INSTITUTE OF SCIENCE, TECHNOLOGY & ADVANCED STUDIES (VISTAS)
(Deemed to be University Estd. u/s 3 of the UGC Act, 1956)
PALLAVARAM - CHENNAI
NAAC ACCREDITED WITH 'A' GRADE
Marching Beyond 25 Years Successfully

Learning Outcomes based Curriculum Framework (LOCF) – Curriculum and Syllabus for M.Sc. IMMUNOLOGY AND MICROBIOLOGY

Effective from the academic year 2018 - 2019

VELS INSTITUTE OF SCIENCE TECHNOLOGY AND ADVANCED STUDIES
PALLAVARAM, CHENNAI
TAMIL NADU – 600 117

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

The Programme Educational Objectives of the M.Sc. in Immunology & Microbiology programme at VISTAS are given below and are numbered from **PEO1** to **PEO4.**

PEO1	To provide the candidates with in-depth knowledge in immunology and microbiology and a firm grasp of the processes that employ or deal with microbes plus adept use of immunological techniques in relevant technologies that empowers them to deal with the safe and efficient use and monitoring of microbiological and immunological applications with development of competence on par with global standards and helps in the life-long learning of candidates.
PEO2	To enable candidates by imparting updated analytical and hands-on skills to use and implement technological developments related to advanced and potential areas involving molecular diagnostics, automated systems of diagnosis, immunoblotting technology, upstream or downstream processing and nanotechnology with scope for upskilling upto future technologies so as to contribute effectively for Research & Development leading to patenting and publishing.
PEO3	To train candidates to choose a decent career option either as Entrepreneur or having a high degree of employability; or pursue research - by providing training in interpersonal skills, sense of social responsibility, ethical and administrative acumen, ability to handle critical situations allowing them to be good team members and leaders as well as training to excel in competitive examinations.
PEO4	To impart a strong sense of social responsibility with awareness of professional and societal ethical values and scope to develop leadership capabilities with the continuous need for life-long learning.

PROGRAMME OUTCOMES (Pos)

The M.Sc. programme (Biochemistry/Biotechnology/Bioinformatics/microbiology) at VISTAS has documented measurable outcomes that are based on the needs of the programme's stakeholders. The programme outcomes that the department presently adapts to are as follows:

PO-1 **Life Sciences knowledge:** Successful candidates will acquire current/recent specific knowledge in the respective discipline with proficiency in practical skills and leadership skills for a successful career.

PO-2 **Problem analysis:** Successful candidates will be able to analyse, design standards, resolve and troubleshoot problems in implementation or standardization of Life sciences protocols.

PO-3 **Design/development of solutions:** Successful candidates will develop creative and cognitive thinking and cooperate with each other to solve problems in the field of Life sciences.

PO-4 **Conduct investigations of complex problems:** Successful candidates will acquire capabilities to plan and design protocols and utilize practical skills to validate hypothesis by executing experimental techniques independently coupled with the ability to assimilate, analyse, interpret and accurately evaluate subsequent data.

PO-5 **Modern tool usage:** Successful candidates will effectively be able to manage resources and time using ICT and other computer enabled devices.

PO-6 **Ethics:** Successful candidates will be aware of their role and responsibility in handling and use of microbes including genetically modified microorganisms.

PO-7 **Communication:** Successful candidates will have the ability to understand and communicate all ideas and concepts effectively.

PO-8 **Environment sustainability:** Successful candidates will get adequate knowledge to use information and implement solutions for environmental protection, safeguards and remediation.

PO-9 **Lifelong learning**: Successful candidates will carry on to learn, adapt and disseminate knowledge in a world of constantly evolving technology.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

The overall outcome of graduates specific to M.Sc. in Immunology & Microbiology programme at VISTAS can be summarized as:

PSO1	**Microbiology related skills**	The ability to understand, implement and troubleshoot the concepts related to the fields of microbiology and immunology which will enable them to analyse and develop solutions to microbiology, immunology and rDNA related problems using knowledge and hands-on skills in microbiology, molecular identification, immunodiagnostics, screening for useful biomolecules and nanotechnology in the interpretation of data in relevant protocols.
PSO2	**Successful Career and Entrepreneurship:**	The ability to gainfully become an entrepreneur by using microorganisms to mass produce biofertilizers, mushrooms or any other edible forms of SCP, fermented products and pharmaceutically important biomolecules as well as using knowledge, communication and practical hands-on training to become employed in diagnostic, industrial, pharmaceutical, food and research and development laboratories.

