

**Learning Outcomes based Curriculum Framework
(LOCF)
for
MICROBIOLOGY
Undergraduate Programme
2019**



ज्ञान-विज्ञान विमुक्तये

**UNIVERSITY GRANTS COMMISSION
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Preamble

Microbiology is the study of microorganisms or microbes such bacteria, viruses, fungi, algae, cyanobacteria, protozoa and prions. They are extremely important as their diverse activities range from causation of deadly diseases in humans, animals and plants to production of highly useful products like antibiotics, enzymes, alcohol, fermented foods, and recycling of dead and decaying organic matter in the nature. Thus the science of microbiology has an important role to play in health, agriculture, environment and industry. Several discoveries in the last two to three decades, which significantly impact these area have put Microbiology on the centre stage of teaching, research and development all over the globe.

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

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

enhance the expanse of the subject. DSE also give the students a chance to apply their knowledge of microbiology to study societal problems and suggest solutions in the form of small project under the mentorship of their teachers. These are also designed to expose the students to leaders / innovators in the areas related to microbiology for inspiration. The Generic Elective Courses (GEC) are designed to impart comprehensive understanding of Microbiology to students from other disciplines. The Microbiology students will have the choice to select courses from other disciplines depending on their interest and passion besides Microbiology. The CC, DSE and GEC are all 6 credit (4 Credit Theory and 2 Credit Laboratory work) courses. A number of Skill based Elective Courses (SEC), 4 Credits each would give the students option to develop skills in areas which have direct relevance to employability in diagnostics, health, food and pharmaceutical industries, agriculture and environment-related job opportunities in Microbiology. The focus of the Ability Enhancement Compulsory Courses (AECC) which are 2 Credits each, is to develop communication skills and awareness about our environment. To comply with the education policy of Govt. of India namely access, equity and quality we have included Online Courses (OLC) which are available on NPTEL or SWAYAM portals under MOOCS programme being developed by MHRD to provide opportunity to the most disadvantaged students and to bridge the digital divide. The online courses would also inculcate the habit of self-study at their own pace by the students and also acclimatize them to future technologies of learning processes.

1. Introduction:

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

2. Learning Outcomes based approach to Curriculum Planning:

Learning Outcome based approach to curriculum planning (LOCF) is almost a paradigm shift in the whole gamut of higher education such that it is based on first and foremost identifying the outcomes of the learning required for a particular subject of study, and then planning all components of higher education so as to achieve these outcomes. The learning outcomes are the focal point of the reference to which all planning and evaluation of the end learning

is compared and further modifications are made to fully optimize the education of the individuals in a particular subject. For the subject of Microbiology the outcomes are defined in terms of the understanding and knowledge of the students in microbiology and the practical skills the students are required to have to be competitive microbiologist so that they are able to play their role as microbiologist wherever required in the society such as the diseases caused by the microbes, their diagnosis and remedies; the role of microbiologists in the biotechnology industry and how they may be able to fit the bill in the industry. The students are also trained in such a way that they develop critical thinking and problem solving as related to the microbiology. The curriculum developed and the teaching and the evaluation tasks are such that the students are able to apply their knowledge and training of microbiology to solve the problems of microbiology as these exist or appear from time to time in the society. The curriculum envisions that the student, once graduate as specialists in a discipline, have an important role to play in the newer developments and innovations in the future in the subject for advancement of the discipline.

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

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

microbiologists. The current LOCF in Microbiology has been designed in keeping all these important points in mind.

2.2 Aims of Bachelor's degree programme in MICROBIOLOGY:

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

3. Graduate Attributes in Microbiology:

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

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

4. Qualification Descriptors:

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

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

5. Programme Learning Outcomes of B.Sc. Hons Microbiology course:

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

1. Acquired knowledge and understanding of the microbiology concepts as applicable to diverse areas such as medical, industrial, environment, genetics, agriculture, food and others.

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

6. Structure of B.Sc. Hons Microbiology course

Semester	Core Courses (CC)	Discipline Specific Elective (DSE)	Generic Elective (GEC)	Skill Enhancement Course (SEC)	Ability Enhancement Compulsory Course (AECC)	Total Marks & Credits
Semester I	2 PAPERS T(4x2=8) P(2x2=4) Total =12	1 PAPER T(4x1=4) P(2x1=2) Total =6	NIL	NIL	1 PAPER T(4x1=4) Total =4	400 Marks (22 Credits)
Semester II	2 PAPERS T (4x2=8) P(2x2=4) Total =12	1 PAPER T(4x1=4) P(2x1=2) Total =6	NIL	NIL	1 PAPER T(4x1=4) Total =4	400 Marks (22 Credits)
Semester III	2 PAPERS T (4x2=8) P(2x2=4) Total =12	1 PAPER T(4x1=4) P(2x1=2) Total =6	1 PAPER T(4x1=4) P(2x1=2) Total =6	NIL	NIL	400 Marks (24 Credits)
Semester IV	2 PAPERS T (4x2=8) P(2x2=4) Total =12	1 PAPER T(4x1=4) P(2x1=2) Total =6	1 PAPER T(4x1=4) P(2x1=2) Total =6	NIL	NIL	400 Marks (24 Credits)
Semester V	3 PAPERS T (4x3=12) P(2x3=6) Total =18	NIL	1 PAPER T(4x1=4) P(2x1=2)	1 PAPER T(4x1=4) Total =4	NIL	500 Marks (28 Credits)

			Total =6			
Semester VI	3 PAPERS T (4x3=12) P(2x3=6) Total =18	NIL	1 PAPER T(4x1=4) P(2x1=2) Total =6	1 PAPER T(4x1=4) Total =4	NIL	500 Marks (28 Credits)
Sem. I – VI Each paper of 100 marks	14 PAPERS 1400Marks	4 PAPERS 400Marks	4 PAPERS 400Marks	2 PAPERS 200Marks	2PAPERS 200Marks	2600 Marks (148 Credits)

FOR B. Sc. MICROBIOLOGY (Without Honors)	12 PAPERS 1200Marks (48+24=72)	4 PAPERS 400Marks (16+8=24)	4 PAPERS 400Marks (16+8=24)	2 PAPER S 200Mark s (8)	2 PAPERS 200Mark s (8)	2400Mark s (136 Credits)
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T = Theory; P = Practical or Lab work.

Numbers in parentheses indicate the credits of the course.

Students can opt *any two* on-line courses available on MOOCS through SWAYAM / NPTEL) in lieu of any two of the above courses.

Course credits:

CC, DSE & GEC - Each course is of 6 credits(4 Credits of Theory + 2

Credits of Lab Work)

AECC & SEC – Each course is of 4 credits.

Each course is of 100 Marks

Distributions of Marks within each Paper except Skill-Based Courses*:

Each Paper Per semester : 100 Marks (Theory: 75 Marks + Lab.

Course: 25 Marks) Theory Paper : 75 Marks (Internal

assessment: 15 + Term end Exam: 60)

Internal assessment : Average of 2 best performances out of 3 tests would be considered

2 Test examinations and 1 assignment: 15 marks of each

***Skill-Based Course : 100 Marks**

Theory: 25 Marks and Lab. / Field work: 75 Marks

**➤ Internal assessment: 15 + Term end
Exam:60**

PATTERN OF QUESTION PAPER

SEMESTER END EXAMINATION

- The paper comprises five Units containing one question of 12marks from each unit.
- All five questions are compulsory with internal choice within each question.
- Each question will comprise
 - [a] 2 objective type questions (1 mark each),
 - [b] 2 short answer questions (2 marks each)and
 - [c] 6 conceptual type questions (6 marks each). Of these questions 30% questions would be analytical questions (problem solving type).
- Maximum up to 40% of the question paper's content may be repeated in next examination.

Details of the Courses
CORE COURSES (CC)
CC1: Microbial World and Principles of Microbiology
CC2: Bacteriology and Systematics
CC3: Basic Biochemistry
CC4: Microbial techniques & Instruments
CC5: Virology
CC6: Mycology & Phycology
CC7: Cell and Molecular Biology
CC8: Microbial Genetics
CC9: Microbial Physiology and Metabolism
CC10: Environmental Microbiology and Microbial Ecology
CC11: Industrial Microbiology
CC12: Medical and Veterinary Microbiology, and Immunology
CC13: Agriculture, Food and Dairy Microbiology
CC14: Advanced Microbiology

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

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE)
DSE 1: Biophysics, Biomathematics & Biostatistics
DSE 2: Basic Computer & Bioinformatics
DSE 3: Microbial Biotechnology
DSE 4: Hereditary and Evolution
DSE 5: Biosafety and Intellectual Property Rights
DSE 6: Plant Pathology & Disease Management
DSE 7: Pharmaceutical Microbiology

DSE 8: Advanced Instrumentation: Principles and Applications
DSE 9: Project Work on Microbiology of Societal Importance
DSE 10: Veterinary Microbiology

GENERIC ELECTIVE COURSE (GEC): Any Four
GEC1: Microbial World and Microbial Diversity
GEC2: Bacteriology and Virology
GEC3: Medical Microbiology and Immunology
GEC4: Industrial and Food Microbiology
GEC5: Microbes in Sustainable Agriculture and Development
GEC6: Microbial Enzyme Technology
GEC7: Microbial Genetics and Molecular Biology
GEC8: Genetic Engineering and Biotechnology

SKILL ENHANCEMENT COURSE (SEC): Any Two
SEC1: Microbial Quality Control in Food & Pharmaceutical Industries
SEC2: Microbial Diagnostics and Public Health
SEC3: Human Microbial Disease Management
SEC4: Mushroom Cultivation Technology
SEC5: Food Fermentation Technology
SEC6: Microbial Products (e. g. Antibiotics, Bio-fertilizers, Biofuels, Bio-pesticides, Vaccines etc.)
SEC7: Microbiological Analysis of Air, Water & Soil
SEC8: Interactions with Entrepreneurs in Microbial Biotechnology and Startups

*ON LINE COURSE (OLC):Any Two from MOOCS (NPTEL/SWAYAM)
OLC 1: Applied Environmental Microbiology (NPTEL)
OLC 2: Biochemistry (NPTEL)
OLC 3: Fundamentals of Microbiology (NPTEL)
OLC 4: Food Microbiology and Food Safety (SWAYAM)
OLC 5: Industrial Microbiology (SWAYAM)

Course Learning Outcomes
&
Contents of the Courses
CORE COURSES (CC)

CC1: Microbial World and Principles of Microbiology		
<p>Course learning outcomes: At the conclusion of this course the students -</p> <p>Outcome 1. Have developed a good knowledge of the development of the discipline of Microbiology and the contributions made by prominent scientists in this field.</p> <p>Outcome 2. Have developed a very good understanding of the characteristics of different types of microorganisms, methods to organize/classify these into and basic tools to study these in the laboratory.</p> <p>Outcome 3. Are able to explain the useful and harmful activities of the microorganisms.</p> <p>Outcome 4. Are able to perform basic experiments to grow and study microorganisms in the laboratory.</p>		
THEORY COURSE (4 Credits)		
Unit – 1:	History of microbiology and introduction to the microbial world. Germ theory of disease, Development of various microbiological techniques and golden era of microbiology. Contributions of Antony von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming, Martinus W. Beijerinck, Sergei N. Winogradsky, Selman A. Waksman, Paul Ehrlich, Elie Metchnikoff and Edward	15 Lectures

	Jenner.	
Unit – 2:	Physiochemical and biological characteristics of microorganisms (including viruses); Baltimore classification. Binomial Nomenclature, Whittaker's five kingdom and Carl Woese's three kingdom classification systems and their utility. General characteristics of Cellular microorganisms, wall-less forms - MLO (mycoplasma and spheroplasts) with emphasis on distribution and occurrence, morphology, mode of reproduction and economic importance.	15 Lectures
Unit – 3:	General concept of phytoplanktons and zooplanktons. General characteristics, structure, mode of reproduction and economic importance of actinomycetes with special reference to its application in medicine and industry. General characteristics, occurrence, structure, reproduction and importance of protozoa.	15 Lectures
Unit – 4:	Methods of studying microorganism; Staining techniques: simple staining, Gram staining, negative staining and acid-fast staining. Sterilization techniques (physical & chemical sterilization). Culture media & conditions for microbial growth. Pure culture isolation: Streaking, serial dilution and plating methods; cultivation, maintenance and preservation of pure cultures.	10 Lectures
Unit – 5:	Beneficial and harmful microbes and their role in daily life. Concept of disease in plant and animal caused by microorganism.	5 Lectures
LAB. COURSE (2 Credits)		
<ol style="list-style-type: none"> 1. Microbiology Good Laboratory Practices and Bio-safety. 2. To study the principle and applications of important instruments (biological safety cabinets, autoclave, incubator, BOD incubator, hot air oven, light microscope, pH 		

meter) used in the microbiology laboratory.

3. Preparation of culture media (liquid & solid) for bacterial cultivation.
4. Handling and care of laboratory equipment - autoclave, hot air oven, incubator, and laminar airflow.
5. Sterilization of media using autoclave and assessment of sterility.
6. Sterilization of glassware using hot air oven.
7. Sterilization of heat sensitive material by membrane filtration.
8. Demonstration of the presence of microflora in the environment by exposing nutrient agar plates to air.
9. Observation of microorganisms - bacteria, cyanobacteria protozoa, fungi, yeasts, and algae from natural habitats.
10. Study of common fungi, algae and protozoan using temporary / permanent mounts.

Reference Books

11. Prescott, M.J., Harley, J.P. and Klein, D.A. Microbiology. 5th Edition WCB Mc Graw Hill, New York, (2002).
1. Tortora, G.J., Funke, B.R. and Case, C.L. Microbiology: An Introduction. Pearson Education, Singapore, (2004).
2. Alcom, I.E. Fundamentals of Microbiology. VI Edition, Jones and Bartlett Publishers. Sudbury. Massachusetts, (2001).
3. Black J.G. Microbiology-Principles and Explorations. John Wiley & Sons Inc. New York, (2002).
4. Pelczar, MJ Chan ECS and Krieg NR, Microbiology McGraw-Hill.
5. Willey, Sherwood, Woolverton. Prescott, Harley, and Klein's Microbiology McGraw-Hill publication
6. Tortora, Funke, Case. Microbiology. Pearson Benjamin Cummings.
7. JACQUELYN G. BLACK. Microbiology Principles and explorations. JOHN WILEY & SONS, INC.
8. Madigan, Martinko, Bender, Buckley, Stahl. Brock Biology of Microorganisms. Pearson
9. Tom Besty, D.C Jim Koegh. Microbiology Demystified McGRAW-HILL.

CC2: Bacteriology and Systematics		
<p>Course learning outcomes: At the completion of this course, the students are able to -</p> <p>Outcome 1. Describe characteristics of bacterial cells, cell organelles, cell wall composition and various appendages like capsules, flagella or pili.</p> <p>Outcome 2. Differentiate a large number of common bacteria by their salient characteristics; classify bacteria into groups.</p> <p>Outcome 3. Describe the nutritional requirements of bacteria for growth; developed knowledge and understanding that besides common bacteria there are several other microbes which grow under extreme environments.</p> <p>Outcome 4. Perform basic laboratory experiments to study microorganisms; methods to preserve bacteria in the laboratory; calculate generation time of growing bacteria.</p>		
THEORY COURSE (4 Credits)		
Unit – 1	<p>Cell size, shape and arrangement, capsule, flagella, fimbriae and pili.</p> <p>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.</p> <p>Cell Membrane: Structure, function and chemical composition of bacterial and archaeal cell membranes. Cytoplasm: Ribosomes, mesosomes, inclusion bodies, nucleoid. Endospore: Structure, formation, stages of sporulation.</p>	12 Lectures
Unit – 2	<p>Gram negative and Gram positive bacteria: characteristics and examples. Study of typical eubacteria (<i>Bacillus</i>, <i>Clostridium</i>, <i>Staphylococcus</i>, <i>Streptococcus</i>, <i>Corynebacterium</i>, <i>Mycobacterium</i>, <i>Escherichia</i>, <i>Salmonella</i>, <i>Shigella</i>, <i>Vibrio</i>, <i>Helicobacter</i>, <i>Meningococcus</i>, <i>Spirochetes</i>, <i>Rickettsia</i>, <i>Mycoplasma</i> and</p>	12 Lectures

	<i>Chlamydia</i> .	
Unit – 3	Nutritional requirements in bacteria and nutritional categories. Culture media: components of media, natural and synthetic media, chemically defined media, complex media, selective, differential, enriched and enrichment media. Physical methods of microbial control: heat, low temperature, high pressure, filtration, desiccation, osmotic pressure, radiation. Chemical methods of microbial control: disinfectants, types and mode of action. Asexual methods of reproduction, logarithmic representation of bacterial populations, phases of growth, calculation of generation time and specific growth rate.	12 Lectures
Unit – 4	Aim and principles of classification, systematics and taxonomy, concept of species, taxa, strain; conventional, molecular and recent approaches to polyphasic bacterial taxonomy, evolutionary chronometers, rRNA oligonucleotide sequencing and its importance.. Differences between eubacteria and archaeobacteria.	12 Lectures
Unit – 5	General characteristics, phylogenetic overview of archaeobacteria. Introduction to Nanoarchaeota (<i>Nanoarchaeum</i>), Crenarchaeota (<i>Sulfolobus</i> , <i>Thermoproteus</i>) and Euryarchaeota [Methanogens (<i>Methanobacterium</i> , <i>Methanocaldococcus</i>), thermophiles (<i>Thermococcus</i> , <i>Pyrococcus</i> , <i>Thermoplasma</i>), and Halophiles (<i>Halobacterium</i> , <i>Halococcus</i>)].	12 Lectures

<p style="text-align: center;">LAB. COURSE (2 Credits)</p>		
<ol style="list-style-type: none"> 1. Preparation of different media: synthetic media, complex media- Nutrient agar, McConkey agar, EMB agar. 2. Simple staining 3. Negative staining 4. Gram staining 5. Acid fast staining – study using permanent slide. 6. Capsule staining 7. Endospore staining. 8. Isolation of pure cultures of bacteria by streaking method. 9. Preservation of bacterial cultures by various techniques. 10. Estimation of CFU count by spread plate method/pour plate method. 11. Motility by hanging drop method. <p>Reference Books</p> <ol style="list-style-type: none"> 1. Prescott, M.J., Harley, J.P. and Klein, D.A. Microbiology. 5th Edition WCB Mc Graw Hill, New York, (2002). 2. Tortora, G.J., Funke, B.R. and Case, C.L. Microbiology : An Introduction. Pearson Education, Singapore, (2004). 3. Alcomo, I.E. Fundamentals of Microbiology. VI Edition, Jones and Bartlett Publishers. Sudbury. Massachusetts, (2001). 4. Black J.G. Microbiology-Principles and Explorations. John Wiley & Sons Inc. New York, (2002). 5. Tom Besty, D.C Jim Koegh. Microbiology Demystified McGRAW-HILL. 		

