposure to ultraviolet (UV) light.
4	Isolation of Plasmid DNA from *E.coli.*
5	Study different conformations of plasmid DNA through Agaraose gel electrophoresis.
6	Demonstration of Bacterial Conjugation.
7	Demonstration of Ames test.
8	Analysis of soil – pH, moisture content, water holding capacity, percolation, capillary action.
9	Isolation of microbes (bacteria & fungi) from soil (28°C & 45°C).
10	Isolation of microbes (bacteria & fungi) from rhizosphere and rhizoplane.
11	Assessment of microbiological quality of water.
12	Determination of BOD of waste water sample.
13	Study the presence of microbial activity by detecting (qualitatively) enzymes (dehydrogenase, amylase, urease) in soil.
14	Isolation of *Rhizobium* from root nodules.

15	Demonstration of Winogardsky coloumn
16	Evaluation of metal chelating bacteria
17	Quality check of given microbial product

Course Outcomes: Upon successful completion students should be able to:

1. Gain knowledge of prokaryotic gene transfer mechanisms.
2. Use the properties of microorganisms, principally bacteria, as bioindicators of contamination and to remedy problems of contamination and other environmental impacts.

SUGGESTED READINGS

1. Weaver, D. and Tart, R. C., "A Laboratory Manual for General Microbiology" (1998). *Biology*. 46. https://cufind.campbell.edu/biology/46
2. Campbell, JL "A Manual of Scientific and Practical" Publ. BiblioBazaar.
3. Dr. R. C. Dubey and Dr. D. K. Maheshwari 'Practical Microbiology' S. Chand Publications
4. Molecular Cloning: A Laboratory Manual, Volume 1, Joseph Sambrook, David William Russell Cold Spring Harbor Laboratory Press.
5. Molecular Cloning, Volume 2, Joseph Sambrook, Cold Spring Harbor Laboratory Press

L080405V	SKILL DEVELOPMENT COURSE ENTREPRENEURSHIP DEVELOPMENT II	CREDITS: 3 (1T+2P)

Course Objectives

1. Explore and experience the joy of creating unique solutions to market opportunities.
2. Create and exploit innovative business ideas for probable new ventures/start-ups.
3. Test ideas in the light of macro level business indicators, government schemes and programmes.

Unit	Topics	Total No. of Hours
	THEORY	
I	**Business Ideas** Business idea- sources of business ideas- methods of generating business ideas- Pattern Recognition-Experience factor- Business Ideas and Creative thinking- Approaches to unleash creativity: Idea to Opportunity, Idea Canvas.	6
II	**Screening of Opportunities** Screening criteria- Gathering information- Sources- Published- Market Studies- Projections and forecasts: Scanning external environment and industry analysis, Understanding competitive landscape- Business Model Canvas.	6
III	**Business Plan** Essential elements of good business Plans: Executive Summary, Company Overview, Product and Service, Market and Industry	3
	PRACTICAL	
	Business Idea to Start-up Opportunities Sources, challenges and factors influencing opportunity identification-Skill Assessment and Development	15
IV	**Report on Business Plan** Marketing Plan, Revenue Model Operations Plan, Development Plan, Strategy Management, Competitive Advantage, Financial Projections.	15
V	**Business models and Entrepreneurship**	15

	Business Models and value proposition, Business Model Failure: Reasons and Remedies, Incubators: Business Vs Technology, Managing Investor for Innovation, Future markets and Innovation needs for India.	
VI	**Survey/ Report on Government Initiates** 1. Incubators, research parks 2. Various Government policies 3. Integrative approach – Entrepreneurship & IP strategy 4. Capsule revision	15

Course Outcomes: Upon successful completion students should be able to:

1. Build a mindset focusing on developing novel and unique approaches to market opportunities
2. Demonstrate and present successful work, collaboration and division of tasks in a multidisciplinary and multicultural team
3. Demonstrate understanding and application of the tools necessary to create sustainable and viable businesses.

SUGGESED READINGS

1. Stephen Spinnelli Jr and Robert J. Adams Jr New Venture Creation- Entrepreneurship in 21st Century,, Mc Graw Hill International 2016
2. Kathleen R. Allen New Venture Creation , Cengage India, 2012
3. Alexander Osterwalder and Yves Pigneour Business Model Generation, Wiley India P Ltd, New Delhi

SEMESTER –V

L080501T	MAJOR COURSE I RECOMBINANT DNA TECHNOLOGY	CREDITS: 4

Course Objectives

The objective of this course is to make the student familiar with the currently used techniques to manipulate/ analyze DNA, RNA and proteins. The student will be made familiar with how recombinant DNA technology has been exploited in the study of biology as well as in the production of pharmaceutical products.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Biotechnology: an overview** Introduction, History and scope of biotechnology, Milestones in genetic engineering and biotechnology.	2
II	**Molecular Cloning- Tools and Strategies** Cloning Tools; Restriction modification systems: Types I, II and III. Mode of action, nomenclature, applications of Type II restriction enzymes in genetic engineering. DNA modifying enzymes and their applications: DNA polymerases. Terminal deoxynucleotidyltransferase, kinases and phosphatases, and DNA ligases. Cloning Vectors: Definition and Properties. Plasmid vectors: pBR and pUC series. Bacteriophage lambda and M13 based vectors. Cosmids, BACs, YACs. Use of linkers and adaptors. Expression vectors: *E.coli* lac and T7 promoter-based vectors, yeast YIp, YEp and YCp vectors, Baculovirus based vectors, mammalian SV40-based vectors.	20
III	**Methods in Molecular Cloning** Transformation of DNA: Chemical method, Electroporation. Gene delivery: Microinjection, electroporation, biolistic method (gene gun), liposome and viral-mediated delivery, *Agrobacterium* - mediated delivery. DNA, RNA and Protein analysis: Agarose gel electrophoresis, Southern - and Northern - blotting techniques, dot blot, DNA microarray analysis, SDS-PAGE, Gel Shift Assay and Western blotting.	16
IV	**DNA Amplification and DNA sequencing** PCR: Basics of PCR, RT-PCR, Real-Time PCR. Sanger's method of DNA Sequencing: traditional and automated sequencing. Introduction to new generation sequencing. Primer walking and shotgun sequencing.	10
V	**Construction and Screening of Genomic and cDNA libraries** Genomic and cDNA libraries: Preparation and uses, Screening of libraries: Colony hybridization and colony PCR, Chromosome walking and chromosome jumping.	6
VI	**Applications of Recombinant DNA Technology** Products of human therapeutic interest - insulin, hGH, antisense molecules. Bt transgenic - cotton, brinjal, Gene therapy, recombinant vaccines, protein engineering and site directed mutagensis.	6

Course Outcomes: Upon successful completion students should be able to:

1. Handle microorganisms for isolation and amplification of DNA and transform host cells.
2. Will be able to describe the various applications of PCR, and know how to make and screen genomic and cDNA libraries.
3. Will be able to understand the methods by which DNA is sequenced and will gain insights into how entire genomes of organisms are sequenced.
4. Will be aware of the different bacterial and eukaryotic systems available for overexpression of proteins.

SUGGESTED READINGS

1. Brown TA. (2010). Gene Cloning and DNA Analysis. 6th edition. Blackwell Publishing, Oxford, U.K.
2. Clark DP and Pazdernik 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. Primrose SB and Twyman RM. (2008). Genomics: Applications in human biology. Blackwell Publishing, Oxford, U.K.

L080502T	MAJOR COURSE II APPLIED MICROBIOLOGY	CREDITS: 4

Course Objectives

The goal of the course is to provide fundament knowledge of the applications of microorganisms and their components to various microbiology allied sectors.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Agriculture Microbiology** Role of microorganisms in soil fertility. Interactions between microbes and plants - rhizosphere, phyllosphere, mycorrhizae. Biofertilizer for sustainable agriculture *Rhizobium*, *Azospirillium*, *Azotobacter*, *Azolla*, Applications methods of biofertilizers - significance of biofertilizers. Microorganisms used as biocontrol agents against microbial plant pathogens (*Trichoderma* sp. and *Pseudomonas fluorescens*), Bacterial, fungal and viral bio-insecticides and bio-herbicides	10
II	**Food Microbiology** Factors influencing microbial growth in foods - extrinsic and intrinsic. Principles of food preservation - preservation methods - irradations - drying, heat processing, chilling and freezing, and chemical preservatives. Microbial production of Dairy Cheese, Yogurt, Butter, Buttermilk. prebiotics, probiotics-health benefits and types of microorganisms used. Cultural and rapid detection of food borne pathogens	10
III	**Industrial Microbiology** Introduction to fermentation. Industrially important organisms – Isolation, preservation and strain improvement. Types of fermentation processes - Solid-state and liquid-state (stationary and submerged) fermentations	12

	Components of a typical bio-reactor, types of bioreactors, downstream processing. Microbial productions: Wine and ethyl alcohol, citric acid, glutamic acid, penicillin Recombinant products: vaccine	
IV	**Medical and Pharmaceutical Microbiology** History and Importance of Medical Microbiology, Significance of Microbiome: Normal microflora, True pathogen, Opportunistic Pathogens. Bacterial, Viral, Fungal and Protozoan Diseases Antimicrobial Chemotherapy: General Characteristics and model of action of different classes of Antibiotics, Antiviral, Antifungal and Anti protozoal Agents.	10
V	**Microbiology of waste management** Solid and liquid waste treatment methods, Determination of water quality: BOD, COD, bacteriological examination of water (Presumptive, confirmed, completed test, SPC, MPN, Membrane filter technique). Waste treatment: Types of wastes, Effluent treatment - Primary, secondary (aerobic and anaerobic) and tertiary Methods, Disinfection, Biogas production. Solid waste management - Composting, vermicomposting, and Mushroom cultivation.	10
VI	**Microbial Applications and ethical issues** Bioremediation strategies (environment modification, microbial application), Enhanced metal recovery; Transgenic plants (BT crops, golden rice), transgenic animals, advantages, social and environmental aspects. Advances and trends, ethical issues, quality control, legislation, FDA & FPO, (India), safety and security at workplace	8

Course Outcomes: Upon successful completion students should be able to:

1. Get opportunities in various fields like healthcare organizations, forensic science laboratories, environmental organizations, food and drink, pharmaceuticals and many other industries.
2. Students will be able to define and analyse the role microorganisms in dairy, food, and environment.
3. Students will be able to apply the knowledge for start-ups in the field of microbiology.

SUGGESTED READINGS

1. Ananthanarayan R. and Paniker C.K.J. (2009) Textbook of Microbiology. 8th edition, University Press Publication.
2. Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing, USA
3. Bare Act, 2007.Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., New Delhi
4. Coyne MS. (2001). Soil Microbiology: An Exploratory Approach. Delmar Thomson Learning.
5. Crueger W, Crueger A (1990) Biotechnology: A text Book of Industrial Microbiology 2nd edition Sinauer associates, Inc.
6. Demain, A. L and Davies, J. E. (1999). Manual of Industrial Microbiology and Biotechnology, 2nd Edition, ASM Press.
7. Goel D & Prashar S (2013).IPR, Biosafety and Bioethics. Pearson.
8. Goering R., Dockrell H., Zuckerman M. and Wakelin D. (2007) Mims' Medical Microbiology. 4th edition. Elsevier.
9. Lynch JM & Hobbie JE. (1988). Microorganisms in Action: Concepts & Application in Microbial Ecology. Blackwell Scientific Publication, U.K.

10. Stanbury PF, Whitaker A, Hall SJ (1995) Principles of Fermentation Technology 2nd edition., Elsevier Science.

L080503T	MAJOR COURSE III AGRICULTURE MICROBIOLOGY	CREDITS: 4

Course Objectives

The course aims to provide fundamental knowledge about of microorganisms, with emphasis to their role in nature and their use in agricultural biotechnology, in relation to soil fertility, organic matter degradation, and microbial interactions with plants and other biotic and abiotic components of soil ecosystem.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Concepts and scope of agricultural microbiology** Importance of microorganisms in agriculture, influence of microorganisms in plant growth, modern concepts of microbial inoculants in agriculture. Concepts of plant microbiome, Rhizosphere and phylloplane. Mass culturing and quality control of microbial inoculants-mother culture, shake culture and brief account of large scale production of biofertilizers, types of carrier materials, packing, storage, bench life and transportation of biofertilizers. Traditional organic farming: Bulky organic manures (farmyard manure, urban compost), Night-soil. Concentrated organic manures – Oil Cakes, Fishmeal. Green manure – *Sesbania* sps., *Crotalaria juncea*. Green leaf manure. ISI standards and quality testing at different levels. Methods of biofertilizer application- seed inoculation, soil amendment and nursery application.	14
II	**Nitrogen fixation** Symbiotic and non-symbiotic nitrogen fixation, mechanisms of nitrogen fixation and importance. Brief account of production and application of Rhizobium inoculant; strain selection and mass culturing. Brief account of production and utility of Azotobacter, Azospirillum, cyanobacteria, Azolla. Salient features and significance of strains and application of these organisms. Phosphate-solubilizing microorganisms-importance, culturing and applications of these microorganisms in agriculture. Mycorrhizae: types, Mass production and application of mycorrhizae.	8
III	**Phytopathology** Introduction and historical milestones, significance of plant diseases, types of plant diseases, basic procedure of plant disease diagnosis, parasitism, pathogenicity and plant disease development, disease cycle, infection cycle and plant disease triangle. Levels of plant- pathogen interaction: Prepenetration, host recognition, role of host exudates, entry by plant pathogens through natural openings and wounds, direct penetration, process of pathogenesis, infection and establishment of pathogens in the host tissues.	8
IV	**Brief account of some important plant diseases** (with one example for each group with description of pathogen, symptoms and management) - rots, damping-offs, downy mildews, powdery mildews, smuts, rusts, wilts, anthracnose, galls, ergots, bacterial diseases, viral diseases, phytoplasmal diseases, protozoal diseases, viroid diseases, non-parasitic	10

	diseases and post-harvest diseases.	
V	**Plant Disease Management I** Cultural methods-exclusion, eradication, crop rotation and sanitation. Inspection and certification, quarantine regulations. Physical methods-soil solarization, hot water treatment, mulching and other methods. Chemical control of plant diseases-preparation and use of different chemicals, types of chemicals used in plant disease management; application of chemicals to soil, seeds, plant and store house problems and remedies for fungicidal resistance.	10
VI	**Plant Disease Management II** Biological control of plant disease selection, testing and use of antagonistic microorganisms and their metabolites, application methodology and significance. Nano-pesticides, nano-fertilizers Transgenic plants for plant disease management. Integrated disease management practices.	10

Course Outcomes: Upon successful completion students should be able to:

1. The role of microbial physiological groups associated with agricultural ecosystem.
2. Gain detailed idea on various micro-organisms, its harmful or beneficial effects on agriculture.
3. Understand how to use them in a safer way for creating a better agriculture system like using as biofertilizer, biopesticide, plant disease management etc.