VELS UNIVERSITY

SCHOOL OF LIFE SCIENCES
DEPARTMENT OF MICROBIOLOGY

BOARD OF STUDIES

S. No	Name and Address	Designation
1.	**Dr. R. Dinakaran Micheal** Dean School of Life Sciences Vels University, Chennai – 600 117.	Chairperson
2.	**Dr. A.K.Kathireshan** Professor and Head Department of Microbiology School of Life Sciences Vels University, Chennai – 600 117.	Internal Member
3.	**Mr. Allen John Henry** Assistant Professor Department of Microbiology School of Life Sciences Vels University, Chennai – 600 117.	Internal Member
4.	**Mrs. G. Gayathri** Assistant Professor Department of Microbiology School of Life Sciences Vels University, Chennai – 600 117.	Internal Member
5.	**Dr. M. Elanchezhiyan** Professor and Head Department of Microbiology University of Madras Dr. ALM PGIBMS Taramani Campus Chennai – 600 113.	External Member
6.	**Dr. Rajkumar Samuel** Managing Director HUBERT ENVIRO LABS Ashok Nagar, Chennai.	External Member
7.	**Ms. Sanchita Nath** Research Scholar Department of Microbiology School of Life Sciences Vels University Chennai – 600 117.	Alumni (M.Sc., Immunology and Microbiology, 2013 – 2015 Batch)

Table of Contents

Preamble

Microbiology is the study of microorganisms or microbes such as bacteria, viruses, fungi, algae, protozoa and infectious proteins like prions. Microbes are extremely important as their diverse activities range from causing diseases in humans, animals and plants to production of highly useful products like antibiotics, vitamins, enzymes, alcohol, fermented foods, in addition to recycling of organic nutrients from dead and decaying organic matter, remediation of contaminants and biodegradation of recalcitrant compounds in the nature. Immunology is the aspect of human biology that deals specifically with the response of host to the presence of extraneous antigens or self-antigens, immunology in cancer, autoimmunity and development of vaccines. Thus, the science of immunology and 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 areas of human endeavour have put Immunology and 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 postgraduate 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 envisions the program learning outcomes of the M.Sc. program in Immunology and Microbiology as well as the learning outcomes of the courses being taught under this program, keeping in view the postgraduate attributes of the program. The curriculum was then developed in tune with the learning outcomes. It is envisaged that the candidates trained under this curriculum will have the required attributes of knowledge, skills, temperament and ethics related to the subjects of Immunology and 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 12 core courses (CC1 - 12) which completely encompass all essential and crucial aspects of the disciplines of Immunology and 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 and immunology to study societal problems and suggest solutions in the form of compulsory minor project under the supervision of expert faculty members. These are also designed to expose the students to leaders / innovators in the areas related to immunology and 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 and DSE are either 4 credit courses for theory and 2 credit courses for laboratory work. Generic Elective Courses (GEC) are 2 credit courses designed to provide insights about microbiology to students from other disciplines. To comply with the education policy of Govt. of India namely access, equity and quality students are encouraged to complete a minimum of 1 Online Course (OLC) which are available on NPTEL or SWAYAM portals under MOOCS program 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 striving to achieve mastery in specialized areas of biology are equipped with complete knowledge, advanced skills, mindsets and behaviours 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 humane societies. To achieve this goal, it is imperative that their educational training is improved such that it exposes them to latest concepts, 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) and research organizations 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 field 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. The outcomes for the subject of Immunology and Microbiology are defined in terms of the complete understanding and knowledge of the students in all fields related to immunology and microbiology and the acquisition of laboratory skills with capability to troubleshoot methodologies. The students are required to have all skills required to be competitive microbiologists or immunologists so that they are able to fulfil their role as microbiologist wherever required in the society such as the diagnosis and monitoring of prognosis of diseases combined with their remedies; the role of microbiologists/ immunologist in the immunodiagnostic, pharmaceutical, food and biotechnology industry and how they may be able to fit the bill in the industry as well as research areas in immunology, molecular biology, rDNA technology etc. The students are also trained in such a way that they develop critical thinking and problem solving as related to the field of microbiology and immunology. The developed curriculum emphasizes the teaching and evaluation tasks are designed in such a way that the students are able to apply their knowledge and training in immunology and microbiology to solve the challenges or problems of microbiology and immunology as these exist or appear from time to time in the society. The curriculum envisions that the student, once graduate as specialists in immunology and microbiology, 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 M.Sc. Program:

The postgraduate program in Immunology and Microbiology is a unique program offering 40-60 ratio of courses respectively leading to the award of the advanced level of university degree. After obtaining this degree, a candidate may choose to become a microbiologist/ immunologist and may enter into the job market or opt for undertaking research in the subject. Successful candidates may join industry, academia, public health, research institutions and establish their role as microbiologists/ immunologists in a useful manner thereby contributing and completing their role in the development of the welfare society. Thus, the postgraduate level degree in immunology and microbiology at VISTAS prepares the students for all these objectives. Thus, the LOCF curriculum developed has a very wide range covering all aspects of Immunology and Microbiology with in-depth knowledge and skills so as to diversify postgraduates in various specialties of the subject enabling them to complete their role professionally as expected of them. It is also imperative that candidates enrolled in the program are evaluated in a manner appropriate to assess their proper development as microbiologists. The current LOCF in Immunology and Microbiology has been designed in keeping all these important points in mind.