CC2: Bacteriology and Systematics

Course learning outcomes: At the completion of this course, the students are able to -

Outcome 1. Describe characteristics of bacterial cells, cell organelles, cell wall composition and various appendages like capsules, flagella or pili.

Outcome 2. Differentiate a large number of common bacteria by their salient characteristics; classify bacteria into groups.

Outcome 3. Describe the nutritional requirements of bacteria for growth; developed knowledge and understanding that besides common bacteria there are several other microbes which grow under extreme environments.

Outcome 4. Perform basic laboratory experiments to study microorganisms; methods to preserve bacteria in the laboratory; calculate generation time of growing bacteria.

THEORY COURSE

(4 Credits)

Unit – 1	<p>Cell size, shape and arrangement, capsule, flagella, fimbriae and pili.</p> <p>Cell-wall: Composition and detailed structure of Gram-positive and Gram-negative cell walls, archaeobacterial cell wall, Gram and acid-fast staining mechanisms, lipopolysaccharide (LPS), sphaeroplasts, protoplasts, and L-forms. Effect of antibiotics and enzymes on the cell wall.</p> <p>Cell Membrane: Structure, function and chemical composition of bacterial and archaeal cell membranes. Cytoplasm: Ribosomes, mesosomes, inclusion bodies, nucleoid. Endospore: Structure, formation, stages of sporulation.</p>	12 Lectures
Unit – 2	<p>Gram negative and Gram positive bacteria: characteristics and examples. Study of typical eubacteria (<i>Bacillus</i>, <i>Clostridium</i>, <i>Staphylococcus</i>, <i>Streptococcus</i>, <i>Corynebacterium</i>, <i>Mycobacterium</i>, <i>Escherichia</i>, <i>Salmonella</i>, <i>Shigella</i>, <i>Vibrio</i>, <i>Helicobacter</i>, <i>Meningococcus</i>, <i>Spirochetes</i>, <i>Rickettsia</i>, <i>Mycoplasma</i> and <i>Chlamydia</i>).</p>	12 Lectures

Unit – 3	Nutritional requirements in bacteria and nutritional categories. Culture media: components of media, natural and synthetic media, chemically defined media, complex media, selective, differential, enriched and enrichment media. Physical methods of microbial control: heat, low temperature, high pressure, filtration, desiccation, osmotic pressure, radiation. Chemical methods of microbial control: disinfectants, types and mode of action. Asexual methods of reproduction, logarithmic representation of bacterial populations, phases of growth, calculation of generation time and specific growth rate.	12 Lectures
Unit – 4	Aim and principles of classification, systematics and taxonomy, concept of species, taxa, strain; conventional, molecular and recent approaches to polyphasic bacterial taxonomy, evolutionary chronometers, rRNA oligonucleotide sequencing and its importance.. Differences between eubacteria and archaeobacteria.	12 Lectures
Unit – 5	General characteristics, phylogenetic overview of archaeobacteria. Introduction to Nanoarchaeota (<i>Nanoarchaeum</i>), Crenarchaeota (<i>Sulfolobus</i> , <i>Thermoproteus</i>) and Euryarchaeota [Methanogens (<i>Methanobacterium</i> , <i>Methanocaldococcus</i>), thermophiles (<i>Thermococcus</i> , <i>Pyrococcus</i> , <i>Thermoplasma</i>), and Halophiles (<i>Halobacterium</i> , <i>Halococcus</i>)].	12 Lectures

LAB. COURSE**(2 Credits)**

1. Preparation of different media: synthetic media, complex media- Nutrient agar, McConkey agar, EMB agar.
2. Simple staining
3. Negative staining
4. Gram staining
5. Acid fast staining – study using permanent slide.
6. Capsule staining
7. Endospore staining.
8. Isolation of pure cultures of bacteria by streaking method.
9. Preservation of bacterial cultures by various techniques.
10. Estimation of CFU count by spread plate method/pour plate method.
11. Motility by hanging drop method.

Reference Books

1. Prescott, M.J., Harley, J.P. and Klein, D.A. Microbiology. 5th Edition WCB Mc Graw Hill, New York, (2002).
2. Tortora, G.J., Funke, B.R. and Case, C.L. Microbiology : An Introduction. Pearson Education, Singapore, (2004).
3. Alcom, I.E. Fundamentals of Microbiology. VI Edition, Jones and Bartlett Publishers. Sudbury. Massachusetts, (2001).
4. Black, J.G. Microbiology-Principles and Explorations. John Wiley & Sons Inc. New York, (2002).
5. Tom Besty, D.C. Jim Koegh. Microbiology Demystified McGRAW-HILL.

CC3: Basic Biochemistry

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

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

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

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

Outcome 4. Student are able to make buffers, study enzyme kinetics and calculate V_{max} , K_m , K_{cat} values.

THEORY COURSE

(4 Credits)

Unit		
– 1	<p>Concept of bio-molecules - Building blocks of life, Macromolecules.</p> <p>Concept of Bioenergetics - First and second laws of Thermodynamics. Definitions of Gibb's Free Energy, enthalpy and Entropy and mathematical relationship among them, Standard free energy change and equilibrium constant Coupled reactions and additive nature of standard free energy change, Energy rich compounds, ATP, amino acids the building blocks of proteins. Titration curve of amino acid and its Significance, Classification, biochemical structure and notation of standard protein amino acids Ninhydrin reaction. General formula of amino acid and concept of zwitterion. Natural modifications of amino acids in proteins hydrolysine, cystine and hydroxyproline, Non protein amino acids: Gramicidin, beta-alanine, D-alanine and D-glutamic acid.</p>	12 Lectures

Unit – 2	Carbohydrate: Families of monosaccharides – aldoses and ketoses, trioses, tetroses, pentoses, and hexoses. Stereo isomerism of monosaccharides, epimers, mutarotation and anomers of glucose. Furanose and pyranose forms of glucose and fructose, Haworth projection formulae for glucose; chair and boat forms of glucose, sugar derivatives, glucosamine. Disaccharides; concept of reducing and non-reducing sugars, occurrence and Haworth projections of maltose, lactose, and sucrose, polysaccharides, storage polysaccharides, starch and glycogen. Structural polysaccharides, cellulose, peptidoglycan and chitin	12 Lectures
Unit – 3	Protein: Primary, secondary, tertiary and quaternary structures. Enzymes: Structure of enzyme, Apoenzyme and cofactors, prosthetic group-TPP, coenzyme -NAD, metal cofactors, Classification of enzymes, Mechanism of action of enzymes: active site, transition state complex and activation energy. Lock and key hypothesis, and 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, Effect of pH and temperature on enzyme activity. Enzyme inhibition: competitive- sulfa drugs; non-competitive-heavy metal salts.	12 Lectures
Unit – 4	Lipids: Definition and major classes of storage and structural lipids. Storage lipids. Fatty acids structure and functions. Essential fatty acids. Triacylglycerols structure, functions and properties. Saponification Structural lipids. Phosphoglycerides: Building blocks, general structure, functions and properties. Structure of phosphatidylethanolamine and phosphatidylcholine, Sphingolipids: building blocks, structure of sphingosine, ceramide. Special mention of sphingomyelins, cerebroside and gangliosides Lipid functions: cell signals, cofactors, prostaglandins, Introduction to lipid micelles, monolayers, bilayers	12 Lectures
Unit – 5	Nucleic acids and vitamins. Biosynthesis of nucleotides. Base composition. A+T and G+C rich genomes. Structure and functions of DNA and RNA. Basic concept of nucleic acids protein interactions. Concept and types of vitamins and their role in metabolism.	12 Lectures

LAB. COURSE**(2 Credits)**

1. Properties of water, concept of pH and buffers, preparation of buffers and Numerical problems to explain the concepts.
2. Numerical problems on calculations of Standard Free Energy Change and Equilibrium constant.
3. Standard Free Energy Change of coupled reactions.
4. Qualitative/Quantitative tests for carbohydrates, reducing sugars, non-reducing sugars.
5. Qualitative/Quantitative tests for lipids and proteins.
6. Study of protein secondary and tertiary structures with the help of models.
7. Study of enzyme kinetics – calculation of V_{max} , K_m , K_{cat} values.
8. Study effect of temperature, pH and heavy metals on enzyme activity.
9. Estimation of any one vitamin.

Reference Books

1. Tortora, G.J., Funke, B.R. and Case, C.L. Microbiology: An Introduction. Pearson Education, Singapore, (2004).
2. Stanbury, Biochemistry
3. Voet. Fundamentals of biochemistry Wiley
4. M.M. Cox, D. L. Nelson. Lehninger's principles of biochemistry. W H Freeman
5. Stryer. Biochemistry W H Freeman

CC4: Microbial techniques & Instruments

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

Outcome 1. Principles which underlies sterilization of culture media, glassware and plastic ware to be used for microbiological work.

Outcome 2. Principles of a number of analytical instruments which the students have to use during the study and also later as microbiologists for performing various laboratory manipulations.

Outcome 3. Handling and use of microscopes for the study of microorganisms which are among the basic skills expected from a practicing microbiologist. They also get introduced a variety of modifications in the microscopes for specialized viewing.

Outcome 4. Several separation techniques which may be required to be handled later as microbiologists.

THEORY COURSE

(4 Credits)

Unit – 1:	Microbial techniques: Pure culture isolation: Streaking, serial dilution and plating methods; cultivation, maintenance and preservation/stocking of pure cultures; cultivation of anaerobic bacteria, and accessing non-culturable bacteria. Buffers in culture medium. Cultivation of fungi, actinomycetes, yeasts, algae. Cultivation of anaerobes.	12 Lectures
Unit – 2:	Sterilization, Disinfection, Antiseptic, Germicide, Sanitizer, Fungicide, Virucide, Bacteriostatic and Bactericidal agent. Chemical Disinfectants. Sterilization by Physical Agent, Heat: Moist Heat, Dry heat, Boiling, Tyndallization, Pasteurisation, Steam under pressure (Autoclave), Incineration, Hot	12 Lectures

	air Oven. Radiations: Ionizing and Non-ionizing radiations. Inoculation and incubation, Principle and application of Laminar airflow.	
Unit – 3:	Microscopy: Principle, mechanism and application of photo optical instruments (different types of Microscopes), Phase contrast microscope, Bright Field Microscope, Dark Field Microscope, Phase Contrast Microscope, Fluorescence microscopy, Confocal microscopy, Scanning and Transmission Electron Microscopy. Micrometry. Principles of Centrifugation and Ultracentrifugation techniques and its applications.	12 Lectures
Unit – 4:	Chromatography: Principle and techniques with applications (Partition, adsorption, ion exchange, exclusion and affinity chromatography). Electrophoretic technique (agarose and polyacrylamide gel) its Components, working and applications	12 Lectures
Unit – 5:	Principle, mechanism and application of instruments used in Spectrophotometric techniques (UV and visible). Radiobiological techniques – characters of radioisotopes, autoradiography, Radioisotope dilution technique and pulse chase experiments. Basic principles & Law of absorption and radiation and its application.	12 Lectures

LAB. COURSE**(2 Credits)**

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

Reference Books

1. Wilson & Walker. Principles and Techniques in Practical Biochemistry. 5th Edition Cambridge University Press (2000).
2. Murphy D.B. Fundamental of Light Microscopy & Electron Imaging. 1st Edition. Wiley-Liss. (2001).
3. K L Ghatak. Techniques And Methods In Biology PHI Publication (2011)
4. Pranav Kumar. Fundamentals and Techniques of Biophysics and Molecular Biology (2016)
5. Aurora Blair. Laboratory Techniques & Experiments In Biology. Intelliz Press
6. D.T Plummer. An Introduction to Practical Biochemistry. McGraw Hill Publication 1987
7. Beckner, W.M., Kleinsmith L.J and Hardin J. The world of cell. IV edition Benjamin/Cummings (2000)
- 9.

CC5: Virology		
<p>Course learning outcomes: Students have-</p> <p>Outcome 1. Understood what are viruses and the chemical nature of viruses, different types of viruses infecting animals, plants and bacteria (bacteriophages)</p> <p>Outcome 2. Understanding about the biology of bacteriophages.</p> <p>Outcome 3. Gained knowledge of a variety of plant viruses and animal viruses.</p> <p>Outcome 4. The ability to describe role of viruses in the causation of the cancer'</p>		
THEORY COURSE (4 Credits)		
Unit – 1	Virology: 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. Viral taxonomy- Classification and nomenclature of different groups of viruses. Baltimore system of classification.	12 Lectures
Unit – 2	Isolation, purification and cultivation of bacterial viruses. Study of one step growth curve of bacterial viruses. Types of bacteriophages, lytic and lysogenic phages (lambda phage) concept of early and late proteins, regulation of transcription in lambda phage. T even, T odd, ϕ X174 and M13 phages.	12 Lectures
Unit – 3	Modes of viral transmission: Persistent, non- persistent, vertical and horizontal. Replication Assembly, maturation and release of viruses. Salient features of viral nucleic acid and the presence of unusual bases. Influenza and Hepatitis B virus, HIV, polio virus, Vaccinia virus, Rabies Virus. TMV, Cauliflower Mosaic Virus.	12 Lectures

Unit – 4	Introduction to oncogenic viruses. Types of oncogenic DNA and RNA viruses: Concepts of oncogenes and proto-oncogenes.	12 Lectures
Unit – 5	Antiviral compounds and their mode of action Interferon and their mode of action; Viral vaccines; Introduction to use of viral vectors in cloning and expression, and gene therapy.	12 Lectures
<p style="text-align: center;">LAB. COURSE (2 Credits)</p>		
<p>1.Study of the structure of important animal viruses (rhabdo, influenza, paramyxo, hepatitis and retroviruses) using electron micrographs.</p> <p>2.Study of the structure of important plant viruses (caulimo, gemini, tobacco ringspot, cucumber mosaic and alpha-alpha mosaic viruses) using electron micrographs.</p> <p>3.Study of the structure of important bacterial viruses (ϕX174,T4,λ) using electron micrograph.</p> <p>4.Isolation and enumeration of bacteriophages (PFU) from water/sewage sample using double agar layer technique.</p> <p>5.Studying isolation and propagation of animal viruses by chick embryo technique.</p> <p>6.Study of cytopathic effects of viruses using photographs.</p> <p>7.Perform local lesion technique for assaying plant viruses.</p> <p>Reference Books</p> <ol style="list-style-type: none"> 1. Pelczar M., Chan E.C.S. and Krieg, N.R. Microbiology. Tata Mc Graw Hill Publishing Co. Ltd., New Delhi. 2. Stainier R.V., Ingraham, J.L., Wheelis, M.L. and Painter P.R. The Microbial World. Printice-Hall of India (Pvt.) Ltd., New Delhi 3. Ellen Strauss, James Strauss. Viruses and Human Disease 2nd Edition. Academic Press 4. Christopher Burrell Colin Howard Frederick Murphy. Fenner and White's Medical Virology 5th Edition. Academic Press 		

5. Bernard N. Fields. Fields Virology Lippincott Williams & Wilkins
6. S. Jane Flint. Principles of Virology. American Society for Microbiology

CC6: Mycology & Phycology		
<p>Course learning outcomes: By the completion of this course the students able to-</p> <p>Outcome 1. Describe useful and harmful activities of fungi and algae.</p> <p>Outcome 2. Identify commonly available fungi and algae and their characteristics.</p> <p>Outcome 3. Discuss how fungi and algae are used as biofertilizers in agriculture and as biopesticides.</p> <p>Outcome 4. Grow mushroom in the laboratory.</p>		
THEORY COURSE (4 Credits)		
Unit – 1	Mycology: Characteristics, classification and cellular & thallus organization of fungi. General features, structure, nutrition, reproduction of different fungi group - Phycomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes. Heterothallism and Para-sexuality. Sex hormones in fungi, physiological specialization, phylogeny of fungi.	12 Lectures
Unit – 2	General features, taxonomic status and evolutionary significance economic importance of important fungal genera - Mucor, Saccharomyces, Neurospora, Agaricus, Fusarium, Alternaria, Curvularia and Cladosporium. General account and importance of lichen. Important plant diseases caused by fungi- symptoms, disease cycles and control (Late & Early blight, Black rust, Smut, Wilt and Red rot).	12 Lectures
Unit – 3	Role of fungi in biotechnology, Application of fungi in food industry (Flavour & texture, Fermentation, Baking, Organic acids, Enzymes, Myco -proteins);	12

	Secondary metabolites (Pharmaceutical preparations); Agriculture (Biofertilizers); Mycotoxins; Biological control (Mycofungicides, Mycoherbicides, Mycoinsecticides). Mushroom and its cultivation.	Lectures
Unit – 4	General characteristics and evolution of algae. Occurrence, thallus organization, algae cell ultra-structure, pigments, flagella, eye- spot food reserves and vegetative, asexual and sexual reproduction. Classification of algae.	12 Lectures
Unit – 5	General features, structure and reproduction and economic importance of <i>Chlamydomonas</i> , <i>Chlorella</i> , Diatoms, <i>Microcystis</i> , <i>Oscillatoria</i> , <i>Spirulina</i> , <i>Anabaena</i> , <i>Nostoc</i> , <i>Rivularia</i> and <i>Scytonema</i> . Mass cultivation of algae as a source of protein.	12 Lectures
LAB. COURSE (2 Credits)		
<ol style="list-style-type: none"> 1. Preparation of Potato Dextrose Medium. 2. Isolation and identification of pathogenic and non-pathogenic fungi. 3. Study of host-pathogen interaction. 4. Study of the vegetative and reproductive structures of following genera through temporary and permanent slides: <i>Mucor</i>, <i>Saccharomyces</i>, <i>Penicillium</i>, <i>Agaricus</i> and <i>Alternaria</i> 5. Purification and preservation of pure cultures of common algae and fungi. <p>Reference Books</p> <ol style="list-style-type: none"> 1. Alexopoulos, C.J., Mims, C.W. and Blackwell, M, Introductory Mycology. John Wiley, New York. 2. Mehrotra, R.S. and K.R. Aneja An Introduction to Mycology. New Age International 		

Press, New Delhi.