SUGGESTED READINGS

1. Agrios, G. 2005. Plant Pathology, 5th edition, Reed Elsevier India Private Limited, New Delhi, India.
2. Ayres, P.G. 1992. Pests and Pathogens (Plant Responses to foliar Attack), Bioscientific Publishers.
3. Carlile, M.G., Watkinson, S.C and Gooday, G.W. 1994. The Fungi, Academic Press, UK.
4. Gow, N.A.R and Gadd, G.M. 1996. The growing fungus, Chapman and Hall Publishers, London.
5. Mehrotra, R.S.1980. Plant Pathology, Tata McGraw-Hill publishing Company Limited, New Delhi.
6. Purohit, S.S. 2003. Agricultural Biotechnology, 2nd edition, Agrobios Publisher, Jodhpur, India.
7. Rangaswami, G and Bagyarai, D.J.2005. Agricultural Microbiology, 2nd edition, Prentice-Hall of India Private Limited, New Delhi.
8. Agarwal, V.K and Sinclair, J.B. 1987. Principles of Seed Pathology, CBS Publishers, Delhi.
9. Srivastava, H.N. 2001. Plant Pathology, Pradeep Publications, Jalandhar.
10. Rao, N.S.S. 1993. Biofertilizers In Agriculture and Forestry, 3rd edition, Oxford & IBH Publishing Pvt. Ltd, New Delhi.
11. Dhingra, O.D and Sinclair, J.B. 1985. Basic Plant Pathology Methods, CBS Publishers, Delhi.
12. Nene, Y.L and Thapliyal, P.N. 1971. Fungicides In Plant Disease Control, 2nd edition, Oxford & IBH Publishing Co., New Delhi.

L080504T	MAJOR COURSE IV COMPUTERS AND BIOINFORMATICS	CREDITS: 4

Course Objectives

The major objective of the course is to provide knowledge about the computerization of biological information – data analysis and retrieval systems.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Introduction to Computer Fundamentals** Computers in biology- computer basics, operating systems, Windows and linux, hardware, software, disc operating system, multimedia network concept RDBMS - Definition of relational database. Mode of data transfer (FTP, SFTP, SCP), advantage of encrypted data transfer.	8
II	**Introduction to Artificial Intelligence, Machine Learning and Bioinformatics** Introduction to AI and ML, Computational biology , Application of AI/ ML in microbiology Bioinformatics-Definition, History, Scope and Applications. Opportunities in Bioinformatics. Emerging areas of Bioinformatics	3
III	**Biological Databases** Biological databases - nucleic acid, genome, protein sequence and structure, gene expression databases, Database of metabolic pathways, Mode of data storage - File formats - FASTA, Genbank and Uniprot, Data submission & retrieval from NCBI, EMBL, DDBJ, Uniprot, PDB	12
IV	**Sequence Alignments, Phylogeny and Phylogenetic trees** Local and Global Sequence alignment, pairwise and multiple sequence alignment. Scoring an alignment, scoring matrices, PAM & BLOSUM series of matrices. Types of phylogenetic trees, Different approaches of phylogenetic tree construction-UPGMA, Neighbour joining, Maximum Parsimony, Maximum likelihood.	15
V	**Genome organization and analysis** Diversity of Genomes: Viral, prokaryotic & eukaryotic genomes. Genome, transcriptome, proteome, 2-D gel electrophoresis, MALDI-TOF spectrometery. Major features of completed genomes: *E.coli, S.cerevisiae, Arabidopsis,* Human.	10
VI	**Protein Structure Predictions** Hierarchy of protein structure - primary, secondary and tertiary structures, modeling Structural Classes, Motifs, Folds and Domains. Protein structure prediction in presence and absence of structure template. Energy minimizations and evaluation by Ramachandran plot. Protein structure and rational drug design.	12

Course Outcomes: Upon successful completion students should be able to:

1. Understand fundamentals of computers.
2. Analyze and introduces the basic and fundamental concepts of Bioinformatics.
3. Obtain in-depth information on biological databases and assimilate knowledge on genome and structure database.

SUGGESTED READINGS

1. Saxena Sanjay (2003) A First Course in Computers, Vikas Publishing House.

2. Pradeep and Sinha Preeti (2007) Foundations of Computing, 4th ed., BPB Publications.
3. Lesk M.A.(2008) Introduction to Bioinformatics. Oxford Publication, 3rd International Student Edition.
4. Rastogi S.C., Mendiratta N. and Rastogi P. (2007) Bioinformatics: methods and applications, genomics, proteomics and drug discovery, 2nd ed. Prentice Hall India Publication.
5. Primrose and Twyman (2003) Principles of Genome Analysis & Genomics. Blackwell.
6. Ghosh, Z. and Mallick, V. (2008) Bioinformatics- Principles and Applications. Oxford University Press.

L080505P	MAJOR COURSE V	CREDITS: 6
	PRACTICAL WORK: EXPERIMENTS IN RDT, BIOINFORMATICS, AGRICULTURE AND APPLIED MICROBIOLOGY	

Course Objectives

The candidate will study the basic principle behind recombinant DNA technique, bioinformatics, and acquire adequate skill required to separate and observe chromosomal DNA in rDNA Technology and will gain hands-on knowledge and acquire adequate skill required to screening and utilization of industrially important microorganisms, and selection and control of plant pathogens.

	Content
1	Preparation of competent cells for transformation.
2	Demonstration of Bacterial Transformation and calculation of transformation efficiency.
3	Digestion of DNA using restriction enzymes and analysis by agarose gel electrophoresis.
4	Ligation of DNA fragments.
5	Cloning of DNA insert and Blue white screening of recombinants.
6	Interpretation of sequencing gel electropherograms.
7	Designing of primers for DNA amplification.
8	Demonstration of Amplification of DNA by PCR.
9	Detection of given gene sequence homology using NCBI GenBank
10	Demonstration of alcohol fermentaion
11	Isolation of beneficial microbes from the soil: *Rhizobium* sp., *Azotobacter* sp. etc
12	Authentication of rhizobia by biochemical and by plant infection test (tubes and Leonard jar experiment).
13	Study the growth response of crops due to biofertilizer application
14	Compost making
15	Acetylene reduction assay to evaluate nitrogenase activity.

Course Outcomes: Upon successful completion students should be able to:

1. Develop method for isolating genomic DNA and plasmid DNA.
2. Appraise restriction analysis of DNA.
3. Analyze the outcome of transformation.
4. To create the importance of microbial strains and fermentation media.
5. To construct the methods of industrial fermenter.
6. Deal with plant-associated microbes and to combat diseases that attack important food crops.

SUGGESTED READINGS

1. Weaver, D. and Tart, R. C., "A Laboratory Manual for General Microbiology" (1998). *Biology*. 46. https://cufind.campbell.edu/biology/46
2. Campbell, JL "A Manual of Scientific and Practical" Publ. BiblioBazaar.
3. Dr. R. C. Dubey and Dr. D. K. Maheshwari 'Practical Microbiology' S. Chand Publications
4. Molecular Cloning: A Laboratory Manual, Volume 1, Joseph Sambrook, David William Russell Cold Spring Harbor Laboratory Press.
5. Molecular Cloning, Volume 2, Joseph Sambrook, Cold Spring Harbor Laboratory Press

L080506R	INDUSTRIAL TRAINING/ REVIEW/ SURVEY/ RESEARCH PROJECT	CREDITS: 4
	RESEARCH ASSIGNMENT I	

Course Objectives

A term (or research) paper is primarily a record of intelligent reading in several sources on a particular subject. The students will get informed about the topic at the beginning of the session in consultation with the faculties assigned for the major courses. The progress of the assignment will be developed under regular monitoring of the faculty. At the end of the semester the detailed paper/ proposal on the topic will be submitted to the faculty assigned.

Note:

1. The IPR rights of all such work lie with the University only.

Course Outcomes: Upon successful completion students should be able to:

1. Collect information of given subject and compile it in sequential order.
2. Review notes to find main sub-divisions of the subject.

SEMESTER –VI

L080601T	MAJOR COURSE I MEDICAL MICROBIOLOGY ND IMMUNOLOGY	CREDITS: 4

Course Objectives

The objective of the course is to introduce to the micro-organisms that cause human disease and the host's immune response associated with micro-organism infection.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Normal microflora of the human body and host pathogen interaction** 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. Transmission of infection.	8
II	**Common diseases, sample collection and diagnosis** Common bacterial, viral, fungal and protozoan diseases of various organ systems and their causative agents. Collection, transport and culturing of clinical samples and their identification characteristics.	15
III	**Antimicrobial agents: General characteristics and mode of action** Antibacterial agents: 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	7
IV	**Immune cells and organs** Structure, Functions and Properties of: Immune Cells – Stem cell, T cell, B cell, NK cell, Macrophage, Neutrophil, Eosinophil, Basophil, Mast cell, Dendritic cell; and Immune Organs – Bone Marrow, Thymus, Lymph Node, Spleen.	7
V	**Antigens and generation of immune response** Characteristics of an antigen (Foreignness, Molecular size and Heterogeneity); Haptens Primary and Secondary Immune Response; Generation of Humoral Immune Response (Plasma and Memory cells), Epitopes (T & B cell epitopes), Adjuvants, Structure, Types and Functions of antibodies; Generation of Cell Mediated Immune Response.	13
VI	**Immunological Disorders and Immunological Techniques** Types of Autoimmunity and Hypersensitivity with examples; Immunodeficiencies - Animal models (Nude and SCID mice). Principles of Precipitation, Agglutination, Immunodiffusion, Immunoelectrophoresis, ELISA, ELISPOT.	10

Course Outcomes: Upon successful completion students should be able to:

1. Discuss the growth and transmission of microorganisms associated with human health.
2. Assess the role of infection control in microbial disease prevention
3. Evaluate fundamental knowledge of microbial genetics
4. Contextualise the host defence mechanisms associated with microbial infections

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. 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

L080602T	MAJOR COURSE II FOOD AND DIARY MICROBIOLOGY	CREDITS: 4

Course Objectives

The objective of the course is to provide understanding of the key concepts in food and dairy microbiology and to various methods of microbial analysis of food and dairy products.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Foods as a substrate for microorganisms** Intrinsic and extrinsic factors that affect growth and survival of microbes in foods,natural flora and source of contamination of foods in general.	8
II	**Microbial spoilage of various foods** Principles, Spoilage of vegetables, fruits, meat, eggs, milk and butter, bread, canned foods.	10
III	**Principles and methods of food preservation** Principles, physical methods of food preservation: temperature (low, high, canning, drying), irradiation, hydrostatic pressure, high voltage pulse, microwave processingand aseptic packaging, chemical methods of food preservation: salt, sugar, organicacids, SO_2, nitrite and nitrates, ethylene oxide, antibiotics and bacteriocins.	12
IV	**Fermented foods** Dairy starter cultures, fermented dairy products: yogurt, acidophilus milk, kumiss,kefir, dahi and cheese, other fermented foods: dosa, sauerkraut, soy sauce andtampeh, Probiotics: Health benefits, types of microorganisms used, probiotic foods available in market.	10
V	**Food borne diseases (causative agents, foods involved, symptoms andpreventive measures) and detection of pathogens** Food intoxications: *Staphylococcus aureus*, *Clostridium botulinum* and mycotoxins; Food infections: *Bacillus cereus*, *Vibrio parahaemolyticus*, *Escherichia coli*, Salmonellosis, Shigellosis, *Yersinia enterocolitica*, *Listeria monocytogenes* and *Campylobacter jejuni*.	15

	Cultural and rapid detection methods of food borne pathogens in foods and introduction to predictive microbiology.	
VI	**Food sanitation and control** HACCP, Indices of food sanitary quality and sanitizers.	5

Course Outcomes: Upon successful completion students should be able to:

1. Understand the significance and activities of microorganisms in food and role of intrinsic and extrinsic factors on growth and survival of microorganisms in food and dairy.
2. Know the spoilage mechanisms in foods and dairy and thus identify methods to control deterioration and spoilage.
3. Recognize and describe the characteristics of important pathogens and spoilage microorganisms in foods and dairy.
4. Learn various methods for their isolation, detection and identification of microorganisms in food and dairy and employ in industries.
5. To identify ways to control microorganisms in food and dairy and thus know the principles involving various methods of food preservation.

SUGGESTED READINGS

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

L080603T	MAJOR COURSE III INDUSTRIAL MICROBIOLOGY	CREDITS: 4

Course Objectives

The course will enable students to apply the learning of microbiology concepts toward the exploitation of microbial population for industrial and human benefits. The strategies for development of microbial strains, process optimization, large scale production and product recovery will be covered for industrially relevant microbial products and therapeutic proteins.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Introduction to industrial microbiology and fermentation processes** Brief history and developments in industrial microbiology. Types of fermentation processes - Solid-state and liquid-state (stationary and submerged) fermentations; batch, fed-batch (eg. baker's yeast) and continuous fermentations.	10

	Scale up and scale down of the fermentation process.	
II	**Types of bio-reactors and measurement of fermentation parameters** Components of a typical bio-reactor, Types of bioreactors-Laboratory, pilot- scale and production fermenters, constantly stirred tank and air-lift fermenters, Measurement and control of fermentation parameters - pH, temperature, dissolved oxygen, foaming and aeration.	12
III	**Isolation of industrially important microbial strains and fermentation media** Sources of industrially important microbes and methods for their isolation, preservation and maintenance of industrial strains, strain improvement, Crude and synthetic media; molasses, corn-steep liquor, sulphite waste liquor, whey, yeast extract and protein hydrolysates.	8
IV	**Down-stream processing** Cell disruption, filtration, centrifugation, solvent extraction, precipitation, lyophilization and spray drying.	6
V	**Microbial production of industrial products** Citric acid, ethanol, glutamic acid, Vitamin B12. Enzymes (amylase, protease, lipase). Wine, beer. Antibiotics – Penicillin, Streptomycin.	18
VI	**Microbial production of pharmaceutical compounds** Production process of antibiotics (penicillin, streptomycin); industrial production of interferon, microbial production of insulin, vaccine production and formulation, Biotransformation of steroids.	6

Course Outcomes: Upon successful completion students should be able to:

1. Will have gained insight on industrially important microbes, recent developments in fermentation processes and various optimization strategies at fermenter level.
2. To formulate the methods of immobilization, advantages and applications of Immobilization, large scale applications of immobilized enzymes.
3. Microbial production of industrial products (micro-organisms involved, media, fermentation conditions, downstream processing and uses).