2.2 Aims of Master's degree programme in IMMUNOLOGY & MICROBIOLOGY:

The aim of the postgraduate degree in Immunology and Microbiology is to make students knowledgeable with mastery of the basic and advanced concepts in a wide-ranging context which involve the use of knowledge and skills of Microbiology and Immunology. Their understanding, knowledge and skills in Microbiology as well as Immunology will be developed through a complete teaching learning processes in the class, practical skills through the laboratory work, their presentation and articulation skills via seminars, exposure to industry and interaction with industry experts, write minor 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 M.Sc. degree in Immunology & Microbiology is the advanced level of university degree in the country as in several parts of the world. The students graduating in this degree must have mastery and complete understanding of advanced knowledge or understanding of the fundamentals as well as updated concepts of Microbiology and Immunology as applicable to wide ranging contexts. They should have the appropriate skills of Microbiology and Immunology so as to perform their duties as microbiologists or experts in any other specific areas of immunology and microbiology. They must be able to analyze the problems related to all fields related to microbiology/ immunology and come up with most suitable solutions. As microbiology & immunology 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 or allied areas are very dynamic subjects and practitioners might have to face several unforeseen problems. To this end, the candidates enrolled in the program must be trained to be innovative to solve such emerging problems. Several new developments are taking place in microbiology and immunology. 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.

4. Qualification Descriptors:

The following are the important qualification descriptors for a PG degree in Immunology and Microbiology:

1. Knowledge of the various fields where microbiology or immunology is involved.
2. Understanding of diverse Microbiological as well as immunological processes.
3. Appropriate skills such as culturing, handling, characterising and utilizing microbes, maintaining microbes, safety issues related to handling of microbes, immunodiagnostics, raising antibodies and basic vaccine development, Good Microbiological practices etc.
4. Advanced skills in working with microbes such as pilot scale culturing, downstream processes, immunodiagnostics etc.
5. Generation of new knowledge through small research projects
6. Ability to participate in team work through minor microbiology research projects.
7. Ability to present and articulate their knowledge of Microbiology and Immunology.
8. Knowledge of recent developments in the area of Microbiology and Immunology.
9. Analysis of data collected through study and minor 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 M.Sc. Immunology & Microbiology

A candidate who is conferred an PG degree i.e. M.Sc. degree in Immunology and Microbiology needs to have acquired/developed following competencies defined in Programme Employability Outcomes and Programme specific outcomes in conjunction with course outcomes during the programme of the study.

5.1 Programme Employability Outcomes of B.Sc. Microbiology at VISTAS

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.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

Same as mentioned above; in the beginning of the document.

6. Structure of M.Sc. Immunology & Microbiology program

COURSES OF STUDY AND SCHEME OF ASSESSMENT

(MINIMUM CREDITS TO BE EARNED: 90)

		Hours/Week				Maximum Marks		
Code No.	Course	Lecture	Tutorial	Practical	Credits	CA	SEE	Total
SEMESTER 1								
CORE	Microbiology	4	0	0	4	40	60	100
CORE	Microbiology practical	0	0	6	3	40	60	100
CORE	Immunology	4	0	0	4	40	60	100
CORE	Immunology practical	0	0	6	3	40	60	100
DSE	DSE 1	4	0	0	4	40	60	100
DSE	DSE 2	4	0	0	4	40	60	100
GE	GE 1	2	0	0	2	40	60	100
		18	0	12	24			
SEMESTER 2								
CORE	Microbial Genetics and Molecular Biology	4	0	0	4	40	60	100
CORE	Molecular Biology Practical	0	0	6	3	40	60	100
CORE	Molecular Immunology and Immunogenetics	4	0	0	4	40	60	100
CORE	Immunotechnolgy practical	0	0	6	3	40	60	100
DSE	DSE 3	4	0	0	4	40	60	100
DSE	DSE 4	4	0	0	4	40	60	100
GE	GE 2	2	0	0	2	40	60	100
		18	0	12	24			

DSE - Disciple Specific Elective Course
GE - Generic Elective Course CA
- Continuous Assessment SEE -
Semester End Examination

VELS INSTITUTE OF SCIENCE, TECHNOLOGY AND ADVANCED STUDIES

Programme: M.Sc. Immunology & Microbiology

Code No.	Course	Hours/Week			Credits	Maximum Marks		
		Lecture	Tutorial	Practical		CA	SEE	Total
SEMESTER 3								
CORE	Clinical Immunology and Vaccinology	4	0	0	4	40	60	100
CORE	Vaccines Technology Practical	0	0	6	3	40	60	100
CORE	Applied Microbiology	4	0	0	4	40	60	100
CORE	Applied Microbiology Practical	0	0	6	3	40	60	100
DSE	DSE 5	4	0	0	4	40	60	100
DSE	DSE 6	4	0	0	4	40	60	100
GE	GE 3	2	0	0	2	40	60	100
		18	0	12	24			
SEMESTER 4								
Project		8	0	22	18	40	160	200
		8	0	22	18			

CA - Continuous Assessment SEE - Semester End Examination

Marks for Internal and End Semester Examinations for PART I, II, III

Sl. No	Category	Theory	Practical
1	Continuous Internal Assessment	40	40
2	End Semester Examination	60	60