3. Webster, J. Introduction to fungi. Cambridge University Press. Cambridge, U.K. (1985).
4. Bessey E.A. Morphology and Taxonomy of fungi. Vikas Publishing House Pvt. Ltd., New Delhi.
5. Jhon Webster and R W S Weber. Introduction to Fungi. Cambridge University Press 2007.
6. A. V. S. S. .Sambamurty. A Textbook of Algae. I.K. International Publishing House Pvt. Limited, 2010
7. H.D. Kumar and H.N. Singh.A Textbook on Algae (Macmillan international college edition)

CC7: Cell and Molecular Biology		
THEORY COURSE		
(4 Credits)		
Unit – 1	Concepts of cell- Prokaryotic & Eukaryotic cells. Cell organization of Prokaryotic cells with special reference to Bacteria. Eukaryotic cells - cell wall & plasma membrane; structure & function of cell organelles and inclusions. Episome, Mesosome, Flagella and Fimbriae.	12 Lectures
Unit – 2	Experimentalevidencesfornucleicacidasgeneticmaterial.Structureof DNA; ModelsofDNA replication. Enzymes, proteins and other factors involved in DNA replication. Mechanism of DNA replicationinprokaryotes&eukaryotes.SuperhelicityinDNA,linkingnumber,topological properties, mechanism of action of topoisomerases. Plasmids: Concept, Properties, types and application.	12 Lectures
Unit – 3	Cell cycle: Eukaryotic Cell Cycle, Regulation of Cell cycle progression, Events of Mitotic Phase, Meiosis and Fertilization. Cell cycle and Programmed cell death- Control system, intracellular control of cell cycle events, Apoptosis, extracellular control of cell growth and apoptosis. Growth phase in Bacteria.	12 Lectures
Unit – 4	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. 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	12 Lectures
Unit – 5	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. Principles of transcriptional regulation, regulation at initiation with examples	12

	from <i>lac</i> and <i>trp</i> operons, Sporulation in <i>Bacillus</i> , Yeast mating type switching , Changes in Chromatin Structure - DNA methylation and Histone Acetylation mechanisms.	Lectures
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LAB. COURSE**(2 Credits)**

1. Study a representative plant and animal cell by microscopy.
2. Study of the structure of cell organelles through electron micrographs.
3. Cytochemical staining of DNA–Feulgen
4. Demonstration of the presence of mitochondria in striated muscle cells/cheek epithelial cell using vital stain Janus Green B
5. Study of polyploidy in Onion root tip by colchicine treatment.
6. Identification and study of cancer cells by photomicrographs.
7. Study of different stages of Mitosis.
8. Study of different stages of Meiosis.
9. Isolation of genomic and plasmid DNA from *E.coli*
10. Estimations of DNA and RNA using diphenylamine and orcinol reagent, and UV spectrophotometer (A260 measurement)
11. Resolution and visualization of DNA by Agarose Gel Electrophoresis.

Reference Books

1. Benjamin Lewin, Gene VII, Oxford University Press, (2000).
2. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter, Molecular biology of the Cell, 4th Edition. Garland publishing Inc. (2002).
3. Darnell, Lodish and Baltimore, Molecular Cell Biology, Scientific American Publishing Inc. (2000).
4. Watson. J.D, Baker. T.A, Bell. S.P, Gann. A. Levine. M. Losick. R, Molecular Biology of Gene, 5th Edition. The Benjamin/Cummings Pub. Co. Inc. (2003).
5. Brown T.A., Gene Cloning and DNA analysis. 2nd Edition, ASM press. (2004).
6. Sandy Primrose. Principles of Gene Manipulation and Genomics. 7th Ed., Blackwell Publishers. (2006).
7. Glick BR and Pasternak JJ, Molecular Biotechnology, 2nd Ed. ASM press. (2003).
8. Uldis N. Streips, Ronald E. Yasbin. Modern Microbial Genetics. 2nd Edition Wiley-

Liss,Inc.(2002).

9. Gardner E J, Simmons M J and Snupstad DP, Principles of genetics, 8th edition John Wiley & Sons, (2006).
10. Harvey Lodish; Arnold Berk; Chris A. Kaiser; Monty Krieger; Anthony Bretscher; Hidde Ploegh; Angelika Amon; Kelsey C. Martin, Stephen C. Harrison.Molecular Cell biology
11. David Baltimore and Harve Lodish. Molecular and Cell Biology. Macmilan learning. 2016

CC8: Microbial Genetics

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

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

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

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

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

THEORY COURSE (4 Credits)

Unit – 1	Genome organization: <i>E. coli</i> , <i>Saccharomyces</i> , <i>Tetrahymena</i> . 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 Lectures
Unit – 2	Microbial Genetics: Transformation- discovery, Griffith's experiment, mechanism of transformation; Factors affecting transformation process, Competence and development of competence in <i>S. Pneumonia</i> . Transduction – discovery, Lederberg and Tatum's experiment, mechanism and types of transduction- Generalized transduction,	12 Lectures

	Specialized transduction, Sexduction and abortive transduction.	
Unit – 3	Conjugation- discovery, experimental evidence, F-factor, F ⁺ &Hfr, mechanism of conjugation, Cross between Hfr, F ⁺ &F ⁻ Conjugant and its application. Features of T4 genetics , Genetic basis of lytic <i>versus</i> lysogenic switch of phage lambda	12 Lectures
Unit – 4	Types of plasmids – F plasmid, R Plasmids, colicinogenic plasmids, Ti plasmids, linear plasmids, yeast- 2 3 plasmid, Plasmid replication and partitioning, Host range, plasmid- incompatibility, plasmid amplification, Regulation of copy number, curing of plasmids	12 Lectures
Unit – 5	Prokaryotic transposable elements – Insertion Sequences, composite and non-composite transposons, Replicative and Non replicative transposition, Mu transposon. Eukaryotic transposable elements - Yeast (Ty retrotransposon), Drosophila (P elements), Maize (Ac/Ds). Uses of transposons and transposition	12 Lectures

LAB. COURSE**(2 Credits)**

1. Preparation of Master and Replica Plates.
2. Study the effect of chemical (HNO₂) 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 agarose gel electrophoresis.
6. Demonstration of bacterial conjugation
7. Demonstration of bacterial transformation and transduction.
8. Demonstration of Ames test.

Reference Books

1. Benjamin Lewin, Gene VII, Oxford University Press, (2000).
2. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter, Molecular biology of the Cell, 4th Edition. Garland publishing Inc. (2002).
3. Darnell, Lodish and Baltimore, Molecular Cell Biology, Scientific American Publishing Inc. (2000).
4. Watson. J.D, Baker. T.A, Bell. S.P, Gann. A. Levine. M. Losick. R., Molecular Biology of Gene, 5th Edition. The Benjamin/Cummings Pub. Co. Inc. (2003).
5. Brown T.A., Gene Cloning and DNA analysis. 2nd Edition, ASM press. (2004).
6. Sandy Primrose. Principles of Gene Manipulation and Genomics. 7th Ed., Blackwell Publishers. (2006).
7. Glick BR and Pasternak JJ, Molecular Biotechnology, 2nd Ed. ASM press. (2003).
8. Uldis N. Streips, Ronald E. Yasbin. Modern Microbial Genetics. 2nd Edition Wiley-Liss, Inc. (2002).
9. Gardner E J, Simmons M J and Snupstad DP, Principles of genetics, 8th edition John Wiley & Sons, (2006).
10. Harvey Lodish; Arnold Berk; Chris A. Kaiser; Monty Krieger; Anthony Bretscher;

Hidde Ploegh; Angelika Amon; Kelsey C. Martin, Stephen C. Harrison..Molecular Cell biology. Macmillan Higher Education

11. David Freifelder.Essentials of molecular biology.Jones and Bartlett Publishers, 1998

CC9: Microbial Physiology and Metabolism

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

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

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

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

THEORY COURSE (4 Credits)

Unit – 1	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 -Temperature (psychrophiles, mesophiles, thermophiles, extremophiles, thermotolerants, psychrotrophs), pH (acidophiles, alkaliphiles), solute and water activity (halophiles, xerophiles, osmophilic), Oxygen (aerobic, anaerobic, microaerophilic, facultative aerobe, facultative anaerobe), barophilic.	12 Lectures
Unit – 2	Microbial growth in response to nutrition and energy – Autotroph/Phototroph, heterotrophy, Chemolithoautotroph, Chemolithoheterotroph, Chemoheterotroph, Chemolithotroph, photolithoautotroph, Photoorganoheterotroph. Passive and facilitated diffusion. Primary and secondary active transport, concept of uniport, symport and antiport Group translocation Iron uptake	12 Lectures

Unit – 3	<p>Concept of aerobic respiration, anaerobic respiration and fermentation</p> <p>Sugar degradation pathways</p> <p>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, uncouplers and inhibitors. Fermentation - Alcohol fermentation and Pasteur effect; Lactate fermentation (homofermentative and heterofermentative pathways), concept of linear and branched fermentation pathways</p>	12 Lectures
Unit – 4	<p>Introduction to aerobic and anaerobic chemolithotrophy with an example each. Hydrogen oxidation (definition and reaction) and methanogenesis (definition and reaction). Introduction to phototrophic metabolism - groups of phototrophic microorganisms, anoxygenic vs. oxygenic photosynthesis with reference to photosynthesis in green bacteria, purple bacteria and Cyanobacteria</p>	12 Lectures
Unit – 5	<p>Anaerobic respiration with special reference to dissimilatory nitrate reduction (Denitrification; nitrate/nitrite and nitrate/ammonia respiration; fermentative nitrate reduction). Introduction to biological nitrogen fixation Ammonia assimilation. Assimilatory nitrate reduction, dissimilatory nitrate reduction, denitrification.</p>	12 Lectures

LAB. COURSE (2 Credits)
<ol style="list-style-type: none"> 1. Study and plot the growth curve of <i>E.coli</i> by turbidometric and standard plate count methods. 2. Calculations of generation time and specific growth rate of bacteria from the graph plotted with the given data. 3. Effect of temperature on growth of <i>E.coli</i>. 4. Effect of pH on growth of <i>E.coli</i>. 5. Effect of carbon and nitrogen sources on growth of <i>E.coli</i>. 6. Effect of salt on growth of <i>E.coli</i>. 7. Demonstration of alcoholic fermentation. 8. Demonstration of the thermal death time and decimal reduction time of <i>E.coli</i>.
<p>Reference Books</p> <ol style="list-style-type: none"> 1. Stanier, Ingraham, Wheelis and Painter. The Microbial world. Mc Millan Educational Ltd., London. 2. Moat and Foster, Microbial Physiology. Wiley. 3. Umbreit. Essentials of Bacterial Physiology. 4. Skokatch. Bacterial Physiology and Metabolism. 5. Kushner, D.J. Microbial life in Extreme Environments. Academic Press. 6. Pawar. C.B. Cell Biology. 7. Sturart. Harris and Harris. The control of Antibiotic Resistance in Bacteria. 8. Franklin and Snow, Biochemistry of Antimicrobial Action. Chapman and Hall, New York. 9. Philipp. G. Mannual of Methods for General Bacteriology. 10. David T. Plummer. An Introduction to Practical Biochemistry. 11. Subba Rao, N.S. Soil Microorganisms and Plant Growth.

12. Pelczar, MJ Chan ECS and Krieg NR, Microbiology McGraw-Hill.
13. Willey, Sherwood, Woolverton. Prescott, Harley, and Klein's Microbiology McGraw-Hill publication
14. Tortora, Funke, Case. Microbiology. Pearson Benjamin Cummings.
15. JACQUELYN G. BLACK. Microbiology Principles and explorations. JOHN WILEY & SONS, INC.
16. Madigan, Martinko, Bender, Buckley, Stahl. Brock Biology of Microorganisms. Pearson
17. Tom Besty, D.C Jim Koegh. Microbiology Demystified McGRAW-HILL.
18. J. R. Sokatch Bacterial Physiology and Metabolism. Academic Press
19. Daniel R. Caldwell . Microbial Physiology and Metabolism . Star Pub Co; (1999)

CC10: Environmental Microbiology and Microbial Ecology

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

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

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

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

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

THEORY COURSE

(4 Credits)

Unit – 1	Terrestrial Environment: Soil profile and soil microflora. Aquatic Environment: Microflora of fresh water and marine habitats Atmosphere: Aeromicroflora and dispersal of microbes. Animal Environment: Microbes in/on human body (microbiomics) & animal (ruminants) body. Extreme Habitats: Extremophiles: Microbes thriving at high & low temperatures, pH, high hydrostatic & osmotic pressures, salinity, & low nutrient levels.	12 Lectures
Unit – 2	Solid Waste management: Sources and types of solid waste, Methods of solid waste disposal	12

2	(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	Lectures
Unit – 3	Principles and degradation of common pesticides, organic (hydrocarbons, oil spills) and inorganic (metals) matter, biosurfactants. 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.	12 Lectures
Unit – 4	History, significance and developments in the field of microbial ecology. Contributions of Beijerinck, Winogradsky, Kluver, Van Niel, Martin Alexander, Selman A. Waksman Structure and function of ecosystems. Microbial succession in decomposition of plant organic matter. Biological Interaction: A. Microbe–Microbe Interactions- Mutualism, Synergism, Commensalism, Competition, Amensalism, Parasitism, Predation, Biocontrol agents. B. Microbe–Plant Interactions Roots, Aerial Plant surfaces, Biological Nitrogen fixation (symbiotic/nonsymbiotic - biofertilizers) C. Microbe-Animal Interactions - Role of Microbes in Ruminants, Nematophagous fungi, Luminescent bacteria as symbiont	12 Lectures
Unit – 5	Carbon cycle: Microbial degradation of cellulose, hemicelluloses, lignin and chitin 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 Lectures

LAB. COURSE**(2 Credits)**

1. Analysis of soil pH, moisture content, water holding capacity, percolation, capillary action.
2. Isolation of microbes (bacteria & fungi) from soil (28°C&45°C).
3. Isolation of microbes (bacteria & fungi) from rhizosphere and rhizoplane.
4. Assessment of microbiological quality of water.
5. Determination of BOD of wastewater sample.
6. Study the presence of microbial activity by detecting (qualitatively) enzymes (dehydrogenase, amylase, urease) in soil.
7. Isolation of *Rhizobium* from root nodules.

Reference Books

1. Medigan, M.T., Martinko, J. M. and Parker, J. Brock Biology of Microorganisms. Pearson Education Inc. , New York
2. Alexander, M John. Microbial ecology. Wiley & Sons, Inc., New York.
3. Alexander, M John. Introduction to soil microbiology. Wiley & Sons Inc., New York.
4. Barker, KH, and Herson, D.S. Bioremediation. Mc Craw Hill Inc., New York.
5. Pelczar, MJ Chan ECS and Krieg NR, Microbiology McGraw-Hill.
6. Willey, Sherwood, Woolverton. Prescott, Harley, and Klein's Microbiology McGraw-Hill publication
7. Tortora, Funke, Case. Microbiology. Pearson Benjamin Cummings.
8. JACQUELYN G. BLACK. Microbiology Principles and explorations. JOHN WILEY & SONS, INC.
9. Madigan, Martinko, Bender, Buckley, Stahl. Brock Biology of Microorganisms. Pearson
10. Tom Besty, D.C Jim Koegh. Microbiology Demystified McGRAW-HILL.

CC11: Industrial Microbiology

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

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

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

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

THEORY COURSE

(4 Credits)

Unit – 1	Brief history and developments in industrial microbiology. 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	12 Lectures
Unit – 2	Types of fermentation processes - Solid-state and liquid-state (stationary and submerged) fermentations; batch, fed-batch (e.g. baker's yeast) and continuous fermentations. 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 Lectures
Unit – 3	Down-stream processing; Cell disruption, filtration, centrifugation, solvent extraction, precipitation, lyophilization and spray drying.	

	Microbial cells as food. SCP -mushroom cultivation,	12 Lectures
Unit – 4	Microbial production of industrial products (micro-organisms involved, media, fermentation conditions, downstream processing and uses)- Citric acid, ethanol, penicillin, glutamic acid, Vitamin B12. Enzymes (amylase, protease, lipase) wine, beer.	12 Lectures
Unit – 5	Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase). Role of Microbes in Medicine and textile industry.	12 Lectures

LAB. COURSE**(2 Credits)**

1. Study different parts of fermenter
2. Microbial fermentations for the production and estimation (qualitative and quantitative) of:
3. Enzymes: Amylase and Protease
4. Amino acid: Glutamic acid
5. Organic acid: Citric acid
6. Alcohol: Ethanol
7. A visit to any educational institute/industry to see an industrial fermenter, and other downstream processing operations.

Reference Books

1. Richard H. Baltz. Julian E Davies and Arnold L. Demain Manual of Industrial Microbiology and Biotechnology. 3rd edition, ASM Press (2010).
2. Daniel Forciniti. Industrial Bioseparation: Principles and practice. 1st edition, Wiley-Blackwell (2008).
3. Reed. G. Prescott and Dunn's Industrial Microbiology. CBS Publishers. (1999).
4. Demain, A. L. Industrial Microbiology and Biotechnology. 2nd Edition. (2001).
5. EL Mansi. E.M.T. Fermentation Microbiology and Biotechnology. 2nd Edition, CRC Taylor & Francis (2007).
6. Waites, M.J., Morgan, N.L., Rockey, J.S. and Higton, G. Industrial Microbiology: An Introduction. Blackwell Science Publishers (2002).
7. Casida LE, Industrial Microbiology, J. Wiley, (1968).
8. Pelczar, MJ Chan ECS and Krieg NR, Microbiology McGraw-Hill.
9. Willey, Sherwood, Woolverton. Prescott, Harley, and Klein's Microbiology McGraw-Hill publication
10. Tortora, Funke, Case. Microbiology. Pearson Benjamin Cummings.
11. JACQUELYN G. BLACK. Microbiology Principles and explorations. JOHN WILEY & SONS, INC.