SUGGESTED READINGS

1. Patel A.H. (1996). Industrial Microbiology. 1st edition, Macmillan India Limited.
2. Okafor N. (2007). Modern Industrial Microbiology and Biotechnology. 1st edition. Bios Scientific Publishers Limited. USA.
3. Waites M.J., Morgan N.L., Rockey J.S. and Higton G. (2001). Industrial Microbiology: An Introduction. 1st edition, Wiley – Blackwell.
4. Glaze A.N. and Nikaido H. (1995). Microbial Biotechnology: Fundamentals of Applied Microbiology. 1st edition. W.H. Freeman and Company.
5. Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley Eastern Limited.
6. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd edition. Panima Publishing Co. New Delhi.
7. Stanbury PF, Whitaker A and Hall SJ. (2006). Principles of Fermentation Technology. 2nd edition, Elsevier Science Ltd.

L080604T	MAJOR COURSE IV MICROBIAL BIOTECHNOLOGY	CREDITS: 4

Course Objectives

This course develops concepts in technologies used in agriculture, mining, energy production and human health with respect to microorganisms and genetically engineered microorganisms.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Microbial Biotechnology and its Applications** Microbial biotechnology: Scope and its applications in human therapeutics, agriculture (Biofertilizers, PGPR, Mycorrhizae), environmental, and food technology. Use of prokaryotic and eukaryotic microorganisms in biotechnological applications. Genetically engineered microbes for industrial application: Bacteria and yeast.	12
II	**Therapeutic and Industrial Biotechnology** Recombinant microbial production processes in pharmaceutical industries - Streptokinase, recombinant vaccines (Hepatitis B vaccine). Microbial polysaccharides and polyesters, Microbial production of bio-pesticides, bioplastics Microbial biosensors.	10
III	**Applications of Microbes in Biotransformations** Microbial based transformation of steroids and sterols. Bio-catalytic processes and their industrial applications: Production of high fructose syrup and production of cocoa butter substitute.	10
IV	**Microbial Products and their Recovery** Microbial product purification: filtration, ion exchange & affinity chromatography techniques Immobilization methods and their application: Whole cell immobilization.	10
V	**Microbes for Bio-energy and Environment** Bio-ethanol and bio-diesel production: commercial production from lignocellulosic waste and algal biomass, Biogas production: Methane and hydrogen production using microbial culture. Microorganisms in bioremediation: Degradation of xenobiotics, mineral recovery, removal of heavy metals from aqueous effluents.	12
VI	**RNAi** RNAi and its applications in silencing genes, drug resistance, therapeutics and host pathogen interactions.	6

Course Outcomes: Upon successful completion students should be able to:

1. Apply the knowledge of various techniques in developing technology for sustainable development.
2. Explain commercialisation of a technology.

SUGGESTED READINGS

1. Ratledge, C and Kristiansen, B. (2001). Basic Biotechnology, 2nd Edition, Cambridge University Press.

2. Demain, A. L and Davies, J. E. (1999). Manual of Industrial Microbiology and Biotechnology, 2nd Edition, ASM Press.
3. Swartz, J. R. (2001). Advances in Escherichia coli production of therapeutic proteins. Current Opinion in Biotechnology, 12, 195–201.
4. Prescott, Harley and Klein's Microbiology by Willey JM, Sherwood LM, Woolverton CJ (2014), 9th edition, Mc Graw Hill Publishers.
5. Gupta PK (2009) Elements of Biotechnology 2nd edition, Rastogi Publications.
6. Glazer AN and Nikaido H (2007) Microbial Biotechnology, 2nd edition, Cambridge University Press.
7. Glick BR, Pasternak JJ, and Patten CL (2010) Molecular Biotechnology 4th edition, ASM Press,
8. Stanbury PF, Whitaker A, Hall SJ (1995) Principles of Fermentation Technology 2nd edition., Elsevier Science.
9. Crueger W, Crueger A (1990) Biotechnology: A text Book of Industrial Microbiology 2nd edition Sinauer associates, Inc.

L080605P	MAJOR COURSE V	CREDITS: 6
	PRACTICAL WORK : EXPERIMENTS IN MEDICAL MICROBIOLOGY, IMMUNOLOGY, FOOD MICROBIOLOGY, INDUSTRIAL MICROBIOLOGY AND MICROBIAL BIOTECHNOLOGY	

Course Objectives

The course is designed to educate our graduates in key medical microbiology laboratory disciplines, and develop skills of testing of food, and various microbiological techniques.

	Content
1	Identify pathogenic 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 pathogenic 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.
10	MBRT of milk samples and their standard plate count.
11	Alkaline phosphatase test to check the efficiency of pasteurization of milk.
12	Isolation and detection of food borne bacteria (*Staphylococcus* or *Salmonella*) from different food samples.
13	Isolation of spoilage microorganisms from spoiled vegetables/fruits.
14	Isolation of spoilage microorganisms from bread.
15	Preparation of Yogurt/Dahi.
16	Optimization of microbial processes

Course Outcomes: Upon successful completion students should be able to:

1. Effectively communicate laboratory findings, methodologies and strategies to both specialist and non-specialist audiences.
2. Demonstrate and employ practical skills with both classical and modern laboratory techniques in

clinical chemistry, microbiology, immunology, environment cleaning and food industry, including trouble-shooting and problem solving.

SUGGESTED READINGS

1. Weaver, D. and Tart, R. C., "A Laboratory Manual for General Microbiology" (1998). *Biology*. 46. https://cufind.campbell.edu/biology/46
2. Campbell, JL "A Manual of Scientific and Practical" Publ. BiblioBazaar.
3. Dr. R. C. Dubey and Dr. D. K. Maheshwari 'Practical Microbiology' S. Chand Publications
4. Molecular Cloning: A Laboratory Manual, Volume 1, Joseph Sambrook, David William Russell Cold Spring Harbor Laboratory Press.
5. Molecular Cloning, Volume 2, Joseph Sambrook, Cold Spring Harbor Laboratory Press

L080606R	INDUSTRIAL TRAINING/ REVIEW/ SURVEY/ RESEARCH PROJECT	CREDITS: 4
	RESEARCH ASSIGNMENT II	

Course Objectives

A term (or research) paper is primarily a record of intelligent reading in several sources on a particular subject. The students will get informed about the topic at the beginning of the session in consultation with the faculties assigned for the major courses. The progress of the assignment will be developed under regular monitoring of the faculty. At the end of the semester the detailed paper/ proposal on the topic will be submitted to the faculty assigned.

Note:

2. The IPR rights of all such work lie with the University only.

Course Outcomes: Upon successful completion students should be able to:

3. Collect information of given subject and compile it in sequential order.
4. Review notes to find main sub-divisions of the subject.

SEMESTER VII

L080701T	MAJOR COURSE I CELLULAR MICROBIOLOGY	CREDITS: 4

Course Objectives

The primary objective of the course is to build a strong foundation in the area of bacterial cell structure, division, survival and propagation. The course will help to understand the structural organization and function of intracellular organelles in eukaryotes.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Prokaryotes** Cell Theory, Differentiate between prokaryotic and eukaryotic cells. Prokaryotes: Cell morphology, Structure, function and synthesis of cell wall, cell membrane, capsules, Endospores, flagella, pili, cilia. Storage granule metabolism- volutin, polyhydroxybutyrates and glycogen. Gas vesicles, carboxysomes, magnetosomes and phycobilisomes.	10
II	**Eukaryotes** Structural organization and function of intracellular organelles: Cell wall, molecular organization of cell membrane, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure & function of cytoskeleton and its role in motility.	10
III	**Genes and Chromosomes** Organization of prokaryotic and eukaryotic genes and chromosomes (Operon, unique and repetitive DNA, interrupted genes, gene families, structure of chromatin and chromosomes, heterochromatin, euchromatin.	8
IV	**Cell division and Cell cycle** Mitosis and meiosis, interphase, comparison of mitosis and meiosis, cell cycle regulation Ecological amplitude of cells in high altitude, sediments, arctic, hot springs, arid, brackish and freshwater environments.	12
V	**Sensing and movement** Overview and Significance in prokaryotic systems, phototaxis, magnetotaxis, Chemotaxis, movement of flagella: clockwise, counter clockwise rotation, tumbling, running; mechanism of flagellar rotation	8
VI	**Signal Transduction pathways** Signal transduction in bacteria (G protein coupled receptors, and Protein kinases), Quorum Sensing and bacterial pheromones, mechanism of quorum sensing, quorum sensing related signalling pathways (AHL, AI), bioluminescence, multicellular organization in microbes (coordination in microbes).	12

Course Outcomes: Upon successful completion students should be able to:

1. Describe the morphological features, cell arrangement and structural components of bacterial cell
2. Learn about molecular organization of eukaryotic cell membrane, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum chloroplasts etc.
3. Will have gathered detailed information about structure of chromatin and chromosomes.
4. Will be able to understand cell cycle and its regulation.
5. Understand the signal transduction pathway (G protein coupled receptors and protein kinases).

SUGGESTED READINGS

1. Lodish et al., Molecular cell Biology, 4th Edition, W.H. Freeman & Company, 2000.
2. Smith & Wood, Cell Biology, 2nd Edition, Chapman & Hall, London, 1996.
3. Watson et al., Molecular Biology of the gene, 5th Edition, Pearson Prentice Hall. USA, 2003.
4. B. M. Turner, Chromatin & Gene regulation, 1st Edition, Wiley-Blackwell, 2002.
5. Benjamin Lewin, Gene IX, 9th Edition, Jones and Barlett Publishers, 2007.
6. Alberts et al. Molecular biology of cell- Bruce Alberts, Cell Biology – Karp, Cell signaling by John T Hancock (Oxford), Darnell, Prescott, Stanier.

L080702T	MAJOR COURSE II MYCOLOGY AND PHYCOLOGY	CREDITS: 4

Course Objectives

The primary objective of the course is to present the diversity of algal, fungal and fungal-like organisms in a systematic order. Special attention will be paid to these taxonomic groups which differed in response to vectors of natural selection related to the occupation of specific ecological niches.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Classification of fungi** Classification of fungi General features, structure and cell differentiation (Hyphae and non-motile unicells, motile cells, spores, dormancy, growth of population and colonies). Life cycle of Aspergillus, Penicillium, Yeasts. Salient characteristics, nutrition, reproduction and significance of Myxomycotina (Plasmodiophomycetes, Myxomycetes); Mastigomycotina (Chytridiales, Peronosporales; Zygomycotina (Zygomycetes, Entomophthorales); Ascomycotina (Hemiascomycetes, Laboulberiomycetes); Basidiomycotina (Teliomycetes, Hymenomycetes); Deuteromycotina (Hypomycetes, Blastomycetes).	12
II	**Fungal Associations** Heterothallism, sex hormones in fungi. Physiological specialization phylogeny of fungi, Lichens – ascolichens, basidiolichens, deuterolichens. Mycorrhiza – ectomycorrhiza, endomycorrhiza, vesicular arbuscular mycorrhiza. Effect of environment on fungal growth, prevention of fungal growth. Saprophytes, substrate groups and nutritional strategies substrate successions, fungal relationships with plants and animals.	10
III	**Fungal infections** Fungi as insect symbiont, fungal diseases – mycoses systemic and subcutaneous, candidiasis, Pneumocystis, blastomyxoses, dermotophytosis. Opportunistic fungal infections.	8
IV	**Algal classification and characteristics** Principles, criteria (pigments, flagellation, food reserve and eye spots) and systems of classification of algae. Cyanophyta: cell structure, heterocyst and akinete development, chromatic adaptation, thallus organization and reproduction. A brief account of thallus organization and reproduction in Chlorophyta, Phaeophyta and Rhodophyta; alternation of generation in Phaeophyta and post -fertilization development and site of meiosis in Rhodophyta.	12
V	**Algal phylum and characteristics**	10

	A brief account of Xanthophyta, Chrysophyta, Bacillariophyta, Pyrrophyta, Euglenophyta, Eustigmatophyta, Prasinophyta and Prochlorophyta. Distribution of algae, algal nutrition, algal thallus, algal reproduction, green algae, diatoms, euglenoids, brown Rhodophyta, Pyrrophyta.	
VI	**Algal ecology and algal biotechnology** Algae in diverse habitats, algal blooms and Phycoviruses. Algae as food, biofertilizers and source of phycocolloids. Commercial potential of *Spirulina*, *Dunaliella* and *Porphyra*; hydrogen production by algae.	8

Course Outcomes: Upon successful completion students should be able to:

1. Know the origin of the individual groups and indicates evolutionary trends within them;
2. Know about their ecology and their importance in nature and human economy.
3. Know the structural and functional diversity of algae and fungi, and their mutual relations.
4. Understand the relationship between the environment and the diversity of microorganisms.
5. Know the specialized terminology from the scope of mycology and algology and literature from these areas.

SUGGESTED READINGS

1. Mehrotra RS and KR Aneja: An introduction to Mycology. New Age International publishers.
2. Introduction to Mycology: CJ Alexopoulos and CW Mims, Wiley Eastern Ltd, New Delhi.
3. Fundamentals of Mycology: JH Burnett, Publisher: Edward.
4. The Fungi: M. Charlile and SC Watkinson, Publisher: Academic Press.
5. Fundamentals of the fungi: E Moore – Landeekeer, Publisher: Prentice Hall.

L080703T	MAJOR COURSE III VIROLOGY	CREDITS: 4

Course Objectives

The purpose of the course is to enable students to understand viral structure, replication strategies and their importance in microbiology.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**History and Classification** History of Virology; Classification and Morphology of Viruses: Cataloging the virus through virus classification schemes of ICTV/ ICNV. Baltimore's Classification; Ultra-structure of viruses: envelop, capsid and nucleic acid; Virus related agents: viroids, virusoids and prions.	8
II	**Cultivation and assay of viruses** Embryonated eggs, experimental animals, cell cultures (Cell-lines, cell strains and transgenic systems). Purification of viruses: Assay of viruses – Electron Microscopy, Infectivity Assays (Plaque and end-point dilution assay). Serological Assays (ELISA, RIA).	12
III	**Viral Multiplication** Mechanism of virus adsorption, entry and exit into the host cell. Replication strategies of DNA and RNA viruses. Lifecycle of bacteriophages-lytic and lysogenic pathways: T series, λ, Mu, M13, ϕX174; Cyanophages and Mycophages.	12

IV	**Pathogenesis of Viruses** Structure, genomic organization, replication cycle; pathogenesis, diagnosis and control. Poxvirus, Adenovirus, Herpes virus, Hepatitis virus, Rota Virus, Picorna virus, HIV, Toga Viruses.	10
V	**Pathogenesis of plant Viruses** TMV, PVX, PVY and insect viruses NPV. Role of insect vectors in transmission of plant viruses.	10
VI	**Cellular transformations and treatments** Host cell transformation by viruses and oncogenesis of DNA and RNA viruses. Control of viral infections through vaccines, interferons, chemotherapeutic agents, Antisense RNA, siRNA, ribozymes. Recent applications of viruses: Nanotechnology, Phage therapy; Phage Display; Gene therapy etc.	8

Course Outcomes: Upon successful completion students should be able to:

1. Know how viruses are classified
2. Understand the architecture of viruses
3. Know the methods used in studying viruses
4. Discern the replication strategies of representative viruses from the seven Baltimore classes
5. Comprehend the intricate interaction between viruses and host cells
6. Understand the interactions between viruses and the host immune system
7. Understand the terms Oncogenes and tumor suppressor genes, and how tumor viruses interact with these products and their intersecting pathways and cause oncogenesis.