Procedure for Awarding Internal Marks:

Course	Continuous Internal Assessment Components	Marks
Theory	Class Test 1	5
	Class Test 2	5
	Assignment / Seminar	5
	Assessment by Faculty	5
	Aptitude of the student	5
	Model Exam	10
	Attendance	5
	Total	**40**
Practical	Assessment by Faculty	5
	Aptitude of the student	5
	Model Practical Exam	10
	Practical Observation	5
	Record work	10
	Attendance	5
	Total	**40**

Awarding Marks for Attendance:

Percentage of Attendance	Marks
Below 65	00
65- 74	03
75- 90	04
91- 100	05

Question Paper Pattern for End Semester (University) Examination

SECTION–A

(30 words) Answer All the questions 10 * 3 marks =30 marks

SECTION – B

(200 words) 5 questions out of 8 questions 5 * 8 marks = 40 marks

SECTION – C

(500 words) 2 questions out of 4 questions 2 * 15 marks = 30 marks

TOTAL **= 100 marks**

Details of courses

List of core courses

CC1: Microbiology

CC2: Microbiology (Practical)

CC3: Immunology

CC4: Immunology (Practical)

CC5: Microbial Genetics and Molecular Biology

CC6: Molecular Biology (Practical)

CC7: Molecular Immunology and Immunogenetics

CC8: Immunotechnolgy (Practical)

CC9: Clinical Immunology and Vaccinology

CC10: Vaccines technology Practical

CC11: Applied Microbiology

CC12: Applied Microbiology Practical

List of Discipline Specific Electives (Any 6 papers)

DSE1: Medical Microbiology

DSE2: Industrial and Pharmaceutical Microbiology

DSE3: Immunotechnology

DSE4: Cloning strategies and Nanomicrobiology

DSE5: Biofertilizers

DSE6: Cell Culture and Fermentation Technology

DSE7: Microbial Biochemistry

DSE8: Medical Parasitology

DSE9: Research methodology

DSE10: Biostatistics

DSE11: Animal Cell culture

DSE12: Good Manufacturing Practice (GMP)

List of Generic Electives (Any 3 papers)

GE 1: Introduction and Scope of Microbiology

GE 2: Bacteriology and Virology

GE 3: Microbial Metabolism

GE 4: Industrial and Food Microbiology

GE 5: Microbes in Environment

GE 6: Medical Microbiology and Immunology

GE 7: Genetic Engineering and Biotechnology

GE 8: Microbial Genetics and Molecular Biology

Course learning outcomes and contents of the courses

CORE COURSES (CC)

18CMIM11 CC1: Microbiology (Theory) 4 0 0 4

Course Objective: The candidates undertaking this course will gain knowledge about the structure of bacteria; types of microscopes and microscopy; sterilization methods and quality control; disinfection, antibiotics – testing and quality control; alga structure and life-cycle patterns.

UNIT I INTRODUCTION 15 Lecture hours

Evolution and scope of microbiology. Description of various groups of microorganisms with typical example. Cell cycle and reproduction of bacteria. Bacterial cell structure and components, bacterial growth curve in batch culture.

UNIT II MICROSCOPY 12 Lecture hours

Microscopy – principles of microscopy- bright-field microscopy – PCM, FM CLSM, ICM, TEM, SEM and STEM – description, principle and use.

UNIT III STERILIZATION 12 Lecture hours

Sterilization – High temperature- Tyndallization, Pasteurization, inspissation, incineration, moist heat under pressure; low temperature – preservation; filtration- membrane filters, depth filters; centrifugation; radiation- principle, use and Quality control. Disinfection- Mode of action and evaluation.

UNIT IV ANTIBIOTICS 12 Lecture hours

Antibiotics – Classification, Mode of Action, mechanism of resistance, Evaluation – Disc Diffusion; MIC – Broth dilution, agar dilution; MBC; E- test with Quality control for each method.

UNIT V ALGAE 09 Lecture hours

Structure of algal cell with example; Life-cycle patterns of Algae. Reproduction in algae.Structure of *Paramecium, Amoeba, Euglena, Giardia*.

Total: 60 Lecture hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Significant knowledge will be obtained about various microbes including cell structure, cell cycles, reproduction in bacteria and aspects of bacterial growth.

CO2: A firm grasp of the basics of microscopy and the principles, working and applications of bright field microscopes and electron microscopes.

CO3: A thorough understanding of the various physical and chemical methods for the control of microbial growth and evaluation of the methods.

CO4: An in-depth study of different antibiotics from the viewpoint of targets, resistance mechanisms and spectrum evaluation methods.

CO5: Full understanding of alga – including life cycles and reproduction and few important protozoa.

TEXTBOOK:

Michael T. Madigan, John M Martinko, Brock's Biology of Microorganisms, Pearson-Prentice Hall. Ed. 11; 2006.