12. Madigan,Martinko, Bender,Buckley,Stahl.Brock Biology of Microorganisms. Pearson
13. Tom Besty,D.C Jim Koegh.Microbiology Demystified McGRAW-HILL.
14. Wulf Crueger.Cruegers Biotechnology: A Textbook of Industrial Microbiology 2017

CC12: Medical and Veterinary Microbiology, and Immunology

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

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

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

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

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

THEORY COURSE

(4 Credits)

Unit – 1	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, Pathophysiologic effects of LPS. Collection, transport and culturing of clinical samples, principles of different diagnostic tests (ELISA, Immunofluorescence, Agglutination based tests, Complement fixation, PCR, DNA probes).	10 Lectures
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Unit – 2	List of diseases of various organ systems and their causative agents. Symptoms, mode of transmission, prophylaxis and control of the diseases caused by <i>Streptococcus pyogenes</i> , <i>Mycobacterium</i> , <i>Haemophilus influenzae</i> , <i>tuberculosis</i> , <i>Bacillus anthracis</i> , <i>Clostridium tetani</i> , <i>Treponema pallidum</i> , <i>Clostridium difficile</i> , and the viruses causing Polio, Herpes, Hepatitis, Dengue, AIDS, influenza and Japanese encephalitis.	10 Lectures
Unit – 3	Study of following animal diseases with respect to etiology, symptoms, mode of transmission, prophylaxis and control: FMD, swine flu, bird flu, Rabies, bovine tuberculosis, Marek's, ranikhet, brucellosis, distemper.	10 Lectures
Unit – 4	Mycoses: Cutaneous mycoses: Tinea pedis (Athlete's foot) Systemic mycoses: Histoplasmosis Opportunistic mycoses: Candidiasis. Occurrence, habitat, morphology and reproduction of Protozoa. Structure and reproduction of important Protozoans- Entamoeba, Giardia, Trichomonas, Leishmania, Trypanosoma and Plasmodium.	10 Lectures
Unit – 5	Immune system: Structure and function of the cells, tissues and organs of immune system. Types of immunity - Humoral and cell-mediated, innate, acquired immunity. Complement system – function and pathways. Antigens and Antibodies: types, properties. Haptens, adjuvants, Immunoglobulins: Structure types, Properties and their function - Theory of antibody production. Antigen-Antibody Interactions, Agglutination, Precipitation, Complement fixation test. Hypersensitivity reactions; IgE mediated Type I Hypersensitivity, Antibody-mediated cytotoxic (Type II) Hypersensitivity, Immune complex mediated (Type III) Hypersensitivity, DTH mediated (Type IV) Hypersensitivity.	20 Lectures

LAB. COURSE**(2 Credits)**

Identify bacteria (any three of *E.coli*, *Salmonella*, *Pseudomonas*, *Staphylococcus*, *Bacillus*)

using laboratory strains on the basis of cultural, morphological and biochemical characteristics: IMViC, TSI, nitrate reduction, urease production and catalase tests.

1. Study of composition and use of important differential media for identification of bacteria: EMB Agar, McConkey agar, Mannitol salt agar, Deoxycholate citrate agar, TCBS
2. Study of bacterial flora of skin by swab method.
3. Perform antibacterial sensitivity by Kirby-Bauer method.
4. Determination of minimal inhibitory concentration (MIC) of an antibiotic.
5. Study symptoms of the diseases with the help of photographs: Polio, anthrax, herpes, chickenpox, HPV warts, AIDS (candidiasis), dermatomycoses (ringworms).
6. Study of various stages of malarial parasite in RBC using permanent mounts.

Reference Books

1. Ananthanarayan R and Paniker CKJ. Textbook of Microbiology. 7th Edition. University Press Publication. (2005).
2. Brooks GF, Carroll KC, Butel JS and Morse SA. Jawetz, Melnick and Adelberg's Medical Microbiology. 24th edition. McGraw Hill Publication. (2007).
3. Goering R, Dockrell H, Zuckerman M and Wakelin D. Mims Medical microbiology. 4th edition. Elsevier. (2007).
4. Bernard, Davis B. Dulbecco, Eisen and Ginsberg. Microbiology including immunology and molecular Genetics. 3rd Edition
5. Roitt I. Essential Immunology. 10th Ed. Blackwell Science.
6. Kuby. Immunology. 4th edition. W. H. Freeman & company.
7. Ellen Strauss, James Strauss. Viruses and Human Disease 2nd Edition. Academic Press

8. Christopher Burrell Colin Howard Frederick Murphy.Fenner and White's Medical Virology 5th Edition.Academic Press
9. Patrick R. Murray PhD, Ken S. Rosenthal PhD,Michael A. Pfaller MD.Medical microbiology.Elsvier
10. Jawetz.Medical microbiology.Mc. Graw Hill
11. Kenneth, J. Ryan.Medical microbiology, Sherri's an introduction to infectious diseases.Mc. Graw Hill

CC13: Agriculture, Food and Dairy Microbiology		
<p>Outcome 1. Developed a clear understanding of the multifarious roles of microorganisms in soil, in association with plants and thus in the field of agriculture.</p> <p>Outcome 2. Are able to describe the role of microorganisms in the production of food, its spoilage, including their role in homemade fermented foods.</p> <p>Outcome 3. Are able to identify the role of microorganisms in the causation of the diseases and how to protect against food-borne pathogens.</p> <p>Outcome 4. Developed experimental skills for testing the milk and different foods for the presence of microorganisms</p>		
THEORY COURSE (4 Credits)		
Unit – 1	History of Agricultural Microbiology; Microbes and their importance in maintenance of soil, Biogeochemical cycles, role of microbes in maintaining the fertility of soil. Bio fertilizers – Bacterial, - Azotobacter and vermiform compost. Soil microorganism -association with vascular plants- phyllosphere, Rhizobium, Rhizoplane associative nitrogen fixation. Biofertilizers- Cyanobacterial and Azolla.	12 Lectures
Unit – 2	Intrinsic and extrinsic factors that affect growth and survival of microbes in foods, natural flora and source of contamination of foods in general. Principles, Spoilage of vegetables, fruits, meat, eggs, milk and butter, bread, canned Foods. Principles of food preservation: temperature, canning, drying, irradiation, microwave processing and aseptic packaging, chemical methods of food preservation: salt, sugar, organic acids, SO ₂ , citrates, benzoates,	12 Lectures

	nitrite and nitrates etc.	
Unit – 3	Dairy starter cultures, fermented dairy products: yogurt, acidophilus milk, kumiss, kefir, dahi and cheese, other fermented foods: dosa, sauerkraut, soy sauce and tampeh, Probiotics: Health benefits, types of microorganisms used, probiotic foods available in market. Utilization and disposal of dairy by-product – whey.	12 Lectures
Unit – 4	Food borne diseases (causative agents, foods involved, symptoms and preventive measures)- 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	12 Lectures
Unit – 5	Food sanitation and control; HACCP, Indices of food sanitary quality and sanitizers. Cultural and rapid detection methods of food borne pathogens in foods and introduction to predictive microbiology. Genetically modified foods, Nutraceuticals, Biosensors in food, Applications of microbial enzymes in dairy industry [Protease, Lipases].	12 Lectures
LAB. COURSE (2 Credits)		
<ol style="list-style-type: none"> 1. MBRT of milk samples and their standard plate count. 2. Alkaline phosphatase test to check the efficiency of pasteurization of milk. 3. Isolation of any foodborne bacteria from food products. Isolation of spoilage microorganisms from spoiled vegetables/fruits. 4. Isolation of spoilage microorganisms from bread. 5. Preparation of Yogurt/Dahi. 		

Reference books

1. Stanbury, PF., Principles of Fermentation Technology. Whittaker, A and Hall, S.J 2nd Edition. Pergamon Press (1995).
 2. Banwart, GJ. Basic Food Microbiology. CBS Publishers and Distributors, Delhi. (1989).
 3. Hobbs BC and Roberts D. Food poisoning and Food Hygiene. Edward Arnold (A division of Hodder and Stoughton) London.
 4. Joshi. Biotechnology: Food Fermentation Microbiology, Biochemistry and Technology. Volume 2.
 5. John Garbult. Essentials of Food Microbiology. Arnold International.
 6. John C. Ayres. J. Orwin Mundt. William E. Sandinee. Microbiology of Foods. W.H. Freeman and Co.
 7. D. J. Bagyaraj and G. Rangaswami. AGRICULTURAL MICROBIOLOGY. Prentice Hall of India Pvt Ltd. 2005
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8. N S Subba Rao. Soil Microbiology. Oxford and IBH publishing Company 2009
 9. Photis Papademas. Dairy Microbiology: A Practical Approach. CRC Press
 10. Rao M.K.. Food and Dairy Microbiology. Manglam Publishers
 11. William Frazier. Food Microbiology. McGraw Hill Education
 12. Jay, James M., Loessner, Martin J., Golden, David A. Modern Food Microbiology. Springer .

CC14: Advanced Microbiology

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

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

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

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

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

THEORY COURSE

(4 Credits)

Unit – 1	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	12 Lectures
Unit – 2	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, meta transcriptomics, metaproteomics and metabolomics.	12 Lectures

Unit – 3	Molecular Basis of Host-Microbe Interaction: 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	12 Lectures
Unit – 4	Systems and Synthetic Biology: Networking in biological systems, Quorum sensing in bacteria, Co-ordinated regulation of bacterial virulence factors, Basics of synthesis of poliovirus in laboratory, Future implications of synthetic biology with respect to bacteria and viruses	12 Lectures
Unit – 5	Microbiomes and importance of microbial communities, VBNC (viable but not culturable bacteria). Genetically modified organisms and their uses. Modern methods of rapid identification of microbes (PCR, mass spectrometry, fluorescence based techniques). CRISPR-Cas system.	12 Lectures
LAB. COURSE (2 Credits)		
	<ol style="list-style-type: none"> 1. Extraction of metagenomics DNA from soil. 2. Understand the impediments in extracting metagenomics DNA from soil. 3. PCR amplification of metagenomics DNA using universal 16s ribosomal gene primers. 4. Case study to understand how the polio virus genome was synthesized in the laboratory. 5. Case study to understand how networking of metabolic pathways in 	

	<p>bacteria takes place.</p> <p>Reference Books</p> <ol style="list-style-type: none"> 1. Benjamin Lewin, Gene VII, Oxford University Press, (2000). 2. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter, Molecular biology of the Cell, 4th Edition. Garland publishing Inc, (2002). 3. Darnell, Lodish and Baltimore, Molecular Cell Biology, Scientific American Publishing Inc. (2000). 4. Watson, J.D, Baker, T.A, Bell, S.P, Gann, A. Levine, M. Losick, R, Molecular Biology of Gene, 5th Edition. The Benjamin/Cummings Pub. Co. Inc (2003). 5. David Frifielder, Stanely R. Maloy, Molecular biology and Microbial genetics. 2nd Edition, Jones and Barlett Publishers. (1994). 6. Brown T.A., Gene Cloning and DNA analysis. 2nd Edition, ASM press. (2004). 7. Sandy Primrose. Principles of Gene Manipulation and Genomics. 7th Ed., Blackwell Publishers. (2006). 8. Glick BR and Pasternak JJ, Molecular Biotechnology, 2nd Ed. ASM press. (2003). 9. Udis N. Streips, Ronald E. Yasbin. Modern Microbial Genetics. 2nd Edition Wiley-Liss, Inc. (2002). 10. Russel P J, Essential genetics, Blackwell Science Inc, 2 sub edition, (1987). <p>Gardner E J, Simmons M J and Snupstad</p>	
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DISCIPLINE SPECIFIC ELECTIVE (DSE) COURSES

DSE1: Biophysics, Biomathematics & Biostatistics		
<p>Course learning outcomes: By the conclusion of this course, the students clearly -</p> <p>Outcome 1. Understand the basic physical parameters of cells or biological processes and basic methods used to study these.</p> <p>Outcome 2. Have developed basic knowledge of mathematics as applied to biological phenomenon.</p> <p>Outcome 3. Have developed basic concepts of statistics and their importance</p>		
THEORY COURSE (4 Credits)		
Unit – 1	Diffusion and Brownian motion; Langevin eqn., diffusion eqn., Einstein Relation. Biological applications - Sedimentation, bacterial metabolism, pattern formation. Electrostatic interactions - Poisson-Boltzmann eqn and its solution. Cooperative transitions - Helix coil transition, Stretching of macromolecules, Protein folding, Unzipping of DNA Machines in membranes - Electro-osmotic effects, Ion pumping. Nerve Impulses - Action Potentials, Ion Channels; Physical Techniques and related biology - X-ray diffraction, light and neutron scattering, Nuclear magnetic Resonance, Fluorescence, Tomography, Patch clamps	12 Lectures
Unit – 2	Sets. Functions and their graphs: polynomial, linear, power, periodic, exponential and logarithmic functions. Illustration of these functions in biological systems; Basic idea of differentiation and integration.	12 Lectures
Unit – 3	Statistical methods: Applications and scope of statistics, Principles of statistical analysis of biological data. Sampling parameters. Difference between sample and population, Sampling errors, Censoring, difference	12 Lectures

	between parametric and non-parametric statistics; Mean and Variance of discrete and continuous distributions namely binomial, poisson and normal distribution. Fitting of distributions.	
Unit – 4	Measures of central tendency, Mean, Median and Mode; Measures of dispersion, standard deviation and variance; Skewness, kurtosis; Probability; Discrete and continuous random variable, Curve fitting; Correlation and regression. Emphasis on examples from biological systems;	12 Lectures
Unit – 5	Sampling size determination, Testing of hypothesis, Level of significance and degree of freedom; Large sample test based on normal distribution; Small sample test based on <i>t</i> -test, Z-test and F-test; Confidence interval; Distribution-free test; Chi-square test; Basic introduction to multivariate statistics.	12 Lectures
LAB. COURSE (2 Credits)		
<ol style="list-style-type: none"> 1. Word Problems based on Differential Equations 2. Mean, Median, Mode from grouped and ungrouped Dataset 3. Standard Deviation and Coefficient of Variation 4. Skewness and Kurtosis 5. Curve fitting 6. Correlation 7. Regression 8. Finding area under the curve using normal probability 9. Testing of Hypothesis-Normal Distribution ,t-test and Chi-Square-test 10. Confidence Interval <p>Reference Books</p> <ol style="list-style-type: none"> 1. Wilson & Walker. Principles and Techniques in Practical Biochemistry. 5th Edition Cambridge University Press (2000). 2. Khan I A and Khan I A. Fundamentals of Biostatistics, Ukaaz Publications, 		

(1994).MurphyD.B. FundamentalofLightMicroscopy&Electron Imaging.1st Edition.Wiley-Liss.(2001).

4. Beckner, W.M., Kleinsmith L.J and Hardin J. The world of cell. IV edition Benjamin/Cummings (2000).
5. Myra L. Samuels, Jeffrey A.Witmer, Andrew A. Schaffner. Statistics for the life sciences.Pearson
6. Chap T. Le.IntroductoryBiostatistics.Wiley- Interscience
7. Jagdish Arya and Robin W. Lardner. Mathematics for the Biological Sciences.Prentice Hall New Jersey
8. Chap T. Le and Lynn E. Eberly .Introductory Biostatistics 2nd Edition . Wiley (2016)

DSE2: Basic Computer & Bioinformatics		
<p>Course learning outcomes: By the conclusion of this course, the students have -</p> <p>Outcome 1. Developed skills to use computers for analysis of biological data.</p> <p>Outcome 2. Skill to use important biological databases, use tools to retrieve data, and compare the data of the biological macromolecules</p> <p>Outcome 3. Developed basic skills for data retrieval, representation, analysis and interpretation</p>		
THEORY COURSE (4 Credits)		
Unit – 1	Computer fundamentals: Basic concept of computer organization, generations of computer, hardware, software, number system, flow chart and basics of operating systems (windows, unix), Classification of computers and computer languages. Internet & Web: MS office and internet - introduction, importance, requirements of internet. Electronic mailing, chatting, search engines, webpages.	12 Lectures
Unit – 2	RDBMS - Definition of relational database; Mode of data transfer (FTP, SFTP, SCP), advantage of encrypted data transfer. 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, PD.	12 Lectures
Unit – 3	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	12 Lectures

	joining, Maximum Parsimony, Maximum likelihood	
Unit – 4	Diversity of Genomes: Viral, prokaryotic & eukaryotic genomes; Genome, transcriptome, proteome; 2-D gel electrophoresis, MALDI TOF spectroscopy; Major features of completed genomes of <i>E.coli</i> , <i>S.cerevisiae</i> , and <i>Arabidopsis</i> .	12 Lectures
Unit – 5	Hierarchy of protein 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 Lectures
LAB. COURSE (2 Credits)		
<ol style="list-style-type: none"> 1. Introduction to different operating systems - UNIX, LINUX and Windows 2. Introduction to bioinformatics databases (any three): NCBI/PDB/DDBJ, Uniprot, PDB 3. Sequence retrieval using BLAST 4. Sequence alignment & phylogenetic analysis using clustal W& phylip 5. Picking out a given gene from genomes using Genscan or other softwares (promoter region identification, repeat in genome, ORF prediction). Gene finding tools (Glimmer, GENSCAN), Primer designing, Genscan/Genetool 6. Protein structure prediction: primary structure analysis, secondary structure prediction using psi-pred, homology modeling using Swiss model. Molecular visualization using jmol, Protein structure model evaluation(PROCHECK) 7. Prediction of different features of a functional gene 		
Reference Books		
<ol style="list-style-type: none"> 1. Mount D., Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press, New York. (2004). 2. Baxevanis, A.D. and Francis Ouellette, B.F., Bioinformatics- A Practical Guide to the Analysis of Genes and Proteins. Wiley India Pvt Ltd. (2009). 		