SUGGESTED READINGS

1. Medical Virology 10 Th Edition by Morag C and Tim bury M C . Churchil Livingstone, London.
2. Introduction to Modern Virology 4th Edition by Dimmock N J, Primrose S. B. Blackwell Scientific Publications. Oxford.
3. Virology 3 rd Edition by Conrat H.F., Kimball P.C. and Levy J.A. Prentice Hall, Englewood Cliff, New Jersey.
4. Text Book on Principles of Bacteriology, Virology and Immunology Topley and Wilsons.
5. Molecular Biology, Pathogenesis and Control by S.J. Flint and others. ASM Press, Washington, D.C.
6. Clinical virology Manual by Steven, S., Adinka, R.L., Young, S.A.

L080704T	MAJOR COURSE IV EXTREME MICROBIOLOGY	CREDITS: 4

Course Objectives

1. The goal of the course is to describe different extreme environments and molecular approaches to explore microbial communities in extreme environments.
2. Comprehend adaptations strategies of various extremophilic microorganisms.
3. Knowledge about extremozymes, exomicrobiology and their application.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Introduction to extremophiles** Concept of extremophiles v/s conventional microbial forms & archaea, habitats in universe, econiches, communities and community associations, biofilms, microbial community analysis of extreme	10

	environments using various molecular approaches (DGGE, cloning and next generation sequencing, functional genomics and transcriptomics).	
II	**Adaptation strategies** Occurrence, Physiological features, adaptation strategies of various extremophilic microbes: a) anearobes, barophiles/ peizophiles, cryophiles & thermophiles; b) oligotrophs, osmophiles, halophiles & xerophiles; c) radiophiles, metallophiles & xenobiotic utilizers; d) alkaliphiles/ basophiles, acidophiles. Potential applications of extremophilic microbes.	12
III	**Microbes in toxic environments** Ore deposits/ mining areas (Fe, Mn, Cu), Acid mine drainage, waste containing cyanides, xenobiotics, pesticides, heavy metals and radio isotopic materials, extremozymes and their applications, field and case studies.	8
IV	**Mechanisms of sensing stresses** Protein-protein interactions: Two-component systems, sRNAs: Regulating translation mRNA of RpoS (the general stress response activator), Small molecules: The stringent response	8
V	**Mechanisms of mitigating stresses** Pumping out toxins: Antibiotics Scavenging toxins: Reactive oxidative species Promoting tolerance: Extreme heat and cold Repair calls: Single-stranded DNA damage Gene expression in hyperthermophilic bacteria and archaea.	10
VI	**Exomicrobiology** Life detection methods - Evidence of metabolism - Evidence of photosynthesis (autotrophic and heterotrophic) - ATP production - Phosphate uptake and Sulphur uptake. Hyper-extremophiles and their novel metabolic machinery and biomolecules- future unique applications. Antartica as a model for Mars. Search for life on Mars, Viking mission, Viking landers, and Biology box experiment. Gas exchange, Label release and pyrolytic release experiments. Monitoring of astronauts microbial flora: Alterations in the load of medically important microorganisms, changes in mycological autoflora, and changes in bacterial autoflora.	12

Course Outcomes: Upon successful completion students should be able to:

1. Know the types of microbial diversity flourish in extreme environments.
2. Understand how organisms cope under extreme living conditions with biochemical and molecular adaption of extremphilic microorganisms.
3. Understand modern techniques used for exploration of unculturable extremophiles.
4. Understand potential application of extremozymes in various industries and in functional genomics.

SUGGESTED READINGS

1. Brock, T. D. (1978). Thermophilic Microorganisms and Life at High Temperatures, Springer, New York.
2. Fred A Rainey and Aharon Oren (2006). Extremophiles, Academic Press.
3. Horikoshi, K. and W. D. Grant (1998). Extremophiles-Microbial Life in Extreme Environments,Wiley, New York.
4. Gerday, C. And Glansdorff, N. (2007). Physiology and biochemistry of extremophiles. Washington, DC: ASM Press.

L080705P	MAJOR COURSE V	CREDITS: 4
	PRACTICAL WORK : CELULAR MICROBIOLOGY, MYCOLOGY, PHYCOLOGY, VIROLOGY AND EXTREME BIOTECHNOLOGY	

Course Objectives

The course is designed to educate our graduates in key cellular and microbiology laboratory disciplines, and develop skills of testing of fungi, algae, and viruses in various sources.

	Content
1	To observe budding of *Saccharomyces cerevisiae*
2	Cytochemical staining of DNA – Feulgen.
3	Study of different stages of Mitosis.
4	Isolation of fungi by baiting method.
5	Culturing and morphological study of some common molds: *Rhizopus*, *Mucor*, Penicillium, *Alternaria*, *Trichodema*
6	Identification of plat diseases eg., Apple scab, Citrus canker, Late blight of potato, Rust of wheat, Red rot of sugarcane
7	Isolation of algae from soil and water
8	Study of morphology of given algal sample
9	Isolation of bacteriophages from sewage/ Ganga water using plaque assay
10	Study of DAS –ELISA assay for given viruses.
11	Observation of viral pathogenicity using phase contrast microscope.
12	Studies on halophiles isolated from seawater. [Pigmentation and Salt tolerance]
13	Studies on alkalophiles isolated from sea water. [Study at least one enzyme]

Course Outcomes: Upon successful completion students should be able to:

1. To screen and identify the plant diseases.
2. Know the cellular structure and division cycle of microorganisms.
3. Isolate and handle viruses
4. Evaluate extremophiles for beneficial characteristics.

SUGGESTED READINGS

1. Weaver, D. and Tart, R. C., "A Laboratory Manual for General Microbiology" (1998). *Biology*. 46. https://cufind.campbell.edu/biology/46
2. Campbell, JL "A Manual of Scientific and Practical" Publ. BiblioBazaar.
3. Dr. R. C. Dubey and Dr. D. K. Maheshwari 'Practical Microbiology' S. Chand Publications

	INDUSTRIAL TRAINING/ REVIEW/ SURVEY/ RESEARCH PROJECT REVIEW WRITING AND PRESENTATION	CREDITS: 4

Course Objectives

A term (or research) paper is primarily a record of intelligent reading in several sources on a particular subject. The students will get informed about the topic at the beginning of the session in consultation with the assigned faculty. The progress of the review writing will be developed under regular monitoring of the faculty. At the end of the semester the detailed report and/or presentation on the topic will be submitted to the faculty assigned.

Note:

1. The IPR rights of all such work lie with the University only.

Course Outcomes: Upon successful completion students should be able to:

1. Collect information of given problem statement and compile it in sequential order.
2. Review notes to find main sub-divisions (problems, possible solutions) of the subject.

SEMESTER VIII

L080801T	MAJOR COURSE I PLANT PATHOLOGY	CREDITS: 4

Course Objectives

The major objective of the course is to help students build a framework for the integration and synthesis of information presented in courses taught in their majors with fundamental information in the science of Plant Pathology.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Introduction and History of plant pathology** Concept of plant disease- definitions of disease, disease cycle & pathogenicity, symptoms associated with microbial plant diseases, types of plant pathogens, economic losses and social impact of plant diseases. Significant landmarks in the field of plant pathology- Contributions of Anton DeBary, Millardet, Burrill, E. Smith, Adolph Mayer, Ivanowski, Diener, Stakman, H.H. Flor, Van Der Plank, molecular Koch's postulates. Contributions of eminent Indian plant pathologists (K.C. Mehta, Mundkur, Dastur and Sadasivan).	5
II	**Stages in development of a disease** Infection, invasion, colonization, dissemination of pathogens and perennation.	4
III	**Plant disease epidemiology** Concepts of monocyclic, polycyclic and polyetic diseases, disease triangle & disease pyramid, forecasting of plant diseases and its relevance in Indian context	6
IV	**Host Pathogen Interaction** Virulence factors of pathogens, Effects of pathogens on host physiological processes (photosynthesis, respiration, cell membrane permeability, translocation of water and nutrients, plant growth and reproduction). Concepts of constitutive defense mechanisms in plants.	10
V	**Control of Plant Diseases** Principles & practices involved in the management of plant diseases by different methods, *viz.* regulatory - quarantine, crop certification, avoidance of pathogen, use of pathogen free propagative material. cultural - host eradication, crop rotation, sanitation, polyethylene traps and mulches. chemical - protectants and systemic fungicides, antibiotics, resistance of pathogens to chemicals. biological - suppressive soils, antagonistic microbes-bacteria and fungi, trap plants. genetic engineering of disease resistant plants- with plant derived genes and pathogen derived genes.	10
VI	**Specific Plant diseases** Study of *some* important plant diseases giving emphasis on its etiological agent, symptoms, epidemiology and control A. Important diseases caused by fungi: White rust of crucifers - *Albugo candida.* Late blight of potato - *Phytophthora infestans.* Ergot of rye - *Claviceps purpurea.*	25

	Black stem rust of wheat - *Puccinia graminis tritici.* Red rot of sugarcane - *Colletotrichum falcatum.* Rice blast disease – *Magnaporthe oryzae* B. Important diseases caused by phytopathogenic bacteria: Bacterial blight of rice, Bacterial streak disease of riceAngular leaf spot of cotton and crown gall.	

Course Outcomes: Upon successful completion students should be able to:

1. Know about organisms and causal factor responsible for plant diseases & methods of studying plant diseases.
2. Familiarize with some common plant diseases of India.
3. Gain knowledge on Host-microbe interaction process.

SUGGESTED READINGS

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

L080802T	MAJOR COURSE II ADVANCES IN MICROBIOLOGY	CREDITS: 4

Course Objectives

The course is designed to train the students in basic and advanced areas of Microbiology, keeping in mind the latest advances in the field.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Evolution of Microbial Genomes** Salient features of sequenced microbial genomes, core genome pool, flexible genome pool and concept of pangenome, Horizontal gene transfer (HGT), Evolution of bacterial virulence - Genomic islands, Pathogenicity islands (PAI) and their characteristics, CRISPR/CAS system.	15
II	**Metagenomics** Brief history and development of metagenomics, Understanding bacterial diversity using metagenomics approach, Prospecting genes of biotechnological importance using metagenomics Basic knowledge of viral metagenome, metatranscriptomics, metaproteomics and metabolomics.	15
III	**Molecular Basis of Host-Microbe Interactions** Epiphytic fitness and its mechanism in plant pathogens, Hypersensitive response (HR) to plant pathogens and its mechanism, Type three secretion systems (TTSS) of plant and animal pathogens Biofilms: types of microorganisms, molecular aspects and significance in environment, health care, virulence and antimicrobial resistance.	15
IV	**Systems** Networking in biological systems, Quorum sensing and quenching in bacteria, Co-ordinated regulation of bacterial virulence factors.	15
V	**Synthetic Biology**	5

	Basics of synthesis of poliovirus in laboratory, Future implications of synthetic biology with respect to bacteria and viruses.	
VI	**Nanobiotechnology** Introduction, history and recent developments, sources of nanoparticles, microbial producers of nanoparticles, advantages of microbial nanoparticles, applications, social and ethical implications, ethical concerns about patenting of living organisms and genetic materials.	5

Course Outcomes: Upon successful completion students should be able to:

1. Become familiar with the most recent advances in microbiology.
2. Have gained hands-on experience in advance in microbiology, including metagenomics, nanotechnology and molecular basis of microbial interactions.

SUGGESTED READINGS

1. Fraser CM, Read TD and Nelson KE. Microbial Genomes, 2004, Humana Press.
2. Miller RV and Day MJ. Microbial Evolution- Gene establishment, survival and exchange, 2004, ASM Press.
3. Bull AT. Microbial Diversity and Bioprospecting, 2004, ASM Press.
4. Sangdun C. Introduction to Systems Biology, 2007, Humana Press.
5. Klipp E, Liebermeister W. Systems Biology – A Textbook, 2009, Wiley –VCH Verlag.
6. Madigan MT, Martink JM, Dunlap PV and Clark DP (2014) Brock's Biology of Microorganisms, 14th edition, Pearson-Bejamin Cummings.
7. Wilson BA, Salyers AA Whitt DD and Winkler ME (2011)Bacterial Pathogenesis- A molecular Approach, 3rd edition, ASM Press.
8. Bouarab K, Brisson and Daayf F (2009) Molecular Plant-Microbe interaction CAB International.
9. Voit EO (2012) A First Course in Systems Biology, Ist edition,Garland Science.
10. Nanobiotechnology: Concepts, Applications and Perspectives, Christof M.Niemeyer, Chad A.Mirkin, Wiley-VCH, Weinheim, 2004.

L080803T	MAJOR COURSE III ENTREPRENEURIAL MICROBIOLOGY	CREDITS: 4

Course Objectives

The course is reasoning and application based, making the students eligible for higher studies, jobs in various sectors and entrepreneurship abilities. The course exposes students to various aspects of business development.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Entrepreneur development** Concept and need of entrepreneurship development, activity, Institutes involved, Differences between entrepreneurship, Entrepreneur & Enterprise, Government contributions to entrepreneur. Business Idea to Start-up opportunities, sources, challenges and factors influencing opportunity identification- risk assessment and development, idea canvas.	8
II	**Microbial cells as fermentation products** Baker's yeast, food and feed yeasts, bacterial insecticides, legume inoculants, Mushrooms, Algae, Enzymes as fermentation products- bacterial and fungal amylases, proteolytic enzymes.	8

	prebiotics, probiotics – their use as flavor enhancers and disease/ infection combats	
III	**Recycling of wastes** Production of biofuels-ethanol, methane, hydrogen, other hydrocarbons, compost, vermicompost, production of single cell protein, mushroom cultivation (*Agaricus campestris*, *Agaricus bisporous* and *Volvoriell volvaciae* eg.), microbial bioplastics. Bioleaching of copper, gold and uranium.	12
IV	**Agriculture technologies** Microbial Bioinoculants – production (Bacterial, fungal and Mycorhhiza), Silent features of secondary agriculture, use of agricultural and agro-industrial waste for biodegradable packaging, higher value secondary products (dietary fiber, phenolic acids), food colours/dyes. Genetic engineering in biological control and plant growth promotory product production, transgenic plants for biotic and abiotic stress resistence, quality enhancement	14
V	**Brewing** Media components, preparation of medium, microorganisms involved, maturation, carbonation, packaging, keeping quality, contamination, by products. Production of industrial alcohol.	8
VI	**Patients and secret process** History of patenting, composition, subject matter and characteristics of a patent, inventor, infringement, cost of patent. Patents in India and other countries. Fermentation economics. Advances and trends, ethical issues, quality control, legislation, FDA & FPO, (India), safety and security at workplace	10

Course Outcomes: Upon successful completion students should be able to:

1. Research and develop entrepreneurship with strong ethics.
2. Understand communication and management skills to usher next generation of Indian industrialists and researchers.
3. Know the importance and scope of the IPR in Microbiology
4. Get acquainted with regulatory practices undertaken at commercial level.