REFERENCE BOOKS:

1. Ananthanarayanan R & C.K.Jeyaram Paniker; Textbook of Microbiology;Orient Longman. Ed.7;
2005.
2. Michael T. Madigan, John M Martinko; Brock's Biology of Microorganisms, Pearson-Prentice Hall. Ed. 11; 2006
3. Ronald M.Atlas; Principles of Microbiology, WCB Publishers. Ed. 2; 1997
4. Roger Y. Stanier, John L. Ingraham, Mark L. Wheelis,Page R. Painter, General Microbiology, MacMillan Press. Ed. 5; 2004.
5. Topley & Wilson's: Principles of Bacteriology, Virology & Immunology, Edward Arnold. Ed. 9; 2002.
6. Lansing M. Prescott, John P Harley, Donald A. Klein; Microbiology, McGraw Hill. Ed. 6; 2005.

18PMIM11 **CC2: Practical - Microbiology** **0 0 6 2**

Course Objective: The candidate will gain hands-on knowledge and acquire adequate skill required to stain and observe microbes, identify pathogens and other bacteria based on biochemical reactions.

1. Staining – Simple, Gram's Staining, Acid fast Staining, Metachromatic granule staining, staining of lipid, Endospore staining, Staining of flagella, Capsule staining. Observation of motility – Wet mount; Hanging drop
2. Sterilization of antibiotic solution. Methods for testing effectiveness of antibacterial antibiotics – Kirby-Bauer method.
3. Biochemical tests: IMViC test, O-F Test, Sugar fermentation test.
4. Preservation of bacterial cultures. Cultivation of anaerobes.
5. Collection and transport of specimens- Faeces, pus, sputum, throat/ ear/ nasal/ wound swab, CSF and other body fluids.
6. Bacterial typing methods- Serotyping, phage typing and bacteriocin typing methods.
7. Identification of medically important pathogenic bacteria- *Staphylococci, Streptococci, E. coli, Klebsiella, Shigella, Salmonella, Vibrio.*
8. KOH examination of skin, hair and nail infections.LPCB examination of fungi.Isolation and identification of fungi- *Mucor*, *Rhizopus*, *Aspergillus*, *Penicillium*, Dermatophytes and Yeasts - SDA/ Corn meal agar - Slide culture technique - Germ tube test – Capsular and Gram stain – Sugar assimilation and fermentation tests for yeasts.
9. Examination of parasites in clinical specimens- Ova/ cyst in faeces by Lugol's iodine wet mount method.Concentration methods- Formol ether and Zinc sulphate methods, Salt saturation methods.
10. Blood smear examination for malarial parasites.
11. Cultivation of viruses by egg inoculation methods. Observation and interpretation of CPE.
12. Detection of HBs Ag by ELISA

Total: 90 Practical Hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Acquire technical skills on staining methods.

CO2: Know how to perform sterilization and antibiotics sensitivity tests

CO3: Gain the basic skill on identification of bacteria and culture methods

CO4: Skilled in identification pathogenic bacteria, fungi and protozoa

CO5: Gain the knowledge on collection & transport specimens

18CMIM12 CC3: Immunology (Theory) 4 0 0 4

Course Objective: The candidate will gain knowledge about immunity, organs of immunity and cells involved; Types of antigens and properties; immunoglobulin – types; MHC and its significance; hypersensitivity reactions.

UNIT I INTRODUCTION 12 Lecture Hours

Introduction- immunity- types-innate, acquired. Ontogeny and Physiology of immune system- Primary and Secondary lymphoid organs, lymphoid tissues. Immunoreactive cells- structure and functions-macrophages, granulocytes, NK cells, T and B lymphocytes – origin, development, differentiation, lymphocyte subpopulation in humans.

UNIT II ANTIGENS 12 Lecture Hours

Antigens and immunogenicity- terminologies and definition- antigen, immunogen, haptens, super antigen, tolerates, epitope, paratope. Features associated with antigenicity and immunogenicity. Basis of antigen specificity. MHC – types and importance- distribution and function. Antigen processing and presentation to T- lymphocytes.

UNIT III IMMUNOGLOBULINS 12 Lecture Hours

Immunoglobulin- structure, types, distribution, biological and chemical properties - Theories of antibody production- its regulation and diversity. Monoclonal and polyclonal antibodies. Complement system – mode of activation- Classical, Alternate and Lectin pathways, biological functions.

UNIT IV IMMUNE RESPONSE 12 Lecture Hours

Antigen recognition – TCR, BCR, MHC restriction, lymphocyte activation, clonal proliferation and differentiation. Physiology of acquired immune response – various phases of HI, CMI – cell mediated cytotoxicity, DTH response.

UNIT V HYPERSENSITIVITY 12 Lecture Hours

Hypersensitivity – types and mechanisms, Autoimmunity, Tumour and Transplantation immunology. Immune regulation mechanisms – brief account on immuno-induction, immuno-suppression, immuno-tolerance, immuno-potentiation. Role of cytokines, lymphokines and chemokines.