3. Teresa K. Attwood, David J. Parry-Smith, Introduction to Bioinformatics. Pearson Education. (1999).
4. Jean-michel Claverie Cedric Notredame. Bioinformatics for Dummies. Publisher: Dummies (2007).
5. Arthur M. Lesk. Introduction to bioinformatics. Oxford University Press. (2004)
6. Dan E. Krane and Michael L. Raymer Fundamental Concepts of Bioinformatics (2002)
7. KRANE .Fundamental Concepts of Bioinformatics, (2003)
8. Teresa Attwood. Introduction to Bioinformatics . (2007)

DSE3: Microbial Biotechnology		
<p>Course learning outcomes: By the conclusion of this course, the students have -</p> <p>Outcome 1. Developed an understanding how microbiology is relevant to technological developments for agriculture and environment.</p> <p>Outcome 2. Developed an understanding how microbiology is relevant to technological developments for industries related to food and fermentations.</p> <p>Outcome 3. Developed an understanding how developments in recombinant DNA technology is juxtaposed with microbially-based technological developments for agriculture, industry and environment.</p>		
THEORY COURSE (4 Credits)		
Unit – 1	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 applications: Bacteria and yeast	12 Lectures
Unit – 2	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	12 Lectures
Unit – 3	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	12 Lectures

Unit – 4	Microbial product purification: filtration, ion exchange & affinity chromatography techniques Immobilization methods and their application: Whole cell immobilization. RNAi and its applications in silencing genes, drug resistance, therapeutics, and host pathogen interactions	12 Lectures
Unit – 5	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 Lectures
LAB. COURSE (2 Credits)		
<ol style="list-style-type: none"> 1. Study yeast cell immobilization in calcium alginate gels 2. Study enzyme immobilization by sodium alginate method 3. Pigment production from fungi (<i>Trichoderma</i> / <i>Aspergillus</i> / <i>Penicillium</i>) 4. Isolation of xylanase or lipase producing bacteria <p>Reference Books</p> <ol style="list-style-type: none"> 1. Richard H. Baltz. Julian E Davies and Arnold L.DemainManual of Industrial Microbiology and Biotechnology. 3rd edition, ASM Press (2010). 2. Daniel Forciniti. Industrial Bioseperation :Principles and practice. 1st edition edition, Wiley-Blackwell (2008). 3. Reed. G. Prescott and Dunn’s Industrial Microbiology. CBS Publishers. (1999). 4. Demain, A. L. Industrial Microbiology and Biotechnology. 2nd Edition. (2001). 5. EL Mansi. E.M.T., FermentationMicrobiologyand Biotechnology. 2ndEdition,CRC Taylor&Francis (2007). 6. Waites,M.J.,Morgan, N.L.,Rockey, J.S.andHigton,G.Industrial Microbiology: An Introduction. Blackwell SciencePublishers(2002). 		

7. Casida LE, Industrial Microbiology, J. Wiley, (1968).
8. James Bailey and David Ollis, Fundamentals of Biochemical Engineering, 2nd edition, McGraw-Hill, (1986).
9. Jayanta Kumar Patra Gitishree Das Han-Seung Shin. Microbial Biotechnology. Springer

DSE4: Hereditary and Evolution		
<p>Course learning outcomes: By the conclusion of this course, the students have -</p> <p>Outcome 1. Developed perception of evolution taking examples from well-studied models organisms of bacteria, fungi and other organisms.</p> <p>Outcome 2. Good understanding of concepts of Mendelian genetics and structural organizations of chromosomes.</p> <p>Outcome 3. Developed practical skills to do karyotyping and pedigree analysis.</p>		
THEORY COURSE (4 Credits)		
Unit – 1	Introduction to Genetics: Historical developments; Model organisms in genetic analyses and experimentation: <i>Escherichia coli</i> , <i>Saccharomyces cerevisiae</i> , <i>Neurospora crassa</i> , <i>Caenorhabditis elegans</i> , <i>Drosophila melanogaster</i> , <i>Arabidopsis thaliana</i> . Mendel's Laws: Dominance, segregation, independent assortment, deviation from Mendelian inheritance, Chromosome theory of inheritance: Allele, multiple alleles, pseudoallele, complementation tests.	12 Lectures
Unit – 2	Extensions of Mendelian genetics: Allelic interactions, concept of dominance, recessiveness, Incomplete dominance and co-dominance, Multiple alleles, Epistasis, penetrance and expressivity. Linkage and recombination of genes, Cytological basis of crossing over, Crossing over at four- strand stage, Molecular mechanisms of crossing over, mapping	12 Lectures
Unit – 3	Interaction of genes (Factor hypothesis) – Complementary gene, Inhibitory gene, Duplicate gene And lethal gene. Rules of extranuclear inheritance, Organelle heredity-	12 Lectures

	Chloroplast mutations in <i>Chlamydomonas</i> , mitochondrial, mutations in <i>Saccharomyces</i> , Maternal effects–Shellcoiling in <i>Limnaea peregra</i> Infectious heredity - Kappa particles in <i>Paramecium</i> .	
Unit – 4	Structural organization of chromosomes - centromeres, telomeres and repetitive DNA, Packaging DNA molecules into chromosomes, Concept of euchromatin and heterochromatin, Normal and abnormal karyotypes of human chromosomes, Chromosome banding, Giant chromosomes: Polytene and lampbrush chromosomes, Variations in chromosome structure: Deletion, duplication, inversion and translocation, Variation in chromosomal number and structural abnormalities- Klinefelter syndrome, Turner syndrome, Down syndrome	12 Lectures
Unit – 5	Homologous and non-homologous recombination, including transposition, site-specific recombination. Pedigree analysis, LOD score for linkage testing, karyotypes, genetic disorders. Polygenic inheritance, heritability and its measurements, QTL mapping	12 Lectures
LAB. COURSE (2 Credits)		
<ol style="list-style-type: none"> 1. Mendelian deviations in dihybrid crosses 2. Studying Barr Body with the temporary mount of human cheek cells 3. Studying <i>Rhoeo</i> translocation with the help of photographs 4. Karyotyping 5. Chi-Square Analysis 6. Study of polytene chromosomes using temporary mounts of salivary glands of <i>Chiromonas/ Drosophila</i> larvae 7. Study of pedigree analysis 		

8. Analysis of a representative quantitative trait

Reference books

1. Benjamin Lewin, Gene VII, Oxford University Press, (2000).
2. David Frifielder, Stanley R. Maloy, Molecular biology and Microbial genetics. 2nd Edition, Jones and Barlett Publishers. (1994).
3. Brown T.A., Gene Cloning and DNA analysis. 2nd Edition, ASM press. (2004).
4. Sandy Primrose. Principles of Gene Manipulation and Genomics. 7th Ed., Blackwell Publishers. (2006).
5. Glick BR and Pasternak JJ, Molecular Biotechnology, 2nd Ed. ASM press. (2003).
6. Udis N. Streips, Ronald E. Yasbin. Modern Microbial Genetics. 2nd Edition Wiley-Liss, Inc. (2002).
7. L. C. Dunn. Heredity and Variation: Continuity and Change in the Living World. LLC 2012

DSE5: Biosafety and Intellectual Property Rights		
<p>Course learning outcomes: By the conclusion of this course, the students have -</p> <p>Outcome 1. Full knowledge of working in a microbiology laboratory taking all safety measures, handling of live bacteria, disposal of infectious waste, care of the equipment requiring safety audit</p> <p>Outcome 2. Developed knowledge of basic concepts related to IPR.</p> <p>Outcome 3. Developed knowledge of patent filing, and some well-known/well-publicized case studies related to IPR</p>		
THEORY COURSE (4 Credits)		
Unit – 1	Biosafety: Introduction; biosafety issues in biotechnology; Biological Safety Cabinets & their types; Primary Containment for Biohazards; Biosafety Levels of Specific Microorganisms AERB/RSD/RES guidelines for using radioisotopes in laboratories and precautions.	12 Lectures
Unit – 2	Biosafety Guidelines: Biosafety guidelines and regulations (National and International); GMOs/LMOs- Concerns and Challenges; Role of Institutional Biosafety Committees (IBSC), RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of International Agreements - Cartagena Protocol.	12 Lectures
Unit – 3	Introduction to Intellectual Property: Patents, Types, Trademarks, Copyright & Related Rights, Industrial Design and Rights, Traditional Knowledge, Geographical	12 Lectures

	Indications- importance of IPR – patentable and non patentables – patenting life – legal protection of biotechnological inventions – World Intellectual Property Rights Organization (WIPO)	es
Unit – 4	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 Lectures
Unit – 5	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 Lectures

LAB. COURSE**(2 Credits)**

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

Reference books

1. Private Power, Public Law: The Globalization of Intellectual Property Rights By Susan K. Sell Cambridge University Press, 2000
2. Essentials of Intellectual Property: Law, Economics, and Strategy By Alexander I. Poltorak; Paul J. Lerner Wiley, 2011 (2nd edition
3. M K Sateesh .Bioethics and Biosafety . Kindle Edition
4. Diane O. Fleming, Debra L. Hunt Biological Safety: Principles and Practices, 4th Edition. ASM 2006
5. Shomini Parashar, Deepa Goel IPR, Biosafety and Bioethics Pearson India 2013

DSE6: Plant Pathology & Disease Management

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

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

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

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

THEORY COURSE

(4 Credits)

Unit – 1	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, VanDer Plank, molecular Koch's postulates. Contributions of eminent Indian plant pathologists.	12 Lectures
Unit – 2	Infection, invasion, colonization, dissemination of pathogens and perennation. Concepts of monocyclic, polycyclic and polyetic diseases, disease triangle & disease pyramid, forecasting of plant diseases and its relevance in Indian context. Microbial Pathogenicity: Virulence factors of pathogens: enzymes, toxins (host specific and non specific) growth regulators, virulence factors in	12 Lectures

	viruses (replicase, coat protein, silencing suppressors) in disease development. Effects of pathogens on host physiological processes(photosynthesis, respiration, cell membrane permeability, translocation of water and nutrients, plant growth and reproduction).	
Unit – 3	<p>Genetics of Plant Disease: Concept of resistance (R) gene and avirulence (avr) gene; gene for gene hypothesis, types of plant resistance: true resistance– horizontal & vertical, apparent resistance.</p> <p>Defense Mechanisms in Plant:Concepts of constitutive defense mechanisms in plants, inducible structural defenses (histological- cork layer, abscission layer, tyloses, gums), inducible biochemical defenses [hypersensitive response (HR), systemic acquired resistance (SAR), phytoalexins, pathogenesis related (PR) proteins, plantibodies, phenolics, quinones,oxidative bursts]</p>	12 Lectures
Unit – 4	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 plant; genetic engineering of disease resistant plants- with plant derived genes and pathogen derived genes	12 Lectures
Unit – 5	<p>Study of some important plant diseases giving emphasis on its etiological agent, symptoms, epidemiology and control. White rust of crucifers-<i>Albugocandida</i>; Downy mildew of onion - <i>Peronospora destructor</i> Late blight of potato - <i>Phytophthorainfestans</i>; Powdery mildew of wheat – <i>Erysiphegraminis</i> Ergot of rye - <i>Clavicepspurpurea</i>; Black stem rust of wheat – <i>Pucciniagraministritici</i> Loose smut of wheat - <i>Ustilagonuda</i>; Wilt of tomato - <i>Fusarium oxysporum</i>f.sp.</p>	12 Lectures

	<p><i>lycopersici</i> Red rot of sugarcane - <i>Colletotrichum falcatum</i>; Early blight of potato - <i>Alternaria solani</i>; Angular leaf spot of cotton, bacterial leaf blight of rice, crown galls, bacterial cankers of citrus; Aster yellow, citrus stubborn; Papaya ring spot, tomato yellow leaf curl, banana bunchy top, rice tungro; Potato spindle tuber, coconut cadang cadang</p>	
<p style="text-align: center;">LAB. COURSE (2 Credits)</p>		
<p>Demonstration of Koch's postulates in fungal, bacterial and viral plant pathogens.</p> <p>Study of important diseases of crop plants by cutting sections of infected plant material - <i>Albugo</i>, <i>Puccinia</i>, <i>Ustilago</i>, <i>Fusarium</i>, <i>Colletotrichum</i></p> <p>Reference Books</p> <ol style="list-style-type: none"> 1. Eldor A. Paul. Soil Microbiology. Ecology and Biochemistry. VI Edition: Academic Press, (2007). 2. Eugene L. Madsen. Environmental Microbiology: From Genome to Biogeochemistry. I Edition, Wiley-Blackwell Publishing. (2008). 3. Agrios, G. N. Plant pathology. Harcourt Asia Pvt. Ltd. (2000). 4. Buchanan, B. B., Gruissem, W. and Jones, R. L. Biochemistry and Molecular Biology of Plants. I. K. International Pvt. Ltd. (2000). 5. Mehrotra R S and Ashok Agrawal. Plant Pathology. Tata Mc Graw Hill, 6th reprint (2006). 6. K. S. Bilgrami, H. C. Dube. A textbook of modern pathology. 6th Edition, Vani Educational Books, a division of Vikas, (1984). 7. Plant Pathology. Elsevier Science Publishing Co Inc 2005. George Nicholas Agrios 8. K. R. Aneja Experiments in Microbiology, Plant Pathology and Biotechnology. New Age Publications 2017 		

DSE7: Pharmaceutical Microbiology		
<p>Outcome 1. Acquired detailed knowledge of antimicrobial agents, their chemical nature, and mechanism of action and basis of resistance of microbes to these antimicrobials, formulations involving different antimicrobials, stabilization of formulations.</p> <p>Outcome 2. Developed understanding of different types of disinfectants/antiseptics and their specific uses, and evaluation of their bactericidal and bacteriostatic actions; basic knowledge of cell cultures.</p> <p>Outcome 3. Developed practical skills for testing pharmaceutical products for sterility testing and pyrogenicity testing using different methods</p>		
THEORY COURSE (4 Credits)		
Unit - 1	<p>Antibiotics and Synthetic antimicrobial agents</p> <p>microbial resistance;therapeutic, prophylactic usage and adverse reactions;Antibiotic and Synthetic antimicrobial agents:</p> <p>Mechanism of action of antibiotics</p> <p>Inhibition of cell wall synthesis,nucleic acid and protein synthesis. β-lactam, aminoglycosides, tetracyclines, macrolides.Antifungal antibiotics: Griseofulvin.</p> <p>Antiviral drugs: Amantidines;Nucleoside analogues, interferons.</p> <p>Peptide antibiotics. Synthetic antibiotics: Sulphonamides</p> <p>Chloramphenicol; Quinolone</p> <p>Bacterial resistance to antibiotics;Penetration of antimicrobial agents (cellular permeability barrier, cellular transport system and drug diffusion).</p>	12 lectures

Unit - 2	sources /types of microbial contaminants, assessment of microbial contamination and spoilage.Preservation of pharmaceutical products using antimicrobial agents, evaluation of microbial stability of formulations.	12 lectures
Unit - 3	Classification and mode of action of disinfectants. Factors influencing disinfection, antiseptics and their evaluation. For bacteriostatic and bactericidal actions Evaluation of bactericidal & Bacteriostatic agents. Sterility testing of products (solids, liquids, ophthalmic and other sterile products) according to IP, BP and USP.	12 lectures
Unit - 4	Designing of aseptic area, laminar flow equipments; study of different sources of contamination in an aseptic area and methods of prevention, clean area classification. Principles and methods of different microbiological assay. Methods for standardization of antibiotics, vitamins and amino acids. Assessment of a new antibiotic and testing of antimicrobial activity of a new substance. Safety profile of drugs (Pyrogenicity, Toxicity –hepato, - nephro, -cardio and -neurotoxicity) ;Toxicological evaluation of drug: LD50, Acute, subacute and chronic toxicity ;Mutagenicity (Ames test, micronucleus test), Carcinogenicity and Teratogenicity	12 lectures

Unit - 5	<p>Growth of animal cells in culture, general procedure for cell culture, Primary, established and transformed cell cultures. Application of cell cultures in pharmaceutical industry and research. Molecular principles of drug targeting; Drug delivery system in gene therapy.</p> <p style="text-align: center;">LAB COURSE (2 credits)</p> <ol style="list-style-type: none"> 1. Microbial Examination of sterile and Non Sterile Products 2. Bacterial Endotoxin Testing by Gel Clot Method 3. Test for Confirmation of Labeled LAL Reagent Sensitivity (LAL Test) 4. Antibiotic Potency Testing 5. Bioburden Estimation for Medical Devices 6. Determination of D value, Z value for heat sterilization in pharmaceuticals. 7. Chemical / Microbiological methods for the determination of Penicillin, Streptomycin, Griesofulvin 8. Prediction of binding site of macromolecules using MEDsuMo software 	12 lectures
<p>Reference Books</p> <ol style="list-style-type: none"> 1. A Textbook of Pharmaceutical Microbiology Paperback (2018) by Pulak Mujumder, Sameer Rajan Sahoo Everest Publishing 2. A Textbook of Pharmaceutical Microbiology (2015) Mehra Prahlad Singh IK International Publishing 3. Pharmaceutical Microbiology (2015) by Sheth Z. PCBS Publisher 4. A.V.S.S. Sambamurthy .A Textbook of Plant Pathology. IK International Publishing House 2009 5. Nidhi Goel .Pharmaceutical Microbiology: A Textbook .Alpha Science Intl Ltd .2012 6. 5.Prahlad Singh Mehra .A Textbook of Pharmaceutical Microbiology .IK International Publications 		

DSE8: Instrumentation and Bio-techniques		
<p>Course learning outcomes: By the conclusion of this course, the students have -</p> <p>Outcome 1. Developed understanding of principals, and applications of different microscopic and spectrophotometric methods.</p> <p>Outcome 2. Developed understanding of principals, and applications of different separation techniques especially chromatographic, electrophoretic and centrifugation techniques.</p> <p>Outcome 3. Skills in handling and use of light microscope, spectrophotometer and centrifugation equipment to study/analyze various microbiological samples.</p>		
THEORY COURSE (4 Credits)		
Unit – 1	Microscopy: Bright field and dark field microscopy, Fluorescence Microscopy, Phase contrast Microscopy, Confocal Microscopy, Electron Microscopy (Scanning and Transmission Electron Microscopy) and Micrometry.	12 Lectures
Unit – 2	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.	12 Lectures
Unit – 3	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 Lectures
Unit – 4	Spectrophotometry: Principle and use of study of absorption spectra of biomolecules. Analysis of biomolecules using UV and visible range.	12 Lectures

	Colorimetry and turbidometry.	
Unit – 5	Centrifugation: Preparative and analytical centrifugation, fixed angle and swinging bucket rotors. RCF and sedimentation coefficient, differential centrifugation, density gradient centrifugation and ultracentrifugation.	12 Lectures
<p style="text-align: center;">LAB. COURSE (2 Credits)</p>		
<p>Study of fluorescent micrographs to visualize bacterial cells.</p> <p>Ray diagrams of phase contrast microscopy and Electron microscopy.</p> <p>Separation of mixtures by paper/thin layer chromatography.</p> <p>Demonstration of column packing in any form of column chromatography.</p> <p>Separation of protein mixtures by any form of chromatography.</p> <p>Separation of protein mixtures by Polyacrylamide Gel Electrophoresis (PAGE).</p> <p>Reference books</p> <ol style="list-style-type: none"> 1. Textbook Of Biophysical Chemistry by U N Dash Macmillan Publishers India (2006) 2. Biophysical chemistry by Nath, Nath and Upadhyay 3. Wilson & Walker. Principles and Techniques in Practical Biochemistry. 5th Edition Cambridge University Press (2000). 4. Khan I A and Khan I A. Fundamentals of Biostatistics, Ukaaz Publications, (1994). Murphy D.B. 6. Fundamental of Light Microscopy & Electron Imaging. 1st Edition. Wiley-Liss. (2001). 7. David Plummer .An Introduction To Practical Biochemistry 2006 		

DSE9: Interdisciplinary Project: Microbes and Society

As per the guidance of the supervisors/ departmental management

Course learning outcomes: By the conclusion of this course, the student is capable to-

Outcome 1. Identify problems which are related to microorganisms and has a societal relevance; identify lacunae in knowledge and frame objective of the study, in consultation with the Mentor/Teacher/Academic Advisor.