SUGGESTED READINGS

1. Prescott LM, Harley JP and Klein DA (2003) Microbiology (10th edition) McGraw Hill, New York.
2. Pelczar Jr, M.J. Chan, E.C.S and Krei N.R (1993) Microbiology McGraw Hill, New York.
3. Subba Rao NS (1997). Biofertilizer in Agriculture and Forestry, 3rd edition, Oxford & IBU Publications.
4. LE Cassida JR (2005). Industrial Microbiology. New Age International (P) Ltd., New Delhi.
5. Arora. Entrepreneurial Development in India.
6. Aneja, K.R. Experiments in Microbiology, Plant Pathology, Tissue Culture and Mushroom Production Technology, 6th Edition, New age International Publication.
7. Goyal P (2017) Before You Start Up: How to Prepare to Make Your Startup Dream a Reality. Fingerprint! Publishing

L080804T	DISCIPLINE SPECIFIC ELECTIVE COURSE PLANT TISSUE CULTURE, METHODS AND APPLICATIONS	CREDITS: 4

Course Objectives

The course is intended to make students aware of fundamentals and to provide knowledge of Plant Tissue culture of plant tissue culture as an important agricultural biotechnological tool that contributes in the production of crops with improved food, fiber, fuel, and feed.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Introduction and History** Introduction and history of plant tissue culture, Applications, Selection & sterilization of explants, Media used for sterilization & culture, Growth regulators	6
II	**Plant tissue culture procedure** General Techniques of Micropropagation, Initiation of culture, Multiplication, Rooting – Hardening, callus culture, Embryogenesis. Somaclonal and gametoclonal variation, uses in crop improvement. Synthetic seeds-practical application.	10
III	**Plant tissue culture systems I** Callas, suspension, micropropagation; Anther and microspore culture, Ovary culture, Di haploids and their applications; In vitro fertilization; in vitro germplasm conservation; production of secondary metabolites.	10
IV	**Plant tissue culture systems I** Embryo culture and embryo rescue; protoplast isolation, somatic hybridization – protoplast fusion techniques, selection of hybrid cells and regeneration of hybrid plants; symmetric and asymmetric hybrids, cybrids, Cryopreservation and Germplasm storage.	11
V	**Molecular markers** Conventional versus non-conventional methods for crop improvement; Present status and recent developments on available molecular markers, transformation and genomic tools for crop improvements. Molecular marker-aided breeding, QTL, molecular marker assisted selection.	11
VI	**Plant transformation technology** *Agrobacterium* mediated gene transfer, particle bombardment, Electroporation, transgene stability and gene silencing. Chloroplast transformation, Genetic engineering for resistance against abiotic (drought, salinity, flooding, temperature) and biotic (insect pest, fungal, viral and bacterial diseases, weeds) stresses; genetic engineering for quality improvement.	12

Course Outcomes: Upon successful completion students should be able to:

1. Student knows functioning of cell structures and important relations between cell components, cells themselves and the whole plant organism.
2. Knows rules of planning and conducting of experiments with the use of specific methods applied in vitro cultures.
3. Posseses knowledge about safety and ergonomy rules, ensuring safe and sterile work at the laboratory applying in vitro techniques.

SUGGESTED READINGS

1. M.K. Razdan. Introduction to plant tissue culture. (2003). Science publishers Inc.
2. NIIR Board of Consultants & Engineers (2005). Handbook on plant and cell tissue culture. Asia Pacific Business Press Inc.

3. Gamborg, O.L. and G.C.Philips. 1995. Plant Cell, Tissue and Organ Culture. Fundamental Methods, Narosa Publication.
4. Trevor A. Thorpe, 1995. In vitro embryogenesis in plants. Kluwer Academic Publishers.

L080805T	DISCIPLINE SPECIFIC ELECTIVE COURSE BIOREMEDIATION TECHNOLOGY	CREDITS: 4

Course Objectives

The course develops concepts of sustainable methods for cleaning up contaminated soil or water by enhancing natural biological processes to occur. Microorganisms/plants are able to break-down many types of contamination (e.g. fuels, oil, explosives, pesticides by a clean, efficient & relatively inexpensive biological process.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	Definition of Bioremediation - Types of pollution - organic, inorganic in soil, water and air - Remediation by bacteria, fungi, microalgae and green plants. Nanomaterials for the Remediation of Contaminants	8
II	Bioaccumulation and biomagnification processes - microbial remediation by natural attenuation - biostimulation - bioaugmentation. Application of immobilized microbes in soil decontamination - use of genetically engineered microorganism and bioremediation.	8
III	Bioremediation of soil & water contaminated with oil spills, heavy metals and detergents. Degradation of pesticides and other toxic chemicals by micro-organisms, Biological Degradation and Detoxification of Toxic Contaminants in Leachate, degradation aromatic and chlorinates hydrocarbons and petroleum products.	10
IV	Biodegradation of organic compounds - Degradation of lignin and cellulose using microbes, humification and polymerization reaction - bio-transformation of metal and metal compounds - phyto -remediation use of microalgae, green plants to remove pollutants, Role of Enzymes in Bioremediation of Organic Pollutants	10
V	Phyto-extraction - Types of phytoextraction - induced phyto-extraction and continuous phyto-extraction - phyto-degradation - rhizofiltration - phyto-stabilisation - phyto-volatisation of metals - phyto-remediation of organic. Bioavailability and uptake. Biotransformation and compartmentalisation.	12
VI	Microbial treatment of waste water (sewage of industrial effluent)- aerobic and anaerobic methods Solid waste and management; Bioremediation– concepts and types (in-situ and ex-situ); Bioremediation of toxic metal ions– biosorption and bioaccumulation Microbial bioremediation of pesticides and Xenobiotic compounds Conservation of biodiversity	12

Course Outcomes: Upon successful completion students should be able to:

1. Demonstrate an understanding of the nature and importance of bioremediation.
2. Understand the influence of site characteristics: hydraulic conductivity, soil type, microbial presence, and groundwater properties.
3. Understand the influence of contaminant characteristics to bioremediation (e.g. chemical structure, toxicity, and solubility).
4. Demonstrate the use of course concepts to solve problems in real world applications.

SUGGESTED READINGS

1. Moo-Young, M., Anderson, W.A. and Chakrabarty, A.M. 1996. Environmental biotechnology: Principles and applications. Boston, Mass.: Kluwer Academic Publishers.
2. Wainwright, M. 1999. An introduction to environmental biotechnology. Boston, Mass. Klumer Academic
3. Biotechnology -By H.J. Rehm and G. Reed. VIH Publications, Germany
4. Biogas Technology - By B.T. Nijaguna
5. Biotechnology - By K. Trehan
6. Industrial Microbiology - By L.E. Casida
7. Food Microbiology - By M.R. Adams and M.O. Moss
8. Introduction to Biotechnology - By P.K. Gupta
9. Essentials of Biotechnology for Students - By Satya N. Das
10. Bioprocess Engineering - By Shuler (Pearson Education)
11. Essentials of Biotechnology - By Irfan Ali Khan and AtiyaKhanum (Ukaaz Publications) Publishers.

L080806P	MAJOR COURSE V	CREDITS: 4
	PRACTICAL WORK: EXPERIMENTS IN PLANT PATHOLOGY, ADVANCED MICROBIOLOGICAL TECHNIQUES, ENTREPRENEURIAL MICROBIOLOGY, PLANT TISSUE CULTURE, BIOREMEDIATION	

Course Objectives

To impart training on various methods/ techniques/ instruments used in the study of plant diseases/pathogens, bioremediation and tissue culture.

	Content
1	Demonstration of Koch's postulates in fungal, bacterial and viral plant pathogens
2	Study of important diseases of crop plants by cutting sections of infected plant material - *Albugo, Puccinia, Ustilago, Fusarium, Colletotrichum.*
3	Extraction of metagenomic DNA from soil.
4	Understand the impediments in extracting metagenomic DNA from soil.
5	PCR amplification of metagenomic DNA using universal 16S ribosomal gene primers.
6	Preparation of MS Media.
7	Inoculation, Callus Induction and clonal propagation.
8	Sub culturing and Regeneration of roots
9	Sub culturing and Regeneration of roots
10	Preparation of regenerated plants for hardening.
11	Protoplast Isolation and culture (demonstration).
12	Agro bacterium - mediated transformations (demonstration).
13	Isolation of heavy metals tolerant bacteria
14	Microtox tests
15	Compost development
16	Mushroom development
17	Bioformulations development

Course Outcomes: Upon successful completion students should be able to:

1. Gain knowledge on plant pathological diseases and various biological methods of analysis.
2. To acquire the techniques of isolation, purification and quantification of metagenomic DNA and analysis.
3. Uses basic methods and research tools applied in tissue cultures in vitro and is able to disclose the

rules of their functioning. 4. Understand and apply bioremediation techniques.

SUGGESTED READINGS

1. Weaver, D. and Tart, R. C., "A Laboratory Manual for General Microbiology" (1998). *Biology*. 46. https://cufind.campbell.edu/biology/46
2. Campbell, JL "A Manual of Scientific and Practical" Publ. BiblioBazaar.
3. Dr. R. C. Dubey and Dr. D. K. Maheshwari 'Practical Microbiology' S. Chand Publications
4. Huma Naz, Hadi Husain Khan, Chandan Kumar Singh, Asma Naz, Samiya Maqsood F. I. A. Brima and Ayesha 'Practical lab manual for microbiology and plant pathology' AkiNik Publications
5. Practical Book Of Biotechnology & Plant Tissue Culture. by Nagar Santosh, S Chand Publ.

L080807R	INDUSTRIAL TRAINING/ REVIEW/ SURVEY/ RESEARCH PROJECT	CREDITS: 4
	REVIEW WRITING AND PRESENTATION	

Course Objectives

A term (or research) paper is primarily a record of intelligent reading in several sources on a particular subject. The students will get informed about the topic at the beginning of the session in consultation with the assigned faculty. The progress of the review writing will be developed under regular monitoring of the faculty. At the end of the semester the detailed report and/or presentation on the topic will be submitted to the faculty assigned.

Note:

1. The IPR rights of all such work lie with the University only.

Course Outcomes: Upon successful completion students should be able to:

3. Collect information of given problem statement and compile it in sequential order.
4. Review notes to find main sub-divisions (problems, possible solutions) of the subject.

SEMESTER IX

L080901T	MAJOR COURSE I ANALYTICAL TECHNIQUES	CREDITS: 4

Course Objectives

The course aims to provide knowledge on conventional and advanced techniques in the detection and identification of bacteria, fungi, viruses and biomolecules.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Microscopy** Basic principles of optical microscopy, Concept of resolution and magnification, Different contrast enhancing techniques: Phase contrast, dark field, differential interference contrast, Fluorescence etc. Concepts of digital microscopy and image analysis, Confocal microscopy and introduction to super resolution microscope, Electron and cryo-electron microscopy, Introduction to magnetic and optical tweezers, atomic force microscopy.	8
II	**Chromatographic Techniques** Paper and thin layer Chromatography – Principle, material, methods and applications. Column Chromatography: Adsorption Chromatography, Ion exchange Chromatography- Principle, material, ion exchange gels, media, operative procedures and applications. Affinity Chromatography - Principle, material, methods, and Applications – Industrial and Medical. Molecular exclusion Chromatography (Gel filtration) – Types of Gels, Technique, and Applications. Gas Liquid Chromatography (GLC) – Principle, Equipment, Evaluation of performance, comparison with traditional Chromatography and with HPLC High performance liquid Chromatography (HPLC) – Principle, basic instrumentation (reverse phase, normal phase) and applications.	14
III	**Electrophoretic Techniques** Principles of Electrophoresis, moving boundary and zonal electrophoresis. Paper Electrophoresis – Principle and procedures involved, and applications. Gel Electrophoresis: Protein Electrophoresis – Polyacrylamide Gel Electrophoresis (PAGE), SDS – PAGE and 2-D PAGE, Isoelectrofocussing. Nucleic acid Electrophoresis – DNA sequencing gels, pulse field gel Electrophoresis (PFGE), RNA Electrophoresis	12
IV	**Centrifugation Techniques** Principles of Centrifugation, different types of centrifuges and types of rotors and their usages. Density gradient centrifugation – rate zonal technique, Isopycnic centrifugation, performing density gradient centrifugation – Discontinuous and continuous techniques, applications of preparative centrifuges.	8
V	**Spectroscopic technique** General principles of electromagnetic radiation spectroscopy, principles, procedures and applications UV – visible spectrometry, turbidometry and nephelometry, fluorimetry, luminometry, atomic absorption and	9

	mass spectroscopy, Infra red and Raman spectroscopy; Electron spin and nuclear magnetic resonance spectroscopy.	
VI	**Biophysical Techniques** X ray diffraction analysis and crystallography Radioactivity, radioactive decay, measurement of radioactivity-Geiger Muller counting, scintillation counting, SPA, Autoradiography Geiger – Muller counters; Scintillation counting; Autoradiography	9

Course Outcomes: Upon successful completion students should be able to:

1. Explain the concept of spectrometry and optical techniques
2. Elucidate the working of chromatography, elemental analyser
3. Illustrate the working of X- ray diffractometer and scanning electron microscope
4. Develop skills to understand the theory and practice of bio analytical techniques.
5. Determine a chemical or physical property of a biochemical substance, chemical element, or mixture.
6. Design an analytical work-flow to acquire data and achieve the research objectives of their project.