Total: 60 Lecture Hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Understand the fundamental concepts of immunity, contributions of the organs and cells in immune responses.

CO2: Acquire knowledge the MHC molecules function and host encounters an immune insult.

CO3: Understand the antibodies and complement system

CO4: Understand the mechanisms involved in initiation of specific immune responses and Differentiate the humoral and cell mediated immune mechanisms

CO5: Comprehend the overreaction by our immune system; autoimmunity; immunologic processes governing graft rejection and therapeutic modalities for immunosuppression in transplantation

TEXTBOOK:

1. Richard Coico, Geoffrey Sunshine, Eli Benjamini. Immunology – A Short Course. Wiley-Liss, New York. 5th ed., 2003.

REFERENCE BOOKS:

1. Ivan M. Roitt, J. Brostoff and D. K. Male, Immunology, Gower Medical Publishing, London.1993.
2. Clark WR, The experimental foundations of modern immunology. John Wiley and Sons Inc. New York. 1991.
3. Janis Kuby, Immunology, II edition. W. H. Freeman and Company, New York. 1993.
4. Janeway Travers, Immunobiology- the immune system in health and disease. Current Biology Ltd. London, New York. 3rd ed.,1997.
5. Peter J. Delves, Ivan M. Roitt, Encyclopedia of Immunology; Academic Press. 2nd Ed., 1998.
6. Chapel H and Halbey M, Essentials of Clinical Immunology. ELBS. 1986.
7. Leslie Hudson and Frank C. Hay. Practical Immunology. Blackwell Scientific Publication. 3rd ed., 1989.

8. Pravash Sen. Gupta, Clinical Immunology. Oxford University Press. 2003.

9. Noel R. Rose, Herman Friedman, John L. Fahey. Manual of Clinical Laboratory Immunology. ASM. 3rd ed., 1986.

18PMIM12 CC4: Practical - Immunology 0 0 6 2

Course Objective: The candidate will gain hands-on knowledge and acquire adequate skill required to identify and enumerate immune cells and also perform agglutination reactions.

1. Identification of various immune cells by morphology – Leishman staining, Giemsa staining.
2. Differential counts.
3. Total counts.
4. Agglutination Reactions- Latex Agglutination reactions- RF, ASO, CRP.
5. Heamagglutination Reactions- Blood Grouping – forward and reverse, Rh Typing, Coomb's test, TPHA.
6. Visit to blood bank.
7. Serum electrophoresis.
8. PAGE of serum proteins.
9. Serum myeloperoxidase activity.
10. Serum lysozyme activity.
11. Separation of Leucocytes from Spleen
12. Passive Agglutination Assay

Total: 90 Practical hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Identify various immune cells and enumerate them

CO2: Competently perform serological diagnostic tests such as RF, ASO, CRP.

CO3: Identify blood groups and types

CO4: Diagnose syphilis by performing TPHA test

CO5: Analyze the components of human sera by performing agarose and polyacrylamide gel electrophoresis

18CMIM21 CC5: Microbial Genetics and Molecular Biology (Theory) 4 0 0 4

Course Objective: The candidate will gain knowledge about chromosomes, nucleic acids; DNA damage and repair; RNA and transcription; genetic code and recombination; Plasmids and cloning vectors; methods in molecular analysis.

UNIT I MICROBIAL GENETICS 18 Lecture Hours

Transformation, conjugation and transduction. Nucleic acid as genetic material – DNA and RNA structure. Melting of DNA. DNA replication – general principles, modes of replication, DNA polymerases – structure and function. Superhelicity in DNA, topology of DNA and topoisomerases, chromosome structure and organisation. Replication of ssDNA, retroviral replication. Inhibitors of replication. DNA damage and repair – Types of DNA damage, mechanism of repair - methyl directed, excision, recombinational, SOS.

UNIT II TRANSCRIPTION 10 Lecture Hours

Transcription – general principles, basic apparatus, RNA polymerases and steps involved, inhibitors of RNA synthesis. Monocistronic and polycistronic mRNAs. Regulation of transcription – attenuation and antitermination, heat shock proteins. Structure of tRNA.

UNIT III TRANSLATION 10 Lecture Hours

Genetic Code.Translation – maturation and processing of RNA, RNA polymerase, Sigma-factor switching, post translational modifications, operon concept – *lac*, *trp* and *ara* operon, riboswitches. Recombination – Generalized, Site-specific; Models of recombination.

UNIT IV MUTATION 12 Lecture Hours

Biology of plasmids, structure of F1, Col E1. pSC 101, Ti plasmid – their replication. Transposons – structure, types and functions. Gene as a unit of mutation and recombination – mutagens, mutagenesis – biochemical basis of mutations – spontaneous and induced. Reversion, suppression, genetic analysis of mutants. Fine structure and genetic analysis of phage T4 using rII locus. Genetic mapping of *E. coli* and yeast.