Outcome 2. Design relevant experiments, conduct the experiments, record /collect data and analyze data.

Outcome 3. Draw inferences from data and its presentation.

The student is required to carry out a project requiring experimental work amounting to 6 hours per week. Final report is to be submitted in a standard format as follows:

(Introduction, Objectives, Material and Methods, Results, Discussion, and Bibliography).

DSE10 :Veterinary Microbiology

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

Outcome 1. Developed basic concepts of the causation of diseases by different types of microorganisms.

Outcome 2. Developed knowledge of the common diseases of microbial etiology for animals especially the domesticated animals and the vaccines available for animal immunization.

Outcome 3. Acquired skills on the laboratory identification of disease causing microbes and antibiotic sensitivity testing.

THEORY COURSE**(4 Credits)**

Unit – 1	History of microbiology and introduction to the microbial world. Microorganisms and fermentation, Germ theory of diseases, Development of various Microbiological techniques and golden era of microbiology. Contributions of Antony von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming, Martinus W. Beijerinck, Sergei N. Winogradsky, Selman A. Waksman, Paul Ehrlich, Elie Metchnikoff, Edward Jenner.	12 Lectures
Unit – 2	Physiochemical and biological characteristics of microorganisms (including viruses). Introduction to oncogenic viruses. Types of oncogenic DNA and RNA viruses: Bacterial structure, Nutritional requirements of bacteria, Types of media, Physical conditions required for bacterial growth, Bacterial growth curve, methods of measurement of bacterial growth	12 Lectures
Unit – 3	Microbial techniques: Pure culture isolation: Streaking, serial dilution and plating methods; cultivation, maintenance and preservation/stocking of pure cultures; cultivation of anaerobic bacteria, . Buffers in culture medium. Cultivation of fungi, actinomycetes, yeasts, Cultivation of anaerobes. Optical and Electron microscope (Structure and function),	12 Lectures

Unit – 4	Sources and routes of infection, Transmission of pathogens, portals of entry of pathogen, Microorganisms and animal host interactions, Toxins(endo and exo)	12 Lectures
Unit – 5	Study of following animal diseases with respect to etiology, symptoms, mode of transmission, prophylaxis and control: Q fever FMD, swine flu, bird flu, Rabies, bovine tuberculosis, , Infections caused by Campylobacter, Salmonella Marek's, ranikhet, brucellosis, distemper. Common cattle diseases Bovine Respiratory Disease Complex (BRDC), Clostridial Disease, or "Blackleg" , BRSV (Bovine Respiratory Syncytial Virus) BVD (Bovine Viral Diarrhea) (Infectious Bovine Rhinotracheitis), (Parainfluenza Type 3), Pasteurella haemolytica and Pasteurella multocida.	12 Lectures

LAB. COURSE**(2 Credits)**

1. Staining: Gram staining and Acid fast staining, motility by Hanging drop method.
2. Study of following equipment including care and maintenance) :Optical microscope . Incubator, Hot air oven, Autoclave
3. Preparation of commonly used media, Inoculation of culture plates (streak and spread plate) and broth media.
4. Biochemical tests: Sugar fermentation, IMViC, catalase, Oxidase, etc.
5. Antibiotic sensitivity testing Using disc.(Gram positive and Gram negative bacteria)

Reference Books

1. Textbook of Veterinary Microbiology (2015) By Sharma S.N.Vikas Publishing
2. General Veterinary Microbiology - An introduction (2017) By R.P. Diwakar R.K. Diwakar Astral Publishing
3. Veterinary Microbiology and Microbial Disease (2011), 2nd Edition By P. J. Quinn, B. K. Markey, F. C. Leonard, P. Hartigan, S. Fanning, E. S. Fitzpatrick Wiley
4. N. MacLachlan Edward J Dubovi Fenner's Veterinary Virology 5th Edition Academic Press (2016)
5. G. R. Carter, Darla J. Wise.Essentials of Veterinary Bacteriology and Mycology, Wiley-Blackwell (2003)
6. P. J. Quinn, B. K. Markey, F. C. Leonard, P. Hartigan, S. Fanning, E. S. Fitzpatrick.Veterinary Microbiology and Microbial Disease. Wiley-Blackwell (2011)

GENERIC ELECTIVE COURSE (GEC)

GEC1: Microbial world & Diversity		
<p>Course learning outcomes: By the conclusion of this course, the students-</p> <p>Outcome 1. Has acquired a fairly good understanding of the Diversity of the microbes</p> <p>Outcome 2. Has acquired a fairly good understanding of the activities/importance of microbes.</p> <p>Outcome 3. Has acquired practical skills of handling microorganisms in the laboratory for study.</p>		
THEORY COURSE (4 Credits)		
Unit – 1	Introduction to microbial world, Physiochemical and biological characteristics; Characteristics of Acellular microorganisms (Viruses); Baltimore classification, general structure with special reference to viroids and prions. Binomial Nomenclature, Whittaker's five kingdom and Carl Woese's three kingdom classification systems and their utility. Difference between prokaryotic and eukaryotic microorganisms	12 Lectures
Unit – 2	General characteristics of Cellular microorganisms, types - archaebacteria, eubacteria, wall-less forms - MLO (mycoplasma and spheroplasts) with emphasis on distribution and occurrence, morphology, mode of reproduction and economic importance. Structure, reproduction and economic importance of Mycoplasma.	12 Lectures
Unit – 3	General concept of Phytoplanktons and Zooplanktons. Characteristics, occurrence, thallus organization and classification of Algae. Cyanobacteria - occurrence, thallus organization, cell ultra structure, reproduction and	12 Lectures

	economic importance. Applications of algae in agriculture, industry, environment and food.	es
Unit – 4	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, mode of reproduction and Economic importance of fungi with examples in agriculture, environment, Industry, medicine and food.	12 Lectures
Unit – 5	General characteristics, structure, mode of reproduction and economic importance of Actinomycetes with special reference to <i>its application in medicine and industry</i> . General characteristics, occurrence, classification structure, reproduction and economic importance of Protozoa.	12 Lectures

LAB. COURSE**(2 Credits)**

1. Microbiology Good Laboratory Practices and Bio-safety.
2. To study the principle and applications of important instruments (biological safety cabinets, autoclave, incubator, BOD incubator, hot air oven, light microscope, pH meter) used in the microbiology laboratory.
3. Preparation of laboratory Glass wares (Chemical washing, cleaning and drying).
4. Preparation of culture media (Liquid & solid).for bacterial cultivation.
5. Handling and care of laboratory equipment - Autoclave, Hot air oven, Incubator, pH meter, Highspeed centrifuge, Laminar airflow.
6. Sterilization of medium using Autoclave.
7. Sterilization of glassware using Hot Air Oven and assessment for sterility.
8. Sterilization of heat sensitive material by membrane filtration and assessment for sterility

9. Demonstration of the presence of microflora in the environment by exposing nutrient agar plates to air.
10. Observation of microorganisms - Bacteria, Cyanobacteria Protozoa, Fungi, Yeasts, and Algae from Natural habitats.
11. Study of common fungi, algae and protozoan using temporary mounts

Reference Books

1. Singh, R.P. General Microbiology. Kalyani Publishers, New Delhi (2007).
2. Aneja, K.R. Experiments in Microbiology, Plant pathology and Biotechnology, Fourth edition, New Age International publishers.
3. Dubey, R.C. and Maheshwary, D.K. Text book of Microbiology. S. Chand and company (1999).
4. Powar, C.B. and Dagainawal, H.F. General Microbiology. Vol-I and Vol- II, Himalaya Publishing House.
5. Chakraborty P. A Textbook Of Microbiology. New central book Agency (2005).
6. Prescott, M.J., Harley, J.P. and Klein, D.A. Microbiology. 5th Edition WCB McGraw Hill, New York, (2002).
7. Tortora, G.J., Funke, B.R. and Case, C.L. Microbiology: An Introduction Pearson Education, Singapore, (2004).
8. Alcom, I.E. Fundamentals of Microbiology. VI Edition, Jones and Bartlett Publishers. Sudbury. Massachusetts, (2001).
9. Black J.G. Microbiology- Principles and Explorations. John Wiley & Sons Inc. New York, (2002).
10. Pelczar, M.J. Chan ECS and Krieg NR, Microbiology McGraw-Hill.
11. Willey, Sherwood, Woolverton. Prescott, Harley, and Klein's Microbiology McGraw-Hill publication
12. Tortora, Funke, Case. Microbiology. Pearson Benjamin Cummings.
13. JACQUELYN G. BLACK. Microbiology Principles and explorations. JOHN WILEY & SONS, INC.
14. Madigan, Martinko, Bender, Buckley, Stahl. Brock Biology of Microorganisms. Pearson
15. Tom Besty, D.C Jim Koegh. Microbiology Demystified McGRAW-HILL.

GEC2: Bacteriology and Virology

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

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

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

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

THEORY COURSE

(4 Credits)

Unit – 1	Virology: 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. Viral taxonomy- Classification and nomenclature of different groups of viruses. Diversity, classification of bacteriophages, lytic and lysogenic phages (lambda phage) concept of early and late proteins, regulation of transcription in lambda phage.	12 Lectures
Unit – 2	Modes of viral transmission: Persistent, non-persistent, vertical and horizontal. Salient features of viral Nucleic acid : Unusual bases (TMV, T4 phage), overlapping genes (ϕ X174, Hepatitis B virus), alternate splicing (HIV), terminal redundancy (T4 phage), terminal cohesive ends (lambda phage), partial double stranded genomes (Hepatitis B), long terminal repeats (retrovirus), segmented (Influenza virus), and non-segmented genomes (picornavirus), capping and tailing (TMV) Viral multiplication and replication strategies: Interaction of viruses with cellular receptors and entry of	12 Lectures

	viruses. Replication strategies of viruses as per Baltimore classification (phiX174, Retroviridae, Vaccinia, Picorna), Assembly, maturation and release of virions	
Unit – 3	<p>Bacteria: Cell size, shape and arrangement, glycocalyx, capsule, flagella, endoflagella, fimbriae and pili. Cell-wall: Composition and detailed structure of Gram-positive and Gram-negative cell walls, Archaeobacterial cell wall, lipopolysaccharide (LPS), sphaeroplasts, protoplasts, and L-forms.</p> <p>Cell Membrane: Structure, function and chemical composition of bacterial and archaeal cell membranes. Cytoplasm- Ribosomes, mesosomes, inclusion bodies, nucleoid, genome and plasmids Endospore: Structure, formation, stages of sporulation.</p>	12 Lectures
Unit – 4	<p>Nutritional requirements in bacteria and nutritional categories; Culture media: natural and synthetic media, chemically defined media, complex media, selective, differential, indicator, enriched and enrichment media. Physical methods of microbial control: heat, low temperature, high pressure, filtration, desiccation, osmotic pressure, radiation. Asexual methods of reproduction, logarithmic representation of bacterial populations, phases of growth, calculation of generation time and specific growth rate</p>	12 Lectures
Unit – 5	<p>Aim and principles of classification, systematics and taxonomy, concept of species, taxa, strain; conventional, molecular and recent approaches to polyphasic bacterial taxonomy, evolutionary chronometers, rRNA oligonucleotide sequencing, signature sequences, and protein sequences. Differences between eubacteria and archaeobacteria. Eubacteria: Morphology, metabolism, ecological significance and economic importance of Gram negative and Gram positive bacteria</p>	12 Lectures

LAB. COURSE**(2 Credits)**

1. Preparation of different media: synthetic media, Complex media Nutrient- agar, McConkey agar, EMB agar.
2. Gram staining
3. Acid fast staining-permanent slide only.
4. Isolation of pure cultures of bacteria by streaking method.
5. Preservation of bacterial cultures by various techniques.
6. Estimation of CFU count by spread plate method/pour plate method.
7. Motility by hanging drop method.
8. Study of the structure of important animal viruses (rhabdo, influenza, paramyxoh hepatitis B and retroviruses) using models, videos, and electron micrographs
9. Study of the structure of important plant viruses (caulimo, Gemini, tobacco ringspot, cucumber mosaic and alpha-alpha mosaic viruses) using electron micrographs
10. Study of the structure of important bacterial viruses (ϕ X174, T4, λ) using electron micrograph.
11. Isolation and enumeration of bacteriophages (PFU) from water/sewage sample using double agar layer technique
12. Study of cytopathic effects of viruses using photographs

Reference books

1. Pelczar M., Chan E.C.S. and Krieg, N.R. Microbiology. Tata Mc Grew Hill Publishing Co. Ltd., New Delhi.
2. Stainier R.V., Ingraham, J.L., Wheelis, M.L. and Painter P.R. The Microbial World. Printice-Hall of India (Pvt.) Ltd., New Delhi.
3. Alexopoulos, C.J., Mims, C.W. and Blackwel, M, Introductory Mycology. John Wiley, New York.
4. Mehrotra, R.S. and K.R. Aneja An Introduction to Mycology. New Age International Press, New Delhi.
5. Webster, J. Introduction to fungi. Cambridge University Press. Cambridge, U.K. (1985).
6. Pelczar, MJ Chan ECS and Krieg NR, Microbiology McGraw-Hill.
7. Willey, Sherwood, Woolverton. Prescott, Harley, and Klein's Microbiology McGraw-Hill publication
8. Tortora, Funke, Case. Microbiology. Pearson Benjamin Cummings.
9. JACQUELYN G. BLACK. Microbiology Principles and explorations. JOHN WILEY & SONS, INC.
10. Madigan, Martinko, Bender, Buckley, Stahl. Brock Biology of Microorganisms. Pearson
11. Tom Besty, D.C Jim Koegh. Microbiology Demystified McGRAW-HILL
S. Jane Flint, Lynn W. Enquist, Vincent R. Racaniello, Anna Marie Skalka. Principles of Virology. ASM Press; (2008)

GEC3: Medical Microbiology and Immunology

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

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

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

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

THEORY COURSE

(4 Credits)

Unit – 1	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, Pathophysiologic effects of LPS. Collection, transport and culturing of clinical samples, principles of different diagnostic tests (ELISA, Immunofluorescence, Agglutination based tests, Complement fixation, PCR, DNA probes).	12 Lectures
Unit – 2	List of diseases of various organ systems and their causative agents. Symptoms, mode of transmission, prophylaxis and control of the diseases caused by Streptococcus pyogenes, Haemophilus influenzae, Mycobacterium tuberculosis, Bacillus anthracis, Clostridium tetani, Treponema pallidum, Clostridium difficile, and the viruses causing Polio, Herpes, Hepatitis, Dengue, AIDS, influenza and Japanese encephalitis.	12 Lectures
Unit – 3	Study of following animal diseases with respect to etiology, symptoms, mode of transmission, prophylaxis and control: FMD, swine flu, bird flu, Rabies, bovine	12 Lectures

	tuberculosis, Marek's, Ranikhet, brucellosis, distemper.	
Unit – 4	Mycoses: Cutaneous mycoses: Tinea pedis (Athlete's foot) Systemic mycoses: Histoplasmosis Opportunistic mycoses: Candidiasis. Occurrence, habitat, morphology and reproduction of Protozoa. Structure and reproduction of important Protozoans- Entamoeba, Giardia, Trichomonas, Leishmania, Trypanosoma and Plasmodium.	12 Lectures
Unit – 5	Immune system: Structure and function of the cells, tissues and organs of immune system. Types of immunity - Humoral and cell-mediated, innate, acquired immunity. Complement system - function and pathways. Antigen-Antibody: types, properties. Hapten, adjuvants, Immunoglobulins: Structure types, Properties and their function - Theory of antibody production. Antigen-Antibody Interactions, Agglutination, Precipitation, Complement fixation test. Hypersensitivity reactions; IgE mediated Type I Hypersensitivity, Antibody-mediated cytotoxic (Type II) Hypersensitivity, Immune complex mediated (Type III) Hypersensitivity, TDTM mediated (Type IV) Hypersensitivity.	12 Lectures
<p style="text-align: center;">LAB.</p> <p style="text-align: center;">COURSE</p> <p style="text-align: center;">(2 Credits)</p>		
<ul style="list-style-type: none"> Identify bacteria (any three of <i>E.coli</i>, <i>Salmonella</i>, <i>Pseudomonas</i>, <i>Staphylococcus</i>, <i>Bacillus</i>) using laboratory strains on the basis of cultural, morphological and biochemical characteristics: IMViC, TSI, nitrate reduction, urease production and catalase tests Study of composition and use of important differential media for identification of bacteria: EMB Agar, McConkey agar, Mannitol salt agar, Deoxycholate citrate agar, TCBS Study of bacterial flora of skin by swab method Perform antibacterial sensitivity by Kirby-Bauer method Study symptoms of the diseases with the help of photographs: Polio, anthrax, herpes, 		

chickenpox, HPV warts, AIDS(candidiasis),dermatomycoses(ringworms)

- Study of various stages of malarial parasite in RBCs using permanent mounts.