SUGGESTED READINGS

1. Wilson K and Walker J. Principles and Techniques of biochemistry and molecular biology. Cambridge.
2. J. D. Seader and E. J. Henley, Separation Process Principles, 1st Edition (1998), John Wiley & Sons. Inc., New York.
3. Fundamentals of Biostatistics. Khan and Khanum, Shiba Khan. Ukaaz publications.
4. Fundamentals of Biostatistics. Veer Bala Rastogi.3 Ed.

L080902T	MAJOR COURSE II ADVANCED MOLECULAR BIOLOGY	CREDITS: 4

Course Objectives

The course major objective is to provide a deeper understanding of the molecular principles underlying the biology of microorganisms such as bacteria, viruses, fungi and yeasts. A core focus will be genome structure, regulation and transfer and the implications for DNA technology.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Structures of DNA and RNA / Genetic Material** The beginning of Molecular Biology; DNA: A carrier of genetic information, Chemical structure of DNA and Base composition, biologically important nuleotides, Watson-Crick model, Supercoiled DNA, structure of different types of nucleic acids, hydrolysis of nucleic acids. Conformation of nucleic acids: A-, B-, Z-, DNA, RNA. DNA topology: linking number, topoisomerases. Eukaryotic genome: C-value paradox, Gene numbers, Unique, moderately repetitive and highly repetitive DNA sequences, reassociation kinetics, Cot value and complexity of genome, Interrupted genes, satellite, Rot value.	12
II	**Replication of DNA (Prokaryotes and Eukaryotes)** Bidirectional and unidirectional replication, semi- conservative, semi-discontinuous replication. Mechanism of DNA replication: Enzymes and proteins involved in	10

	DNA replication –DNA polymerases, DNA ligase, primase, telomerase – for replication of linear ends. Various models of DNA replication including rolling circle, D- loop (mitochondrial), Θ (theta) mode of replication and other accessory protein, Mismatch and excision repair.	
III	**Transcription in Prokaryotes and Eukaryotes** Transcription: Definition, difference from replication, promoter - concept and strength of promoter RNA Polymerase and the transcription unit. Transcription in Eukaryotes: RNA polymerases, general Transcription factors.	8
IV	**Post-Transcriptional Processing** Split genes, concept of introns and exons, RNA splicing, spliceosome machinery, concept of alternative splicing, Polyadenylation and capping, Processing of rRNA, RNA interference: si RNA, miRNA and its significance.	8
V	**Translation (Prokaryotes and Eukaryotes)** Translational machinery, Charging of tRNA, aminoacyl tRNA synthetases, Mechanisms of initiation, elongation and termination of polypeptides in both prokaryotes and eukaryotes, Fidelity of translation, Inhibitors of protein synthesis in prokaryotes and eukaryote.	10
VI	**Regulation of gene Expression in Prokaryotes and Eukaryotes** Regulation of gene expression in Prokaryotes: various models, operon, details of lac operon: negative and positive control (catabolite repression), basic features of tryptophan, arabinose, and galactose operon. Sporulation in *Bacillus,* Yeast mating type switching, Changes in Chromatin Structure - DNA methylation and Histone Acetylation mechanisms. Gene regulation in bacteriophage.	12

Course Outcomes: Upon successful completion students should be able to:

1. Understand the structure and function of DNA, RNA and protein and their interactions with each other.
2. Gain hands-on experience of molecular biology techniques.
3. Develop a range of transferrable and research skills that will expand knowledge and may enhance employment potential.

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.

L080903T	DISCIPLINE SPECIFIC ELECTIVE COURSE I MICROBIAL OMIC TECHNOLOGIES	CREDITS: 4

Course Objectives

This course is a survey of the application and interpretation of high-throughput molecular biology methods (-OMIC technologies) used to produce high-volume biological data. The new 'omic' technologies allow the components of a living organism to be analyzed in their entirety and provide new insights into the complexities of organism function.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Overview** General principles of omics technologies in biotechnology, Omics approaches: Genomics, Proteomics, Transcriptomics and Metabolomics, Meta-omics (genomics, proteomics, transcriptomics, metabolomics) and Functional omics for discovery of novel organisms, enzymes, value added products etc., Application of Omics in different fields of biotechnology including agriculture, environment, pharmaceuticals, medicine, forensic etc.	8
II	**Genes and Genomes** Gene- Eukaryotic and prokaryotic gene structure, genome databases, Coding regions (genes) and Non-coding regions (Intergenic sequences); Gene and related sequences – NTS, ETS and ITS, 3' UTR, 5' UTR, Pseudogenes; Repeat sequences: a) Interspersed repeats: LINES, SINES, LTR elements; SINES types: ALU elements, MIR, MIR3; b) Tandem repeats: Transposons; c) Microsatellites; Genetic mapping; Physical mapping (Contig maps, Restriction maps, DNA sequence maps, FISH); Molecular markers for genome analysis-Restriction enzyme sites, EST, STS, microsatellites	12
III	**Whole genome analysis** Preparation of ordered cosmid libraries, bacterial artificial chromosomal libraries, shotgun libraries and sequencing, conventional sequencing (Sanger, Maxam and Gilbert Methods), automated sequencing (NGS technology), Transcriptome profiling; DNA microarrays	12
IV	**Proteome analysis** Two dimensional separation of total cellular proteins, isolation and sequence analysis of individual protein spots by Mass Spectroscopy. Protein microarrary advantages and disadvantages of DNA and protein microarray	10
V	**Proteogenomics** Concepts and principles of genome annotation, genome search specific peptides, alternative translation initiation, small ORFs, Analysis of transcriptomic and proteomic data for genome annotation; Gene prediction algorithms	8
VI	**Metabolites and Metabolomics** Metabolomics-an overview, basic sample preparation strategies-extraction, derivatization, Workflow for lipidomics; Introduction to mass spectrometry and modes of data acquisition, data repositories. Targeted Vs Untargeted metabolomics; development of targeted assays for small molecules	10

Course Outcomes: Upon successful completion students should be able to:

1. Learn about the various –OMIC disciplines.
2. Understands and is able to explain methods for sequence mapping, and for de novo assembly of genomes and transcriptomes.
3. Understands and is able to explain methods for protein identification and analysis of post-translational modifications.
4. Learn how the 'omics' technologies work and about aspects of experimental design, analysis and interpretation.

SUGGESTED READINGS

1. Bioinformatics 2000 by Higgins and Taylor OUP.
2. Nucleic acid Research 2001. Jan. Genome database issue.
3. The Internet and the new Biology: Tools for Genomics and Molecular Research by Peruski, Jr. and Peruske (ASM) 1997.
4. Functional Genomics. A Practical Approach Edited by Stephen P Hunt and Rick Liveey (OUP) 2000.
5. DNA microarrays: A practical approach edited by Mark Schena (OUP).
6. Proteome Research: New Frontiers in Functional Genomics: Principles and Practices.
7. Genomics: The Science and Technology behind the human project.
8. Protein Biotechnology. Edited by Felix Franks. Humana Press, Totowa, New Jarsey.
9. Protein Engineering: Principles and Practice by Cleland.
10. Computer analysis of sequence data by Colte.

L080904T	DISCIPLINE SPECIFIC ELECTIVE COURSE I BIOETHICS, BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS (IPR)	CREDITS: 4

Course Objectives

The major objective of this course is to create awareness on the biosafety, bioethics and patenting of biotechnological processes and products so that students can understand legal, ethical and social impacts of microbiological research and can apply the knowledge to our daily life to solve various environmental problems.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Bioethics** The principles of bioethics Legality, morality and ethics, autonomy, human rights, beneficence, privacy, justice, equity etc. Bioethics and microbiological applications. General issues related to environmental release of genetically modified microorganisms. Ethical issues related to the use of animal as models for microbial diseases.	8
II	**Biosafety Guidelines** Introduction; biosafety issues in biotechnology; Primary Containment for Biohazards; Biosafety Levels of Specific Microorganisms. 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	12

	International Agreements - Cartagena Protocol.	
III	**Guideline for use of radioisotopes** AERB/RSD/RES guidelines for using radioisotopes in laboratories and precautions.	4
IV	**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).	12
V	**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 patent owner.	12
VI	**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.	12

Course Outcomes: Upon successful completion students should be able to:

1. Understand the concepts, criteria, and importance of biosafety and IPR.
2. Analyze the basic principles and legal framework of intellectual property rights and its application to biotechnology.
3. Understand regulatory guidelines and steps involved in protection of intellectual property rights.
4. Identify good laboratory procedures and practices, describe the standard operating procedures for microbiological research.

SUGGESTED READINGS

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.

L080905T	DISCIPLINE SPECIFIC ELECTIVE COURSE II MOLECULAR HOST-MICROBE INTERACTIONS	CREDITS: 4

Course Objectives

To provide an understanding of the biology, physiology, genetics, and biochemistry of interactions between hosts and their pathogens; To provide a good working knowledge of current research tools to address questions in host (human or plant)-pathogen interactions and application of the knowledge in obtaining diseases resistant plants

Unit	Topics	Total No. of

		Lectures/ Hours (60)
I	**Molecular Mechanisms of Pathogenicity I: Human Pathogen** Entry of microorganisms in to the host, portals of entry, adherence, penetration of host defense; contribution of capsules, cell wall components and enzymes in pathogenicity; antigenic variation, penetration into the host cell cytoskeleton; mechanisms of host cells damage caused by bacterial pathogens	8
II	**Molecular Mechanisms of Pathogenicity II: Human Pathogen** Pathogenic properties of viruses, viral mechanisms for evading host defenses, viral cytopathic effects, pathogenic properties of fungi, protozoa, helminthes, and algae; portals of exit for human pathogens	8
III	**Genetics of Plant Disease and Plant Defense** Genes and disease, variability in organisms, adapted pathogen vs non-adapted pathogen, types of plant resistance, quantitative or horizontal resistance, *R*-gene resistance or vertical resistance, apparent resistance, non-host resistance, avirulence (*avr*) genes, gene for gene hypothesis, hypersensitive responses (HR); Plant defense: pre-existing structural and chemical defenses, induced structural and biochemical defenses, immunization of plants against pathogens, systemic induced resistance (SAR), induced systemic resistance (ISR), concept of defense priming in plants.	14
IV	**Molecular Mechanism of Plant Pathogenesis** Concepts of pathogenicity and virulence, Fungal pathogenicity functions (formation of infection structures, degradation of plant cuticle and cell wall, overcoming the plant secondary metabolites, production of fungal toxins and signaling components), bacterial pathogenicity functions (adhesions, surface polysaccharides, secretion systems, effectors, cell wall degrading enzymes bacterial phytotoxins, regulatory networks and sensing system) and viral pathogenicity factors.	12
V	**Plant Immunity** Recognition of pathogen and plant immune responses: The zigzag model of plant immunity, PAMP-triggered immunity, effector-triggered susceptibility and effector-triggered immunity, plant defense signaling components and downstream events, plant hormones in plant defense responses.	10
VI	**Plant Protection** Application of genetic engineering in plant disease control, transgenic and gene manipulation approach for crop protection, use of chemical elicitors in inducing plant defense responses.	8

Course Outcomes: Upon successful completion students should be able to:

1. Acquire the knowledge about the molecular mechanisms of the interaction between the host (plant or human) and pathogenic microbes.
2. Critically analyse, evaluate and summarise the literature on a specific scientific area of infectious disease.

SUGGESTED READINGS

1. Willey, J.M., Sherwood, L., Woolverton, C.J., 2010. Prescott's Microbiology. 8th edition, McGraw-Hill.
2. Agrios, G. N., 1988. Plant Pathology, Academic Press.
3. John A Lucas, 1998. Plant Pathology and Plant Pathogens, Wiley-Blackwell, CRC Press.
4. Dickinson, C. M., 2003. Molecular Plant Pathology, Bios Scientific Publisher

5. Robert, N., Trigiano, Windham, M. T. and Windham, A.S., 2003. Plant Pathology: Concepts and Laboratory Exercises, CRC Press.
6. Bridge, P.D and Clarkson, J.M., 1998. Molecular Variability of Fungal Pathogens, CAB, International
7. Singh, R. S., 2008. Plant Diseases, Oxford and IBH Publishing Co. Pvt Ltd
8. Singh, R. S., 2008. Principles of Plant Pathology, Oxford and IBH Publishing Co. Pvt Ltd.
9. Dhingra, O.D. and James, B. Sinclair, 1995. Basic Plant Pathology Methods, CRC Press
10. Bishen, PS. 2014. Microbes in Practice. I.K. International Publishing House Pvt. Ltd.
11. Aneja, KR, Jain, P and Aneja, KR. 2008. A Text book of Basic and Applied Microbiology. New Age International Publishers, New Delhi.

L080906T	DISCIPLINE SPECIFIC ELECTIVE COURSE II MARINE MICROBIOLOGY	CREDITS: 4

Course Objectives

The aim of this course is to provide students with basic knowledge on the biology and ecology of marine microorganisms, and their ecological role. The study methods and details of the main marine products are also covered.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Microbes and Marine Environment** Introduction marine microbiology, The world's oceans and seas, Chemical and physical factors in the marine environment- Properties of seawater, Solar radiation and temperature. Marine microbial habitats - The water column and marine snow, Sediments, at surfaces—biofilms and microbial mats, Sea ice, Hydrothermal vents and cold seeps, Living organisms as microbial habitats. Microbial loop- phytoplankton and cyanobacteria, photoheterotrophic bacteria, heterotrophic bacteria, marine archaea, heterotrophic protists, marine fungi, marine viruses	12
II	**Dynamics of Marine Microbes** Carbon cycle: Phototrophic microbes, the oceanic carbonate system and global warming; Nitrogen cycle: Nitrogen fixers; Iron limitation; ocean fertilization; phosphorus cycle; Decomposition of organic matter; Bioleaching and biodeteroriation of natural and synthetic materials.	10
III	**Marine viruses** Marine phages and giant marine viruses, significance of viruses in marine ecosystem. Movement of viruses between biomes; Marine viruses as major players in the global ecosystem and global climate change. Marine virus interactions with prokaryotes, planktons, non-host Organisms	8
IV	**Marine Pollution** Sources marine pollution, kinds of pollution and pollutants, enteric viral pollution, effects of marine pollution on marine fauna and flora, effects of marine pollution on microorganisms, eutrophication of estuarine and coastal ecosystems, monitoring of marine pollution, environment protection regulations, impact assessment and standards, marine microbes and climate change.	10
V	**Marine Microbial Disease** Mechanisms of pathogenicity of marine food borne pathogens – Aeromonas, Vibrio, Salmonella, Pseudomonas, Cornybacter.	8

VI	**Marine products** Microbes of biotechnological importance; Primary and secondary metabolites - enzymes, antibiotics, organic acid, toxins, biosurfactants and pigments. Algal products – single cell protein, hydrocolloids, agarose, carrageen alginates and other by products Commercial development of marine natural products- chitosan, chitin.	12

Course Outcomes: Upon successful completion students should be able to:

1. Know the basic biology of marine microorganisms and their activities
2. Understand the ecological role of marine microorganisms and marine microbial communities
3. Know the main marine products of commercial interest

SUGGESTED READINGS

1. Colin Munn, Marine Microbiology: Ecology & Applications 2nd Edition. Garland Science, Taylor & Francis, 2009. ISBN: 978-0815365174.
2. David L. Kirchman, Microbial Ecology of the Oceans, 2nd Edition, John WIley & Sons, 2008. ISBN: 978-0470043448
3. M.T. Madigan and J.M. Martinko, Biology of Microorganisms, 11th Edition, Pearson Prentice Hall, USA, 2006
4. Bhakuni, D.S. and Rawat, D.S. (2005). Bioactive marine natural products. Anamaya Publishers, New Delhi.
5. Joseph Selvin and A. S. Ninawe (2009). Shrimp Disease Management. ANE Publishers.