UNIT V MOLECULAR ANALYSIS 10 Lecture Hours

Methods to study biomolecules – Gel electrophoresis, 2D- Gel electrophoresis, Ion-exchange Chromatography, Gel filtration Chromatography, Affinity Chromatography, Autoradiography, Southern Blot, DNA Fingerprinting and Typing, Western Blot, Restriction mapping, Site-

directed mutagenesis, Northern Blot, S1 Mapping, Nuclear Run-on Transcription, Reporter Gene Transcription, Filter binding assay, Gel Mobility Shift, DNase Footprinting.

Total: 60 Lecture Hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Significant knowledge will be obtained about gene transfer mechanisms in bacteria. Complete information about structure, replication, damage and repair of nucleic acids.

CO2: A firm grasp of the process of transcription and its control.

CO3: A thorough understanding of the process of translation and operons along with recombination of DNA.

CO4: An in-depth study of mutagenesis and genetic analysis with gene mapping.

CO5: Full understanding of all aspects of all important techniques used for the study of biomolecules.

TEXT BOOK:

1**.** Freifelder, D; Molecular Biology. Narosa Publishing House, New Delhi. 2008.

REFERENCE BOOKS:

1. Maloy S.R, Cronan JR, JE. Freifelder, D; Microbial Genetics. Jones and Barlette publishers. 1994.
2. Lodish H, Baltimore O, Berk A, Zipursky SL, MAtsudaira P, Darnell, J.; Molecular Cell Biology. Scientific American Books. 1995.
3. Lewin B; Genes VIII. Oxford University Press. 2004.
4. William Haynes; The Genetics of Bacteria and Their Viruses. Blackwell Scientific Publishers, Oxford. 1985.
5. E.D.P. De Robertis, E.M.F. De Robertis,Jr., Cell And Molecular Biology, Lippincott Williams and Wilkins. Ed. 8; 2001.

6. B.Alberts, A,Johnson, J.Lewis, M.Roff, K.Roberts, P.Walter, Mol;ecular Biology of The Cell, Garland science,NY. Ed. 4; 2002.

7. Robert F.Weaver, Molecular Biology, McGraw – Hill. Ed.4; 2008.

18PMIM21 CC6: Practical - Molecular Biology 0 0 6 2

Course Objective: The candidate will gain hands-on knowledge and acquire adequate skill required to isolate, demonstrate and quantitate nucleic acids, transfer DNA to bacteria and separate biomolecules by electrophoresis.

1. Isolation of genomic DNA. Isolation of plasmid DNA – Alkaline lysis. Isolation of DNA from Fungi.
2. Quantitation of DNA and RNA by chemical methods-Dinitrophenol, orcinol, physical method – UV adsorption
3. Preparation of competent cells. Gene transfer by conjugation method.
4. Estimation of proteins – Lowry method; Bradford method
5. Electrophoretic methods – PAGE native PAGE.
6. TLC – Plant pigments, amino acids, lipids and vitamins. Protein separation by aqueous two phase partitioning.
7. Blotting techniques – Southern blotting and western blotting
8. Strain Improvement - Protoplast and spheroplast fusion, mutation.
9. PCR-standard amplification.
10. Isolation of antibiotic resistant microbes. Isolation of auxotrophic mutants.
11. Screening test for production of Cellulases, Amylases and Proteases, purification and assay.
12. Whole cell and enzyme immobilization. Biogas production. Mushroom cultivation. Wine preparation.

Total Hours: 90 Practical Hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Acquire technical skills on isolation of DNA & Plasmid & their quantification

CO2: Know how to perform gene transfer, protein quantification & TLC

CO3: Gain the basic skill on blotting techniques & PCR

CO4: Skilled in production of microbial enzymes

CO5: Gain the knowledge on strain improvement and enzyme immobilization

18CMIM22 CC7: Molecular Immunology and Immunogenetics (Theory) 4 0 0 4

Course Objective: The candidate will gain knowledge about genes that control properties of immunoglobulin, complement proteins; TCR and other similar markers; MHC/ HLA genes and antigenic structure; ABO and other grouping systems; tumor antigens.

UNIT I IMMUNOGLOBULINS 12 Lecture Hours

Genetics of Immunoglobulins – isotypes, class switching, Molecular biology of immunoglobulin - biosynthesis, generation of antibody diversity, allotypes, and idiotypes and Immunoglobulin purification techniques. Genetics of complement components.

UNIT II LYMPHOCYTES 12 Lecture Hours

Genetics of T – lymphocytes – Surface receptors, Antigens – Diversity of TCR, T cell surface alloantigens, other markers of Human T and B lymphocytes.

UNIT III MAJOR HISTOCOMPATIBILITY COMPLEX 12 Lecture Hours

Major Histocompatibility antigens – MHC genes and products, Structure of MHC molecules, Genetics of HLA Systems – Antigens and HLA typing.

UNIT IV IMMUNOHEMATOLOGY 12 Lecture Hours

Genetics of Immunohematology – Genetic basis and significance of ABO and other minor blood groups in humans, Bombay blood groups, Secretors and Non-secretors, Rh System and genetic basis of D- antigens. Clinical and forensic relevance of ABO and minor blood groups.