Reference books

1. Bernard, Davis B. Dulbecco, Eisen and Ginsberg. Microbiology including immunology and molecular Genetics. 3rd Edition
2. Roitt I. Essential Immunology. 10th Ed. Blackwell Science.
3. Kuby. Immunology. 4th edition. W. H. Free man & company.
4. Ananthanarayan and Paniker. Text book of microbiology. University press. 8th edition
5. Pelczar, MJ Chan ECS and Krieg NR, Microbiology McGraw-Hill.
6. Willey, Sherwood, Woolverton. Prescott, Harley, and Klein's Microbiology McGraw-Hill publication
7. Tortora, Funke, Case. Microbiology. Pearson Benjamin Cummings.
8. JACQUELYN G. BLACK. Microbiology Principles and explorations. JOHN WILEY & SONS, INC.
9. Madigan, Martinko, Bender, Buckley, Stahl. Brock Biology of Microorganisms. Pearson
10. Tom Besty, D.C Jim Koegh. Microbiology Demystified McGRAW-HILL.

GEC4: Industrial and Food Microbiology

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

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

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

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

THEORY

COURSE

(4 Credits)

Unit – 1	Brief history and developments in industrial microbiology. Types of fermentation processes -solid state, liquid state, batch, fed-batch and continuous Types of fermenters – laboratory, pilot-scale and production fermenters. Components of a typical continuously stirred tank bioreactor. Primary and secondary screening. Preservation and maintenance of industrial strains	12 Lectures
Unit – 2	Downstream processing - filtration, centrifugation, cell disruption, solvent extraction. Microbial production of industrial products - citric acid, ethanol and penicillin. Industrial production and uses of the enzymes - amylases, proteases, lipases and cellulases.	12 Lectures
Unit – 3	Ingredients used in fermentation medium - molasses, corn steep liquor, whey & Yeast extract Food as a substrate for microbial growth; Intrinsic and extrinsic parameters that affect microbial growth in food Microbial spoilage of food - milk, egg, bread and canned foods	12 Lectures

Unit – 4	Physical methods - high temperature, low temperature, irradiation, aseptic packaging Chemical methods - salt, sugar, benzoates, citric acid, ethylene oxide, nitrate and nitrite Food sanitation and control – HACCP	12 Lectures
Unit – 5	Fermented dairy products - yogurt, acidophilus milk, kefir, dahi and cheese Probiotics definition, examples and benefits. Food intoxication by <i>Clostridium botulinum</i> and <i>Staphylococcus aureus</i> Food infection by <i>Salmonella</i> and <i>E.coli</i>	12 Lecture
<p style="text-align: center;">LAB. COURSE (2 Credits)</p>		
<ol style="list-style-type: none"> 1. Study of different parts of fermenter 2. Microbial fermentations for the production and estimation (qualitative and quantitative) of: Enzymes: Amylase and Protease; Amino acid: Glutamic acid; Organic acid: Citric acid; Alcohol: Ethanol 3. A visit to any educational institute/industry to see an industrial fermenter, and other downstream processing operations. 4. MBRT of milk samples and their standard plate count. 5. Alkaline phosphatase test to check the efficiency of pasteurization of milk. 6. Isolation of spoilage microorganisms from spoiled vegetables/fruits. 7. Preparation of Yogurt/Dahi. <p>Reference books</p> <ol style="list-style-type: none"> 1. Nduka Okafor. Modern Industrial Microbiology and Biotechnology. 1st Edition. Science Publishers. (2007). 2. Waites, M.J., Morgan, N.L., Rockey, J.S. and Hington, G. Industrial Microbiology: An introduction. Blackwell science Publishers. (2002). Nduka Okafor, Benedict C. Okeke. Modern Industrial Microbiology and Biotechnology. CRC Press. (2017) W Clarke .Biotechnology : Industrial Microbiology A Textbook .CBS Publishers and Distributors (2016) 		

GEC5: Microbes in Sustainable Agriculture and Development

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

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

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

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

THEORY

COURSE

(4 Credits)

Unit – 1	Soil Microbiology: Soil as Microbial Habitat, Soil profile and properties, Soil formation, Diversity and distribution of microorganisms in soil. Microbial Activity in Soil and Green House Gases- Carbon dioxide, methane, nitrous oxide, nitric oxide – production and control	12 Lectures
Unit – 2	Mineralization of Organic & Inorganic Matter in Soil: Mineralization of cellulose, hemicelluloses, lignocelluloses, lignin and humus, phosphate, nitrate, silica, potassium	12 Lectures
Unit – 3	Microbial Control of Soil Borne Plant Pathogens: Biocontrol mechanisms and ways, Microorganisms used as biocontrol agents against Microbial plant pathogens, Insects, Weeds	12 Lectures
Unit – 4	Biofertilization, Phytostimulation, Bioinsecticides: Plant growth promoting bacteria, biofertilizers–symbiotic (<i>Bradyrhizobium</i> , <i>Rhizobium</i> , <i>Frankia</i>),	12 Lectures

	Non Symbiotic (<i>Azospirillum</i> , <i>Azotobacter</i> , Mycorrhizae, MHBs, Phosphatesolubilizers, algae), Novel combination of microbes as biofertilizers, PGPRs	
Unit – 5	Secondary Agriculture Biotechnology: Biotech feed, Silage, Biomanure, biogas, biofuels – advantages and processing parameters. GM crops: Advantages, social and environmental aspects, Bt crops, golden rice, transgenic animals.	12 Lectures
LAB. COURSE (2 Credits)		
<ol style="list-style-type: none"> 1. Isolation and purification of cyanobacteria, actinomycetes, fungi 2. Methods of isolation and identification of fungi by traditional methods Study of soil fungi 3. Staining and observation of plant pathogenic fungi. 4. Isolation of amylase producing microorganisms from soil 5. Isolation of protease producing microorganisms from soil 6. Isolation and Rhizobium and Azotobacter Nitrogen bacteria from soil. 7. Laboratory scale production of biofertilizers. 8. Isolation and characterization of plant growth promoting bacteria. 9. Splash liberation of fungal spores from diseased tissue. 10. Seed health testing by using Standard Blotter Method <p>Reference books</p> <ol style="list-style-type: none"> 1. Eldor A. Paul. Soil Microbiology. Ecology and Biochemistry. VI Edition: Academic Press, (2007). 2. Eugene L. Madsen. Environmental Microbiology: From Genome to Biogeochemistry. I Edition, Wiley-Blackwell Publishing. (2008). 3. Agrios, G. N. Plant pathology. Harcourt Asia Pvt. Ltd. (2000). 4. Buchanan, B. B., Gruissem, W. and Jones, R. L. Biochemistry and Molecular Biology of Plants. I. K. International Pvt. Ltd. (2000). 5. Mehrotra R S and Ashok Agrawal. Plant Pathology. Tata Mc Graw Hill, 6th reprint (2006). 6. K. S. Bilgrami, H. C. Dube. A textbook of modern pathology. 6th Edition, Vani Educational Books, 		

a division of Vikas, (1984).

7. K.R. Aneja .Experiments in Microbiology, Plant Pathology and Biotechnology . New Age Publications.2017

GEC6: Microbial Enzyme Technology

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

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

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

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

THEORY COURSE (4 Credits)

Unit – 1	Basic concepts of enzymes: Nomenclature, classification, methods for determination of enzyme activity. Isolation and purification of enzymes. Enzyme kinetics: Michaelis-Menten equation, effect of pH, substrate concentration, temperature and inhibitors. Isoenzymes and allosteric enzymes. Enzyme inhibition- competitive and non-competitive inhibition	12 Lectures
Unit – 2	Enzymes from microbial sources, large scale production of enzymes, recovery of enzymes, enzyme purification methods - enzyme precipitation, separation by chromatography, enzyme reactors.	12 Lectures
Unit – 3	Immobilized enzymes: Physical and chemical methods of immobilization, immobilization supports, kinetics of immobilized enzymes. Enzyme catalysis in apolar medium, reverse micellar entrapment of enzymes and its applications.	12 Lectures
Unit – 4	Application of enzymes: synthesis of chemicals using enzymes, food technology and medicine. Enzymes in diagnostic assays. Enzyme electrodes, immunoenzyme techniques.	12 Lectures

Unit – 5	Microbial toxins:Types, biochemical and molecular basis of toxin production, implications. Genetically engineered microbes, anti-HIV, anticancer, antifungal, antiplasmodial, anti-inflammatory compounds.	12 Lectures
<p style="text-align: center;">LAB. COURSE (2 Credits)</p>		
<ol style="list-style-type: none"> 1. Isolation Purification of amylase from suitable culture: assay, Purification at least three steps, Determination of Km., Line Weaver Burk plot 2. Isolation Purification of cellulase from suitable culture: assay, Purification at least three steps, Determination of Km., Line Weaver Burk plot Factors affecting enzyme activity (pH, Temperature) Immobilisation of enzyme using calcium alginate 3. ELISA(demonstration) <p>Reference Books</p> <ol style="list-style-type: none"> 1. Berg JM,Tymoczko JL,StryerL., Biochemistry. 6th Edition.Freeman (2006). 2. Prakash Singh Bisen, Anjana Sharma, Introduction to Instrumentation in Life Sciences, Taylor and Francis, (2012). 3. James Bailey and David Ollis, Fundamentals of Biochemical Engineering, 2nd edition, McGraw-Hill, (1986). 4. Casida LE, Industrial Microbiology, J. Wiley, (1968). 5. Chisti. Y.Encyclopedia of Bioprocess Technology, Vol-5, John Wiley and Sons, New York. 6. Michael L. Shuler and Fikret Kargi. Bioprocess Engineering: Basic Concepts, 2nd Edition. Prentice Hall. (2001). 7. Fogarty, W.M., Kelly, C.T. Microbial Enzymes and Biotechnology 8. Goutam Brahmachari .Biotechnology of Microbial Enzymes .Academic Press (2016) 		

GEC 7: Microbial Genetics and Molecular Biology

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

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

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

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

THEORY

COURSE

(4 Credits)

Unit – 1	Structures of DNA and RNA/Genetic Material: DNA structure, Salient features of double helix, Types of DNA, denaturation and renaturation, topoisomerases; Organization of DNA Prokaryotes, Viruses, Eukaryotes. RNA Structure. Replication of DNA: Bidirectional and unidirectional replication, semi-conservative, semi-discontinuous replication Mechanism of DNA replication: Enzymes and proteins involved in DNA replication – DNA polymerases, DNA ligase, primase, telomerase – for replication of linear ends.	12 Lectures
Unit – 2	Gene Expression: Transcription - Definition, promoter - concept and strength of promoter. Transcriptional Machinery and Mechanism of transcription. Translation - Genetic code, Translational machinery, Charging of tRNA, aminoacyl tRNA synthetases, Mechanisms of initiation, elongation and termination of polypeptides.	12 Lectures
Unit – 3	Regulation of gene Expression: Principles of transcriptional regulation, regulation at initiation with examples from <i>lac</i> and <i>trp</i> operons. Mutation: Mutations and mutagenesis: Definition	12 Lectures

	nand types of Mutations; Physical and chemical mutagens; Uses of mutations, DNA repair mechanisms	
Unit – 4	Mechanisms of Genetic Exchange: Transformation - Discovery, mechanism of natural competence Conjugation - Discovery, mechanism, Hfr and F' strains Transduction - Generalized transduction, specialized transduction	12 Lectures
Unit – 5	Plasmids and Transposable Elements: Property and function of plasmids, Types of plasmids. Prokaryotic transposable elements – Insertion Sequences, composite and non-composite transposons, Replicative and Non replicative transposition, Uses of transposons and transposition.	12 Lectures

LAB.
COURSE
(2 Credits)

1. Study of different types of DNA and RNA using micrographs and model / schematic representations
2. Study of semi-conservative replication of DNA through micrographs / schematic representations
3. Estimation of salmon sperm / calf thymus DNA using colorimeter (diphenylamine reagent) or UV spectrophotometer (A₂₆₀ measurement)
4. Resolution and visualization of DNA by Agarose Gel Electrophoresis.
5. Resolution and visualization of proteins by Polyacrylamide Gel Electrophoresis (SDS-PAGE).
6. Study the effect of chemical (HNO₂) and physical (UV) mutagens on bacterial cells
7. Study survival curve of bacteria after exposure to ultraviolet (UV) light
8. Demonstration of Bacterial Transformation and calculation of transformation efficiency.

Reference Books

1. Benjamin Lewin, Gene VII, Oxford University Press, (2000).
2. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter, Molecular biology of the Cell, 4th Edition. Garland publishing Inc, (2002).
3. Darnell, Lodish and Baltimore, Molecular Cell Biology, Scientific American Publishing Inc. (2000).

4. Watson.J.D,Baker.T.A,Bell.S.P,Gann.A.Levine.M.Losick.R, Molecular Biology of Gene, 5th Edition.The Benjamin/Cummings Pub.Co.Inc. (2003).
5. David Frifielder, Stanely R.Maloy, Molecular biology and Microbial genetics. 2nd Edition, Jones and Barlett Publishers. (1994).
6. Brown T.A., Gene Cloning and DNA analysis. 2nd Edition, ASM press. (2004).
7. Sandy Primrose. Principles of Gene Manipulation and Genomics. 7th Ed., Blackwell Publishers. (2006).
8. Glick BR and Pasternak JJ, Molecular Biotechnology, 2nd Ed. ASM press. (2003).
9. Uldis N. Streips, Ronald E. Yasbin. Modern Microbial Genetics. 2nd Edition Wiley-Liss, Inc. (2002).
10. Russel P J, Essential genetics, Blackwell Science Inc, 2 sub edition, (1987).
11. Gardner E J, Simmons M J and Snupstad DP, Principles of genetics, 8th edition John Wiley & Sons, (2006).
12. Larry Snyder , Wendy Champness Molecular Genetics of Bacteria, ASM Press; (2007)

GEC8: Genetic Engineering and Biotechnology

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

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

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

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

THEORY

COURSE

(4 Credits)

Unit – 1	Introduction to genetic engineering: Milestones in genetic engineering and biotechnology Restriction modification systems: Mode of action, applications of Type II restriction enzymes in genetic engineering. DNA modifying enzymes and their applications: DNA polymerases. Terminal deoxynucleotidyl transferase, kinases and phosphatases, and DNA ligases	12 Lectures
Unit – 2	Cloning: Use of linkers and adaptors: Transformation of DNA: Chemical method, Electroporation. Methods of DNA, RNA and Protein analysis: Agarose gel electrophoresis, Southern - and Northern - blotting techniques, dot blot, DNA microarray analysis, SDS-PAGE, and Western blotting	12 Lectures
Unit – 3	Cloning Vectors: Definition and Properties Plasmid vectors: pBR and pUC series Bacteriophage lambda and M13 based vectors Cosmids, BACs, YACs Expression vectors: <i>E.coli</i> lac and T7 promoter-based vectors, yeast YIp, YEp and YCp vectors, Baculovirus based vectors, mammalian SV40-based expression vectors	12 Lectures
Unit – 4	DNA Amplification and DNA sequencing: PCR: Basics of PCR, RT-PCR, Real-Time PCR Genomic and cDNA libraries: Preparation and uses, Genome sequencing Sanger's	12 Lectures

	method of DNA Sequencing: traditional and automated sequencing	
Unit – 5	Application of Genetic Engineering and Biotechnology: Gene delivery: Microinjection, electroporation, biolistic method (gene gun), liposome and viral-mediated delivery, <i>Agrobacterium</i> - mediated delivery. Products of recombinant DNA technology: Products of human therapeutic interest - insulin, hGH, antisense molecules. Bt transgenic - cotton, brinjal, flavosavo tomato, Gene therapy, recombinant vaccine, protein engineering	12 Lectures
LAB. COURSE (2 Credits)		
<ol style="list-style-type: none"> 1. Isolation of Plasmid DNA from <i>E.coli</i> 2. Digestion of DNA using restriction enzymes and analysis by agarose gel electrophoresis 3. Ligation of DNA fragments 4. Interpretation of sequencing gel electropherograms 5. Designing of primers for DN Aamplification 6. Amplification of DNA by PCR 7. Demonstration of Southern blotting <p>Reference books</p> <ol style="list-style-type: none"> 1. Benjamin Lewin, Gene VII, Oxford University Press, (2000). 2. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter, Molecular biology of the Cell, 4th Edition. Garland publishing Inc. (2002). 3. Darnell, Lodish and Baltimore, Molecular Cell Biology, Scientific American Publishing Inc. (2000). 4. Watson. J.D, Baker. T.A, Bell. S.P, Gann. A. Levine. M. Losick. R, Molecular Biology of Gene, 5th Edition. The Benjamin/Cummings Pub. Co. Inc. (2003). 5. David Friefielder, Stanely R. Maloy, Molecular biology and Microbial genetics. 2nd Edition, Jones and Barlett Publishers. (1994). 		

6. Brown T.A., Gene Cloning and DNA analysis. 2nd Edition, ASM press. (2004).
7. Sandy Primrose. Principles of Gene Manipulation and Genomics. 7th Ed., Blackwell Publishers. (2006).
8. Glick BR and Pasternak JJ, Molecular Biotechnology, 2nd Ed. ASM press. (2003).
9. Uldis N. Streips, Ronald E. Yasbin. Modern Microbial Genetics. 2nd Edition Wiley-Liss, Inc. (2002).
10. Desmond S. T. Nicholl. An Introduction to Genetic Engineering. Cambridge University Press; (2008)

SKILL -BASED ELECTIVE COURSE (SEC)

SEC1: Microbial Quality Control in Food & Pharmaceutical Industries (4 Credits)		
<p>Course learning outcomes: By the conclusion of this course, the students-</p> <p>Learning Outcome 1. Have developed a very good understanding of practical aspects of microbiological safety, various detection methodologies and use of different microbiological media in food industries.</p> <p>Learning Outcome 2. Have developed a very good understanding of practical aspects of microbiological safety, various detection methodologies and toxicological testing of products in the pharmaceutical industries.</p>		
Unit – 1	Microbiological Laboratory and Safe Practices: Good laboratory practices - Good laboratory practices, Good microbiological practices. Biosafety cabinets – Working of biosafety cabinets, using protective clothing, specification for BSL- 1, BSL-2, BSL-3. Discarding biohazardous waste – Methodology of Disinfection, Autoclaving & Incineration	12 Hours
Unit – 2	Determining Microbes in Food / Pharmaceutical Samples: 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	12 Hours
Unit – 3	Molecular methods to determine microbes in samples- Nucleic acid probes, PCR based detection, biosensors. Enrichment culture technique, Detection of specific microorganisms - on XLD agar,	12 Hours

	Salmonella Shigella Agar, Manitol salt agar, EMB agar, McConkey Agar, Saboraud Agar	
Unit – 4	Ascertaining microbial quality of milk by MBRT, Rapid detection methods of microbiological quality of milk at milk collection centres (COB, 10 min Resazurin assay)	12 Hours
Unit – 5	HACCP for Food Safety and Microbial Standards: 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	12 Hours
Reference Books <ol style="list-style-type: none"> 1. Quality Control in the Food Industry V1, S Herschdoerfer, ISBN: 9780323152068, Academic Press, 1967 2. Principles of Sensory Evaluation of Food- 1965 MA Amerine, RM , Pangborn and EB Roessler, Elsevier. 		