L080907P	MAJOR COURSE V	CREDITS: 4
	PRACTICAL WORK: EXPERIMENTS IN ANALYTICAL TECHNIQUES, MOLECULAR BIOLOGY, OMIC TECHNOLOGIES MICROBIAL INTERACTIONS, BIOSAFETY AND MARINE MICROBIOLOGY	

Course Objectives

To impart training on various methods/techniques/instruments used in the study of molecular biology, omic technologies and host-microbe interations.

	Contents
1	Separation of bacterial lipids/amino acids/sugars/organic acids by TLC or Paper Chromatography.
2	Study of UV absorption spectra of macromolecules (protein, nucleic acid, bacterial pigments).
3	Demonstration of PCR, DNA sequencer and Fermenter.
4	Separation of serum protein by submerged agarose gel electrophoresis.
5	Identification of *S. typhi* by serotyping.
6	Demonstration of Western blotting.
7	Clinical diagnosis of viral diseases by PCR, ELISA
8	Immobilization of cells and enzyme using Sodium alginate and egg albumin.
9	Isolation of pathogen from diseased plant parts and In planta growth kinetics of pathogens
10	Demonstration of pathogenicity assays
11	Estimation of bacterial pathogen growth in planta

12	Demonstration of Hypersensitive responses in plants
13	Demonstration of plant defense responses in plants
14	Demonstration of non-host resistance
15	Isolation and characterization of microbes from mangroves
16	Isolation and characterization of microbes from coastal waters
17	Case study and reporting of specific points of a patent

Course Outcomes: Upon successful completion students should be able to:

1. Gain knowledge on chromatographic techniques and various biological methods of analysis.
2. Acquire the knowledge of techniques of isolation DNA and PCR analysis.
3. Uses basic methods and research tools applied in host-microbe interactions.

SUGGESTED READINGS:

1. Weaver, D. and Tart, R. C., "A Laboratory Manual for General Microbiology" (1998). *Biology*. 46. https://cufind.campbell.edu/biology/46
2. Campbell, JL "A Manual of Scientific and Practical" Publ. BiblioBazaar.
3. Dr. R. C. Dubey and Dr. D. K. Maheshwari 'Practical Microbiology' S. Chand Publications
4. Molecular Cloning: A Laboratory Manual, Volume 1, Joseph Sambrook, David William Russell Cold Spring Harbor Laboratory Press.
5. Molecular Cloning, Volume 2, Joseph Sambrook, Cold Spring Harbor Laboratory Press.

	INDUSTRIAL TRAINING/ REVIEW/ SURVEY/ RESEARCH PROJECT	**CREDITS: 4**
	RESEARCH PROJECT DISSERTATION	

Course Objectives

This course objective is to impart competent skills to thrive in research institutions and industries.

Note:

1. Project work will involve experimental work.
2. Students are required to do an individual research project.
3. Students are required to submit a report for assessment and need to demonstrate the working of research findings.
4. Students will be asked their choice for Project work at the end of VIII semester and all formalities of topic and mentor selection will be completed by this time.
5. The IPR rights of all such work lie with the University only.

Course Outcomes: Upon successful completion students should be able to:

1. List the objectives and state the hypothesis of the research project.
2. Outline the methodology that will be followed to achieve the listed objectives.
3. Employ the finalised methodology to solve the problem which has been undertaken.
4. Analyse the data which has been generated by carrying out several experiments.
5. Evaluate the data – accuracy and precision, sources of errors, specificity, sensitivity and detection limits, regression analysis, reporting results.
6. Organize the inferences to prove the hypothesis.

SEMESTER X

L081001T	MAJOR COURSE I MOLECULAR MICROBIAL GENETICS	CREDITS: 4

Course Objectives

The objectives of this course are to teach students various techniques used in microbial genetics and enable them to understand the relevance of microbial genetics in biotechnology.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Genome Organization and Mutations** Genome organization: *E. coli, Saccharomyces, Tetrahymena.* Organelle genome: Chroloroplast and Mitochondria. Mutations and mutagenesis: Definition and types of Mutations; Physical and chemical mutagens; Molecular basis of mutations; Functional mutants (loss and gain of function mutants); Uses of mutations. Reversion and suppression: True revertants; Intra- and inter-genic suppression; Ames test; Mutator genes.	12
II	**DNA damage and repair**: Types of damages, damaging agents, Repair mechanisms – mismatch repair, excision repair, photoreactivation, dark repair, recombinational repair, SOS system, Role of DNA repair system in conservation of genome integrity, relationships to life span and aging processes.	8
III	**Plasmids** Types of plasmids – F plasmid, R Plasmids, colicinogenic plasmids, Ti plasmids, linear plasmids, yeast-2 μ plasmid, Plasmid replication and partitioning, Host range, plasmid-incompatibility, plasmid amplification, Regulation of copy number, curing of plasmids.	8
IV	**Mechanisms of Genetic Exchange** Transformation - Discovery, mechanism of natural competence. Conjugation - Discovery, mechanism, Hfr and F' strains, Interrupted mating technique and time of entry mapping. Transduction - Generalized transduction, specialized transduction, LFT & HFT lysates, Mapping by recombination and co-transduction of markers.	12
V	**Phage Genetics** Features of T4 genetics, Genetic basis of lytic *versus* lysogenic switch of phage lambda (Immunity to infection, Prophage integration, Induction of prophage, Induction & Prophage excision, Repressor, Structure of the operator and binding of the repressor and the Cro product, Decision between the lytic and lysogenic Cycles).	8
VI	**Transposable elements** Prokaryotic transposable elements – Insertion Sequences, composite and non-composite transposons, Replicative and Non replicative transposition, Mu transposon. Eukaryotic transposable elements - Yeast (Ty retrotransposon), Uses of transposons and transposition.	12

Course Outcomes: Upon successful completion students should be able to:

1. Understand the processes behind mutations and other genetic changes.
2. Identify and distinguish genetic regulatory mechanisms at different levels.

3. Insight into genetic methods used to investigate interesting biological problems.
4. Insight into current, exciting topics in microbial genetics and related fields.s

SUGGESTED READINGS

1. Klug WS, Cummings MR, Spencer, C, Palladino, M (2011). Concepts of Genetics, 10th Ed., Benjamin Cummings.
2. Krebs J, Goldstein E, Kilpatrick S (2013). Lewin's Essential Genes, 3rd Ed., Jones and Bartlett Learning.
3. Pierce BA (2011) Genetics: A Conceptual Approach, 4th Ed., Macmillan Higher Education Learning.
4. Gardner EJ, Simmons MJ, Snustad DP (2008). Principles of Genetics. 8th Ed. Wiley-India.
5. Russell PJ. (2009). *i* Genetics- A Molecular Approach. 3rd Ed, Benjamin Cummings.

L081002T	MAJOR COURSE II ADVANCED IMMUNOLOGY AND IMMUNOTECHNIQUES	CREDITS: 4

Course Objectives

This course will teach the biology of the Immune system and apply this knowledge to an understanding of human disease and basic immunological research and various immunotechniques.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Immunology – Overview** Distinguishing features of innate and specific immune response, Passive and Active immunity, Three lines of immune defence, Primary and secondary lymphoid organs, Haematopoiesis- innate and acquired immune cells, Inflammation, Cytokines, Defensins	10
II	**Antibody-Immunoglobulins** Classes and subclasses, structure-function relationship, isotypes, idiotypes and allotypes. B cell receptor and B cell signalling, B cell differentiation. T cell dependant and independent B cell activation, Jerne's Idiotypic network	10
III	**Immunogenetics** Blood groups and transplantation antigens, HLA and disease association, antigen processing and MHC, Theories of antibody synthesis and generation of antibody diversity-molecular basis of repertoire generation, Generation of T cell diversity	10
IV	**Cellular Immunology** Burnets cloning selection theory, TCR, T cell signalling, Types of T and B cells, Regulatory T cells, Immune tolerance- Central and Peripheral mechanisms, Autoimmunity mechanisms	10
V	**Immunity to infections** Immunity to infection by viruses, bacteria, fungi and parasites and immunity to tumors, autoimmune diseases – aetiology, pathogenesis and treatment. **Vaccines** Vaccine, adjuvants, cytokines, DNA vaccines, recombinant vaccines, bacterial vaccines, viral vaccines, edible and plant vaccines, tumor vaccines, principles of vaccination, passive & active immunization, immunization programs & role of WHO in immunization programs. Targeted immunotherapy, Vaccine & peptide therapy in Transplantation	10

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VI	**Immunotechniques** Antigen-antibody reactions – complement fixation, agglutination, precipitation, immuno-diffusion, immunoelectrophoresis, Immuno-fluorescence, enzyme-linked immunosorbent assay (ELISA), radioimmunoassay (RIA). Production and applications of monoclonal and polyclonal antibodies for diagnosis and therapy Flow cytometry analysis, ELISPOT, Intracellular cytokine staining, Cytotoxicity assays, apoptosis assays, generation of transgenic and knock out mice.	10

Course Outcomes: Upon successful completion students should be able to:

1. Demonstrate detailed knowledge of how the immune system normally responds to infection.
2. Apply knowledge and incorporate principles to show how aberrations in immuno-regulation underlie autoimmunity, immunodeficiency, allergy and cancer.
3. Acquire, analyse and interpret experimental data on research in immunology.

SUGGESTED READINGS

1. Therapeutic Immunology, authors. K Frank Austen, Steven J Burakoff, Fred Rosen, Terry B Strom, Publisher : Blackwell Science
2. Goldsby RA, Kindt TJ, Osborne BA. (2007). Kuby's Immunology. 6th edition W.H. Freeman and Company, New York.
3. Murphy K, Travers P, Walport M. (2008). Janeway's Immunobiology. 7th edition Garland Science Publishers, New York.
4. Peakman M, and Vergani D. (2009). Basic and Clinical Immunology. 2nd edition Churchill Livingstone Publishers, Edinberg.
5. Richard C and Geiffrey S. (2009). Immunology. 6th edition. Wiley Blackwell Publication.

L081003T	DISCIPLINE SPECIFIC ELECTIVE COURSE I NANOBIOTECHNOLOGY	CREDITS: 4

Course Objectives

The objective of the course is to provide foundational knowledge of the Nanoscience and related fields and to make the students acquire an understanding the Nanobiotechnology and Applications.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Introduction to nanotechnology** What is nanotechnology? - What is Nanobiotechnology? - What is nanomaterial? Evolution of Nanoscience – Need of Nanotechnology – Hurdles for Nanotechnology development – Factors affecting the manufacturing process of nano materials – Role of physicists, chemists, medical doctors, engineers, biologists and computer scientists in nanotechnology. Ethics and society	4
II	**Classification of nanostructures** Nanospheres, Nanotubes, Nanorods, Nanowires, Nanosheets, Quantum dots - Effects of the nanometre length scale - Changes to the system structure - How nanoscale dimensions affect properties - Nanocomposites - Graphene - Carbon Nanotubes - Fullerenes - Natural Nanomaterials - Bio-inspired nanomaterials.	12
III	**Synthesis Methods of Nanomaterials** Physical synthesis- Ball Milling - Electrodeposition - Spray Pyrolysis -	14

	Thermal evaporation Chemical synthesis - Sol-Gel Process - Metal Nanocrystals by Reduction - Solvothermal Synthesis - Biological Synthesis - Protein-Based Nanostructure Formation - DNA-Templated Nanostructure Formation - Protein Assembly	
IV	**Protein based nanostructures** Protein based nanostructures, Biomolecular Nanomotors (E. coli), myosin based mammalian nanostructure, nanobiosensors, self assembly structures, Nano Printing of DNA, RNA, and Proteins, Biochips Applications in Nano Scale Detection, Lab-on-a-chip Devices (LOC)	12
V	**Nanobiotechnology for drug development and medical applications** Nanotechnology for drug solubilization and drug delivery. Diagnosis using nanomaterials. Nanotherapy for cancer treatment – Interior artery expansions – Replacing joints with better stuff. - Radioactive tuberene cages in Nuclear medicine.	10
VI	**Cleaner environment with Nanotechnology** Cleaning the air with Nanotechnology – Nanotechnology for water treatment. Microbial nanoparticles. Nanocarbon ball as deodorizer in ferment process. Biomotors for engineered devices. Possible harm from Nanomaterials (Fate of nanomaterials in environment; cytotoxicity and Ecotoxicity models and assays; Life Cycle Assessment, Containment).	8

Course Outcomes: Upon successful completion students should be able to:

1. Learn about the background on Nanoscience.
2. To provide an introduction to the field of nanoscience and nanotechnology and its scope in biotechnology.
3. Understand the different structure and properties of different types of nanostructures.
4. Understand bio based nanostructures and their working and applications.
5. To have application based understanding of nanobiotechnology in the different fields.
6. Understanding of safety and toxicity issues related with nanobiotechnology.

SUGGESTED READINGS

1. Nanoscale Science and Technology, Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, John Wiley & Sons, Ltd., UK, 2005.
2. Nano:The Essentials: Understanding Nanoscience and Nanotecnology, T.Pradeep, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2008.
3. Nanostructures & Nanomaterials: Synthesis, Properties & Applications, Guozhong Gao, Imperial College Press, 2004.
4. Encyclopedia of Materials Characterization, C. Richard Brundle, Charles A. Evans Jr., Shaun Wilson, Butterworth-Heinemann Publishers, 1992.
5. Nanotechnology: Basic Science and Emerging Technologies - Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse, Overseas Press, 2005.
6. Nanoparticles as Drug carriers, Vladimir P Torchilin, Imperial College Press, USA, 2006.