SEC2: Microbial Diagnostics and Public Health (4 Credits)		
<p>Course learning outcomes: By the conclusion of this course, the students-</p> <p>Outcome 1. Have developed a very good understanding of practical aspects of collection of different clinical samples, their transport, culture and examination by staining, and molecular and immunological diagnostic methods for diagnosis of microbial diseases.</p> <p>Outcome 2. Have developed a very good understanding of practical aspects of antibiotic sensitivity testing, water and food testing skills using kits available in the market.</p>		
Unit – 1	Importance of Diagnosis of Diseases: Bacterial, Viral, Fungal and Protozoan Diseases of various human body systems, Disease associated clinical samples for diagnosis.	06 Hours
Unit – 2	Collection of Clinical Samples :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.	06 Hours
Unit – 3	Direct Microscopic Examination and Culture.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.	06 Hours
Unit – 4	Serological and Molecular Methods: Serological Methods - Agglutination, ELISA, immunofluorescence, Nucleic acid based methods - PCR, Nucleic acid probes. Kits for Rapid Detection of Pathogens: Typhoid, Dengue and	06 Hours

	HIV, Swine flu.	
Unit – 5	Testing for Antibiotic Sensitivity in Bacteria: 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	06 Hours
Reference books <ol style="list-style-type: none"> 1. Ananthanarayan R and Paniker CKJ. Textbook of Microbiology. 7th Edition. University Press Publication. (2005). 		

SEC3: Human Microbial Disease Management (4 Credits)

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

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

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

Unit – 1	Human Diseases: Infectious and non-infectious diseases, microbial and non-microbial diseases, Deficiency diseases, occupational diseases, Incubation period, mortality rate, nosocomial infections Sign and Symptoms of common diseases.	12 Hours
Unit – 2	Microbial diseases: Respiratory microbial diseases, gastrointestinal microbial diseases, Nervous system diseases, skin diseases, eye diseases, urinary tract diseases, Sexually transmitted diseases: Types, route of infection, clinical systems and general prevention methods, study of recent outbreaks of human diseases (SARS/ Swine flu/Ebola) – causes, spread and control, Mosquito borne disease – Types and prevention.	12 Hours
Unit – 3	Therapeutics of Microbial diseases : Treatment using antibiotics: beta lactam antibiotics (penicillin, cephalosporins), quinolones, polypeptides and aminoglycosides. Judicious use of antibiotics, importance of completing antibiotic regimen, Concept of DOTS, emergence of antibiotic resistance, current issues of MDR/XDR microbial strains.	12 Hours
Unit – 4	Treatment using antiviral agents: Amantadine, Acyclovir, Azidothymidine. Concept of HAART.	12 Hours

	Vaccines: Importance, types, vaccines available against microbial diseases, vaccination schedule (compulsory and preventive) in the Indian context.	
Unit – 5	Prevention of Microbial Diseases: 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.	12 Hours
Reference Books <ol style="list-style-type: none"> 1. Ananthanarayan R and Paniker CKJ. Textbook of Microbiology. 7th Edition. University Press Publication. (2005). 2. Brooks GF, Carroll KC, Butel JS and Morse SA. Jawetz, Melnick and Adelberg's Medical Microbiology. 24th edition. McGraw Hill Publication. (2007). 3. Goering R, Dockrell H, Zuckerman M and Wakelin D. Mims Medical microbiology. 4th edition. Elsevier. (2007). 4. Drexler M; What You Need to Know About Infectious Disease. <u>National Academies Press (US)</u>; 2010. 		

SEC4: Mushroom Cultivation & Trading (4 Credits)		
<p>Course learning outcomes: By the conclusion of this course, the students-</p> <p>Outcome 1. Have developed a very good understanding of nutritional aspects and commercial use of mushrooms for human consumption.</p> <p>Outcome 2. Have developed a very good understanding of practical cultivation of mushrooms, management of diseases affecting mushrooms, mushroom harvesting and various avenues for using it into an entrepreneurship</p>		
Unit – 1	Introduction: Morphology, Classification and identification of edible & non-edible/poisonous mushroom. Nutritional and Medicinal value of mushroom, Scope of mushroom cultivation.	12 Hours
Unit – 2	Structure & Life cycle: Button mushroom (<i>Agaricus bisporus</i>), Milky mushroom (<i>Calocybe indica</i>), Oyster mushroom (<i>Pleurotus sajor caju</i>) and paddy straw mushroom (<i>Volvariella volvacea</i>). Breeding and genetic improvement of mushroom strains.	12 Hours
Unit – 3	Principles & Requisites: Sterilization and disinfections of substrates, Pasteurization of different substrates, Isolation, growth media, Spawns production and their maintenance.	12 Hours
Unit – 4	Techniques of Cultivation: Structure and construction of mushroom house, layout of Traditional and Greenhouse method. Multiplication of spawn, Composting, bed and polythene bag preparation, spawning - casing – cropping	12 Hours
Unit – 5	Cultivation management: Insect pests, fungal competitors and other	12 Hours

	important diseases. pest management-chemical control Harvest and Post harvest technology- freezing, dry freezing, drying, canning and entrepreneurship.	
Reference Books <ol style="list-style-type: none"> 1. <u>Handbook on Mushrooms</u> by Bahl N. 2. <u>Benjamin Hirst</u> Mushrooms: A Beginners Guide to Home Cultivation Paperback (20150 3. <u>V. N. Pathak</u> .Mushroom Production and Processing Technology IST Edition Hardcover – 2011 4. <u>Eiri Staff</u> Hand Book of Mushroom Cultivation, Processing and Packaging Paperback – Import, 2007 		

SEC5: Food Fermentations and Domestic Application (4 Credits)		
Course learning outcomes: By the conclusion of this course, the students-		
Outcome 1. Have developed a very good understanding of practical aspects commercially produced food and fermentative products.		
Outcome 2. Have developed a very good understanding of practical use of microbiology for better production of home based food and fermentation products for day to day use		
Unit – 1	Fermented Foods: Definition, types, advantages and health benefits, fermented foods used by Common public, domestication.	12 Hours
Unit – 2	Milk Based Fermented Foods: Dahi, Yogurt, Buttermilk (Chach) and cheese: Preparation of inoculums, types of microorganisms and production process.	12 Hours
Unit – 3	Grain Based Fermented Foods: Soy sauce, Bread, Idli and Dosa: Microorganisms and production process, Preparation and preservation.	12 Hours
Unit – 4	Vegetable Based Fermented Foods: Pickels, Saeurkraut: Microorganisms and production process. Preparation and preservation methods.	12 Hours
Unit – 5	Fermented Meat and Fish:Types, microorganisms involved, fermentation process Probiotic Foods:Definition, types, microorganisms and health benefits	ours
Reference books		
1. Stanbury, PF., Principles of Fermentation Technology. Whittaker, A and Hall, S.J		

2nd Edition. Pergamon Press (1995).

2. Banwart, GJ. Basic Food Microbiology. CBS Publishers and Distributors, Delhi. (1989).
3. Hobbs BC and Roberts D. Food poisoning and Food Hygiene. Edward Arnold (A division of Hodder and Stoughton) London.
4. Dolle Michael P.. Food Microbiology: Fundamentals and Frontiers.
5. Joshi. Biotechnology: Food Fermentation Microbiology, Biochemistry and Technology. Volume 2.
6. John Garbult. Essentials of Food Microbiology. Arnold International.
7. John C. Ayres. J. Orwin Mundt. William E. Sandinee. Microbiology of Foods. W.H. Freeman and Co.
8. E. M. T. El-Mansi (Editor), C. F. A. Bryce (Editor), Arnold L. Demain (Editor), & 1 More Fermentation Microbiology and Biotechnology Hardcover CRC Press 2012

SEC6: Microbial Products – Bio-fertilizer & Bio-pesticides (4 Credits)		
<p>Course learning outcomes: By the conclusion of this course, the students-</p> <p>Outcome 1. Have developed a very good understanding of practical aspects of production of biofertilizers.</p> <p>Outcome 2. Have developed a very good understanding of practical aspects of the production of biopesticides/bioinsecticides.</p>		
Unit – 1	Biofertilizers:General account of the microbes used as biofertilizers for various crop plants and their advantages over chemical fertilizers. Symbiotic N ₂ fixers: <i>Rhizobium</i> - Isolation, characteristics, types, inoculum production and field application, legume/pulses plants <i>Frankia</i> - Isolation, characteristics, Alder, Casurina plants, non-leguminous crop symbiosis.	12 Hours
Unit – 2	Cyanobacteria as bio-fertilizers- Isolation, characterization, mass multiplication, Role in rice cultivation, Crop response, field application. Non - Symbiotic Nitrogen Fixers.Free living <i>Azospirillum</i> , <i>Azotobacter</i> -free isolation, characteristics, mass inoculums, production and field application	12 Hours
Unit – 3	Phosphate Solubilizers :Phosphate solubilizing microbes - Isolation, characterization, mass inoculum production, field application. PGPR – Isolation and Characterization; mass production and application.	12 Hours
Unit – 4	Mycorrhizal Bio-fertilizers: Importance of mycorrhizal inoculum, types of mycorrhizae and associated plants, Mass inoculum production of VAM,	12 Hours

	field applications of Ectomycorrhizae and VAM.	
Unit – 5	Bioinsecticides :General account of microbes used as bioinsecticides and their advantages over synthetic pesticides, <i>Bacillus thuringiensis</i> , production, Field applications, Viruses – cultivation and field applications.	12 Hours
	<p>Reference Books</p> <ol style="list-style-type: none"> 1. Eldor A. Paul. Soil Microbiology. Ecology and Biochemistry. VI Edition: Academic Press, (2007). 2. Eugene L. Madsen. Environmental Microbiology: From Genome to Biogeochemistry. I Edition, Wiley-Blackwell Publishing. (2008). 3. Agrios, G. N. Plant pathology. Harcourt Asia Pvt. Ltd. (2000). 4. Buchanan, B. B., Gruissem, W. and Jones, R. L. Biochemistry and Molecular Biology of Plants. I. K. International Pvt. Ltd. (2000). 5. Mehrotra R S and Ashok Agrawal. Plant Pathology. Tata Mc Graw Hill, 6th reprint (2006). 6. <u>K. S. Bilgrami</u>, <u>H. C. Dube</u>. A textbook of modern pathology. 6th Edition, Vani Educational Books, a division of Vikas, (1984). 7. <u>Shalini Suri</u>. Biofertilizer and Biopesticide Aph Publishing Corporation (2011) 	

SEC7: Microbiological Analysis of Air, Water & Soil to Pollution Control (4 Credits)

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

Outcome 1. Have developed a very good understanding and skills of the analysis of air, water and soil.

Outcome 2. Have developed a very good understanding of how analysis of water, air and soil contribute to control of environmental pollution.

Unit – 1	Aero- microbiology: 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.	12 Hours
Unit – 2	Bioaerosol sampling, air samplers, methods of analysis, CFU, culture media for bacteria and fungi, Identification characteristics .	12 Hours
Unit – 3	Water- microbiology: Water borne pathogens, water borne diseases. Sample Collection, Treatment and safety of drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive/MPN tests, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests	12 Hours
Unit – 4	Control Measures: Fate of bioaerosols, inactivation mechanisms – UV light, HEPA filters, desiccation, Incineration. Precipitation, chemical disinfection, filtration, high temperature, UV light	12 Hours
Unit – 5	Soil- microbiology: Soil borne pathogens, soil borne diseases, Sampling of soil, sample collection	12 Hours

	and analysis. Isolation and identification of pathogens. Soil testing methods. Soil treatment.	
	<p>Reference books-</p> <ol style="list-style-type: none"> 1. Medigan, M.T., Martinko, J. M. and Parker, J. Brock Biology of Microorganisms. Pearson Education Inc. , New York 2. Alexander, M John. Microbial ecology. Wiley & Sons, Inc., New York. 3. Alexander, M John. Introduction to soil microbiology.Wiley & Sons Inc., New York. 4. Barker, KH, and Herson, D.S. Bioremediation. Mc Craw Hill Inc., New York. 5. Chapelle, F.H. <i>Ground Water Microbiology and Geochemistry</i>. New York: John Wiley & Sons, 2000. 6. Droste, R. L. <i>Theory and Practice of Water and Wastewater Treatment</i>. New York: John Wiley & Sons, 1996. 7. K.R. Aneja. Laboratory Manual of Microbiology and Biotechnology New Age Publications.2014 	

SEC8: Interactions with Entrepreneurs in Microbial Technology and startups**(4 Credits)**

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

Outcome 1. Have developed a very good understanding of areas where Microbial Technology has the potential for possible commercialization.

Outcome 2. Have developed a preliminary understanding of how a certain microbial technology may be further developed for initiating startup and developing it into a commercial enterprise

After interaction with experts from microbial biotechnology related industries / enterprises/ startups, the students would submit a short report and bring out innovations, novel ideas or the further improvements related to products being produced by such organizations

*ON LINE COURSE (OLC)		
Any Two through MOOCS available on NPTEL / SWAYAM		
OLC 1:	Applied Environmental Microbiology	(NPTEL)
OLC 2:	Biochemistry	(NPTEL)
OLC 3:	Fundamental of Microbiology	(NPTEL)
OLC 4:	Food Microbiology and Safety	(SWAYAM)
OLC 5:	Industrial Microbiology	(SWAYAM)

*These online courses which are already available on NPTEL / SWAYAM are broadly equivalent to courses of Microbiology in terms of content and Credit hours.

7. Teaching learning processes:

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

1. **Classroom Teaching** for topics which are intensely information-based. This a very regular feature of all the courses in Microbiology
2. **Power Point slides** for topics which involve information related to intricate biological pathways such as metabolic pathways in bacteria and other microorganisms.

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

3. **Classroom Discussions** are a regular feature while teaching. The students are drawn into impromptu discussions by the teacher during the process of teaching.
4. **Video Displaying**, both real-time and animations, are used for topics which require 3D dimensional viewing of the biological mechanisms to drive the point home. These have proved to be very helpful while teaching concepts of molecular biology like DNA replication, transcription and translation. These are also used to convey complexities of antigen-antibody interactions and generation of antibody diversity during the teaching of Immunology.
5. **Model Making** is also used especially for understanding and building a perception of the students for the structures of viruses which cannot be seen by a light microscope and can be seen only under expensive equipment like electron microscopes.
6. **Laboratory Practical** are an integral part of every course included in UG programme in Microbiology. The is also a daily affair for UG students of Microbiology.
7. **Problem Solving** is encouraged during the laboratory work.
8. **Group Activity** as well as discussions with the laboratory supervisor/ among the students themselves/ Mentor is also encouraged during laboratory work.

9. **Project Work** is included in the programme where students work individually or in groups to design experiments to solve/answer a problem suggested by the Mentor or identified by the students in consultation with the Mentor. The students are mentored regularly during the duration the project is in progress.
10. **Presentations by the Students** are regularly done. The students are mentored in presentation of data, interpretation of data and articulation with the students/teachers/Research Scholars during their presentation.
11. **Presentation by Experts** in different specialties of Microbiology are arranged to broaden the horizons of the students.
12. **Interaction with Experts** is also encouraged during/after presentations to satisfy/ignite curiosities of the students related to developments in the different areas of Microbiology.
13. **Visit to Industries/Laboratories** related to Microbiology like fermentation, food, diagnostics etc. are organized to acquaint the students with real-life working environments of the professional microbiologists with a view to broaden their perspective of the subject of Microbiology

8. Assessment Tasks:

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

1. **Multiple Choice Questions (MCQ)** are one of the predominant form of assessment tasks. This task is used during all kinds of term and semester examinations.
2. **Short-Answer Questions** during term and semester examinations are used to assess the ability of the student to convey his thoughts in a coherent way where prioritization of the information in terms of their significance is tested.
3. **Surprise Quizzes** are regularly used during continuous assessment while the teaching learning process is continuing which prepares the student to quickly recall information or quickly analyze a problem and come up with proper solutions.
4. **Visual/Pictorial Quizzes** are used to sharpen the comprehension of the students after looking at all the components of a system.
5. **Impromptu Opinions** on microbiological problems are sought from student during regular teaching learning which help them to think quickly in a given context. This help build their ability to come up with solutions to problems which the students might not have confronted previously.
6. **Problem Solving** question are generally given during the laboratory work.
7. **Data Interpretation** is also another assessment task which is used to develop analytical skills of the students. This assessment is used during laboratory work as well as during conduction of project work.
8. **Analytical Skills** are assessed during work related to several experiments like enzyme kinetics, growth of bacteria and bacteriophages, mutation frequencies.
9. **Paper/ Project presentations** are used to assess the articulation skills of the student. These are carried out both during the duration of the teaching learning processes as well as during end-Semester examinations.
10. **Report Writing** is used to assess the keenness of the students for details related to microbiology while visiting laboratories / industries as students invariably are required to submit a report after such visits.
11. **Assignment Writing** are used to assess the writing abilities of the students during mid-term vacations.
12. **Viva-voce** during the laboratory working hours and during laboratory examination are used to assess the over-all knowledge and intelligence of the students.

9. Key Words:

Microbiology, Teaching, Learning outcomes, Curriculum, Curriculum Framework, Programme outcomes, Course outcomes, UG Programme, Undergraduate programme, Teaching learning processes, Assessment Tasks, Evaluation Tasks, Online Courses, MOOCS, NPTEL, SWAYAM, UGC, India, Higher Education Institutions, HEI