L081004T	DISCIPLINE SPECIFIC ELECTIVE COURSE I PHARMACEUTICAL MICROBIOLOGY	CREDITS: 4

Course Objectives

The goal of the course is for students to acquire the necessary practical skills for application of microbes in production of pharmaceutically active compounds.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Introduction to chemotherapeutic agents** History and development of chemotherapeutic agent, Properties of antimicrobial agents, Types of chemotherapeutic agents – Synthetic, Semisynthetic, Natural. Antibiotics: Types of antibiotics with their mode of action; antibacterial, antifungal, antiviral, antiprotozoal	10
II	**Antibiotic resistance and development of new therapeutics** Development of antibiotic resistance, Mechanism of antibiotic resistance, Antimicrobial Peptides: History, properties, sources, mode of action, application. Phage therapy: types of phages involved in phage therapy. Plant based therapeutic agents.	10
III	**Sterilization and Microbial spoilage of pharma products** Microbial contamination spoilage and hazard: Sources of contamination, factors affecting survival and growth, breakdown of active ingredient and general formulations. Principles of sterilizations with respect to pharmaceutical industries. Methods of sterilizations: Steam, dry heat, Radiation, Gaseous and Filtration	8
IV	**Preservation of Pharma Products: Principles of preservation** Objectives of preservation, the ideal preservative, rational development of a product preservative system etc. Antimicrobial preservatives and their properties: antimicrobial activity, factors affecting antimicrobial activity, preservative monographs. Preservative stability and efficacy. methods of Preservative evaluation and testing	10
V	**Drug Discovery and Development** Microbial, Recombinant, Biochemical and Molecular level screening systems and their construction/ design strategies. Conventional Process; Bio-prospecting. Search of database/data mining for Drug designing; Preclinical and Clinical trials; Estimation of toxicity: LD50 and ED50; Rational Drug Design – Principle (Structure activity relationship -SAR) and Tools (applications of High through Put Screening, Combinatorial synthesis, Pharmaco-genomics)	12
VI	**Regulatory practices, biosensors and applications in Pharmaceuticals** Financing R&D capital and market outlook. IP, BP, USP. Government regulatory practices and policies, FDA perspective. Reimbursement of drugs and biologicals, legislative perspective. Rational drug design. Immobilization procedures for pharmaceutical applications (liposomes). Macromolecular, cellular and synthetic drug carriers.	10

Course Outcomes: Upon successful completion students should be able to:

1. Identify different antimicrobial agents and it's mode of action.
2. Process involved in Drug discovery and development.
3. Regulatory guidelines in pharmaceuticals product.

SUGGESTED READINGS

1. Pharmaceutical Microbiology – Edt. by W.B.Hugo & A.D.Russell Sixth edition. Blackwell scientific Publications
2. Prescott's Microbiology 8th Edition by Willey, Joanne, Sherwood, Linda, Woolverton, Chris
3. Pharmaceutical Microbiology by Ashutosh Kar
4. Hugo, WB and Russell, AD. Pharmaceutical Microbiology, (2003). Blackwell Science, Oxford, UK.
5. Krogsgaard L, Lilijefors T. and Madsen, U. Textbook of Drug Design and Discovery, (2004). Taylor and Francis, London.
6. Geoffrey Hanlon and Norman Hodges. Essential Microbiology for pharmacy and pharmaceutical science. (2013).Wiley Blackwell.
7. S. P. Vyas & V. K. Dixit. Pharmaceutical Biotechnology. (2003) CBS Publishers & Distributors, New Delhi.
8. Bhatia R and Ichhpujani RL. Quality Assurance in Microbiology. (1995). CBS Publishers, New Delhi.
9. Gregory Gregoriadis. Drug Carriers in biology & Medicine. (2001). Academic Press New York.

L081005T	DISCIPLINE SPECIFIC ELECTIVE COURSE II ANIMAL CELL, TISSUE CULTURE AND TRANSGENIC TECHNOLOGY	CREDITS: 4

Course Objectives

The goal of the course is for students to acquire the necessary practical skills for the isolation of mammalian cells for in vitro studies, maintenance of animal cells in vitro, manipulation of animal cells in vitro, and application of molecular techniques to in vitro situations.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Introduction to animal cell and tissue culture** Animal cell and tissue culture advantages and limitations, Applications of animal cell and tissue culture. Basic techniques in animal cell culture: Disaggregation of tissue and setting up of primary culture, established cell line cultures, maintenance of cell culture, culture media and role of serum in cell culture, tissue and organ culture.	10
II	**Cell Culture methods** Biology and characterization of the cultured cells, measurement of growth, measurement of viability and cytotoxicity. Scale up of animal cell culture, cell cloning, cell synchronization and transformation. Production and use of artificial tissues and organs – Skin, liver and pancreas. Apoptosis - mechanism and significance.	10
III	**Stem cells** The biology of stem cells, Different types of stem cells – embryonic stem cells, fetal tissue stem cells, adult stem cells; stem cell differentiation, stem cell plasticity – Differentiation versus stem cell renewal. Isolation and propagation of embryonic stem cells; chimeras; generation of knockout mice and knock-in technology.	10
IV	**Genetic engineering of mammalian cells** Mammalian cell lines, Mammalian cell expression system, Gene transfer techniques in mammalian cells, Sexing of embryos, Somatic cell nuclear transfer and transgenic animals. Production of transgenic animals - mice, sheep and fish. Molecular pharming and animal cloning. Somatic cell nuclear transfer in humans	12

	– Legal and ethical aspects. Potential applications of transgenic animals – Animal models for diseases and disorders. Transgenic poultry and transgenic insects as bioreactor.	
V	**Hybridomas and cell transformation** The basis of hybridoma technology, Storage of hybridoma cells, Monoclonal antibodies and their commercial production, Commercial production of monoclonal antibodies and their use for mankind.	8
VI	**Gene therapy** Genetic disorders, vector engineering, types of gene therapy, strategies of gene delivery, targeted gene replacement/augmentation, gene editing, gene correction, gene silencing. Molecular markers linked to disease resistance genes, Application of RFLP in forensic, disease prognosis, genetic counselling and pedigree analysis.	10

Course Outcomes: Upon successful completion students should be able to:

1. Develop basic aseptic skills for mammalian cell culture and their applications.
2. Understand media constituents and media formulation strategies for mamalian cell culture.
3. Develop proficiency in mammalian cell culture and the maintenance of cell lines.
4. Apply cell and molecular techniques to in vitro situations.

SUGGESTED READINGS

1. Animal Cell Culture: A practical approach by R.I. Freshney, IRL press.
2. Culture of animal cells: A manual of basic techniques by R.I. Freshney, Willy-Liss and Sons publication.
3. Animal cell culture technique by Martin Clynes, Springer publication.
   Animal Cell Culture – A Practical approach Ed. by John R.W.Masters (IRL Press)

L081006T	DISCIPLINE SPECIFIC ELECTIVE COURSE II ENZYME TECHNOLOGY	CREDITS: 4

Course Objectives

The goal of the course is for students to acquire the understanding of enzyme kinetics, sources of enzymes, conditions to be optimized for function and applications; and to impart sense of knowledge of enzyme immobilization and biosensor for advanced future applications.

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Introduction to enzyme and enzyme technology** History and scope of enzymes and enzyme technology, nomenclature of enzymes, enzyme activity units. Enzyme Kinetics: Activation Energy & Transition State concept. Mechanism of enzyme catalysis, simple kinetics of enzyme action, factors affecting enzyme activity, reversible reaction, enzyme inhibition, determination of Vmax and Km values.	
II	**Sources and preparation of enzymes** Sources of enzymes, screening strategies for novel enzymes, media for enzyme production, methods of purification and concentration of intracellular and extracellular enzymes, factors affecting enzyme stability, preparation of enzymes for sale, customer service, safety and regulatory aspects of enzyme use, enzyme business, major manufacturers of enzymes in India and World	
III	**Large Scale use of enzymes in solution**	

	Use of enzymes in detergents, food industry, fruit juice, wine, brewing and distilling industries, textile industries, waste treatment, diagnostics, pharmaceutical and chemical industries, application of enzymes in medicine.	
IV	**Preparation and kinetics of immobilized enzymes** Methods of immobilization of enzymes, Physical adsorption, covalent binding, entrapment and micro encapsulation, kinetics of immobilized enzymes, effect of solute partition and diffusion on the kinetics of immobilized enzymes, use of immobilized enzymes. **Biosensors** Use of enzymes in analysis, biosensors- calorimetric, potentiometric, amperometric, optical, piezoelectric biosensors and immuno-sensors.	
V	**Immobilized enzymes and their use** Enzyme reactors, stirred tank reactors, plug flow reactors, continuous flow stirred tank fluidized bed reactor, Membrane/hollow fiber reactors, selection of reactors, productivity and performance of various types of reactors, immobilized enzyme processes - production of high fructose corn syrups, production of antibiotics, production of acrylamide and use of immobilized invertase, lactase, raffinase.	
VI	**Advanced topics in enzyme technology** Enzyme reactions in biphasic liquid systems; proteases, glycosidases and lipases in synthetic reactions, interesterification of lipids, artificial enzymes, un-natural substrates, enzyme engineering, extremophilic enzymes, hybrid enzymes, high throughput screening and assay techniques.	

Course Outcomes: Upon successful completion students should be able to:

1. Learn the enzyme kinetics and its types.
2. Understand the phenomenon of allostery, various associated models and examples.
3. Understand enzymology and its applications.

SUGGESTED READINGS

1. Enzyme Technology: MF Chaplin and DC Bucks
2. Industrial Enzymology: Godfrey and West
3. Enzyme: Copeland
4. Enzymes in Industry: W Gerhartz

L081007P	MAJOR COURSE V	CREDITS: 4
	PRACTICAL WORK: EXPERIMENTS IN MICROBIAL GENETICS, IMMUNOTECHNIQUES, CELL CULTURE TRANSGENICS, NANOBIOTECHNOLOGY, ENZYME TECHNOLOGY AND PHARMACEUTICAL MICROBIOLOGY	

Course Objectives

The objective of this course is to educate and to provide hands-on training in microbial genetics, immunotechnologies and cell culture techniques and safety issues.

	Content
1	Effect of UV radiations to study the survival pattern of *E. coli*/ yeast.

2	Isolation of antibiotic resistant mutants by chemical mutagenesis.
3	Ampicillin selection method for isolation of auxotrophic mutant.
4	Extraction and Purification of RNA from *S. cerevisiae*.
5	Restriction digestion and agarose gel electrophoresis of DNA
6	Generalized transduction in E. coli using P1 phage
7	Perform immunodiffusion by Ouchterlony method.
8	Perform DOT ELISA
9	Perform immunoelectrophoresis.
10	Preparation of primary cell culture from chick embryo
11	Subculturing and maintenance of cell lines
12	Study of effect of toxins/ toxic chemicals on cell lines
13	Assay of some common enzymes (amylase, protease, pectinase, lipase etc.)
14	Microbial production of an enzyme.
15	Purification of enzyme, determination of Vmax and Km values.
16	Effect of temperature, pH, ionic strength, inhibitors and metal ions on enzyme activity
17	Microbial Examination of Non-Sterile Products
18	To determine MIC, LD 50 of Beta-lactum/aminoglycoside/ tetracycline/ansamycins.
19	Determination of D value, Z value for heat sterilization in pharmaceuticals.
20	Antibiotic Potency Testing

Course Outcomes: Upon successful completion students should be able to:

1. Demonstrate an understanding of the concepts of microbial genetics.
2. Elucidate the basic techniques used in culturing tissues and cells.
3. Design and present results of a immunotechniquess-based experiment.

SUGGESTED READINGS

1. Weaver, D. and Tart, R. C., "A Laboratory Manual for General Microbiology" (1998). *Biology*. 46. https://cufind.campbell.edu/biology/46
2. Campbell, JL "A Manual of Scientific and Practical" Publ. BiblioBazaar.
3. Dr. R. C. Dubey and Dr. D. K. Maheshwari 'Practical Microbiology' S. Chand Publications
4. Molecular Cloning: A Laboratory Manual, Volume 1, Joseph Sambrook, David William Russell Cold Spring Harbor Laboratory Press.
5. Molecular Cloning, Volume 2, Joseph Sambrook, Cold Spring Harbor Laboratory Press
6. Molecular Microbiology: Diagnostic Principles and Practice (ASM Books Book 51) 3rd Edition, Kindle Edition by David H. Persing, Fred C. Tenover, Randall T. Hayden, Margareta Ieven, Melissa B. Miller, Frederick S. Nolte, Yi-Wei Tang, Alex van Belkum

L081008R	INDUSTRIAL TRAINING/ REVIEW/ SURVEY/ RESEARCH PROJECT RESEARCH PROJECT DISSERTATION	CREDITS: 4

Course Objectives

This course objective is to impart competent skills to thrive in research institutions and industries.

Note:

1. Project work will involve experimental work.
2. Students are required to do an individual research project.
3. Students are required to submit a report for assessment and need to demonstrate the working of research findings.
4. Students will be asked their choice for Project work at the end of VIII semester and all formalities of topic and mentor selection will be completed by this time.
5. The IPR rights of all such work lie with the University only.

Course Outcomes: Upon successful completion students should be able to:

1. List the objectives and state the hypothesis of the research project.
2. Outline the methodology that will be followed to achieve the listed objectives.
3. Employ the finalised methodology to solve the problem which has been undertaken.
4. Analyse the data which has been generated by carrying out several experiments.
5. Evaluate the data – accuracy and precision, sources of errors, specificity, sensitivity and detection limits, regression analysis, reporting results.
6. Organize the inferences to prove the hypothesis.

	MINOR ELECTIVE COURSE ANY COURSE*	CREDITS: 4
Course Objectives To enable the students to understand and learn the subject of their liking.		
***Note:** 1. Student can opt course offered by any program running in Chhatrapati Shahu Ji Maharaj University, Kanpur		
Course Outcomes: Upon successful completion students should be able to: 1. Will become able to understand and utilize the skills of interdisciplinary courses.		

Z010101T, Z020201, Z030301, Z040401, Z050501, Z060601	CO-CURRICULAR COURSE *Course Offered As Per University Guidelines	CREDITS: 4
Course Objectives To provide Purposeful and assessable learning opportunities that support academic programming designed to facilitate the development of the whole student.		
Course Outcomes: Upon successful completion students should be able to: 1. Empower and inspire others. 2. Promote cultural diversity within our community. 3. Act with honesty and principles to facilitate positive social change. 4. Identify effective self-care strategies to foster healthy, mind, body, and spirit (purpose, reflection, awareness, personal fulfillment). 5. Demonstrate and apply interdisciplinary connections. 6. Cultivate spirit of creative thought and curiosity to achieve goals.		