UNIT V TUMOR ANTIGENS 12 Lecture Hours

Genetics of neoplastic cell antigens – TL antigens, CEA and others in humans, expression of tumour antigens and humoral and cell – mediated immune responses against tumour antigens in humans.

Total: 60 Lecture Hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Understand the genetic basis of immune cell receptors, proteins involved in humoral and cell mediated immune response

CO2: Learn MHC genes and products.

CO3: Know the genetics of human blood groups and types and their clinical / forensic significance.

CO4: Comprehend cancer genetics and expression of tumor antigens.

CO5: Discern the immune responses against tumor antigens in humans

TEXTBOOK:

Christiansen**,** Frank T**.,** Tait**,** Brian D.**;** Immunogenetics: Methods and Applications; Springer. 2012.

REFERENCE BOOKS:

1. Benacerraf B, Immunogenetics and Immunodeficiency; William Clowes and Sons ltd. London. 1975.
2. Zaleski MB, Dubiski S, Niles EG and Cunningham RK, Immunogenetics; Pitman, Toronto. 1983.
3. Hugh Fudenberg H, Pink JRL, Wang A and Ferrera GB, Basic Immunogenetics; Oxford University Press , NY. 1984.
4. Williamson AR and Turner MN, Essential Immunogenetics; Blackwell Scientific Pulications, London. 1987.
5. K.S.N. Reddy, The Essentials of Forensic Medicine and Toxicology, Ed. 26; 2007.

18PMIM22 CC8: Practical - Immunotechnology 0 0 6 3

Course Objective: The candidate will gain hands-on knowledge and acquire adequate skill required to perform precipitation reactions and purify immunoglobulins and detect antigens via western blotting.

1. Precipitation reactions in gels – SRID, ODD, RE, CIE, Immunoelectrophoresis and staining of precipitation lines.
2. Preparation of lymphocytes from peripheral blood by density gradient centrifugation.
3. Purification of immunoglobulin – Ammonium Sulphate Precipitation.
4. Separation of IgG by chromatography using DEAE cellulose or Sephadex.
5. Western Blotting.
6. Tissue typing – Microcytotoxicity Assay, Mixed Lymphocyte Reaction and Primed Lymphocyte Typing.
7. Isolation of immunoglobulin from serum.
8. Quantification of immunoglobulins.
9. Separation of lymphocytes from whole blood
10. Nylon Wool Separation of T and B Lymphocytes
11. HLA – DNA Typing.

Total: 90 Practical Hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Antigen-antibody interactions demonstrated in gels and to visualize the bands

CO2: Isolating of lymphocytes from blood by density gradient centrifugation

CO3: Purifying and separating immunoglobulins using salt precipitation and affinity chromatography respectively

CO4: Molecular detection of infectious proteins by blotting techniques.

CO5: Serological and Molecular typing of tissues

18CMIM31 CC9: Clinical Immunology and Vaccinology (Theory) 4 0 0 4

Course Objective: The candidate will gain knowledge about immunological against infections; humoral and cell mediated immunity; autoimmunity mechanisms and damage; immunodiagnostic tests and assays; Vaccines- preparations and use.

UNIT I MOLECULAR BASIS 12 Lecture Hours

Microbial pathogens – Bacterial, Viral and Fungal Pathogens and Parasitic diseases. Immune response vs infection. Immunity against bacterial infections – Innate and Acquired Immune responses – cellular involvement – Macrophages, Neutrophils, NK cells, Defensins, Humoral and Cell mediated Immune responses, Intracellular infections.

UNIT II INFECTION AND IMMUNITY 12 Lecture Hours

Immunity against bacterial and viral infections – Innate and Acquired immune responses – Effector mechanisms of HI and CMI – cytokine involvement. Immunodeficiency. Immunity to fungal and parasitic infections – overview of Humoral and Cell mediated immune responses against the pathogens. Immunomodulation in infections.

UNIT III CLINICAL IMMUNOLOGY 12 Lecture Hours

Clinical Immunology - Disease caused by immune response – hypersensitivity, immune tolerance and autoimmunity, mechanism of autoimmunity, therapy for immunological diseases - Immune complex disease, immunosuppression and immunomodulation.

UNIT IV IMMUNODIAGNOSIS 12 Lecture Hours

Diagnostic Immunology - Methods based on precipitation; ODD, CIE, IEP, immunofixation and immunoblotting, RIA, RE, Immunonephlometry. Methods based on Agglutination - agglutination of whole cells, agglutination of inert particles coated with Ag/Ab. Haemagglutination – Direct, indirect, passive; CFT, labelled assays – ELISA, RIA, FISH, IFT- *in vivo* reactions- skin tests, immune complex demonstration. Diagnostic evaluation of lymphocytic haemagglutination inhibition, lymphocytic function and CMI, phagocytosis.

UNIT V VACCINES 12 Lecture Hours

Introduction to Vaccines and Adjuvants - Types of vaccines – Whole cell - Killed and Live Attenuated vaccines. Sub–unit vaccines – polysaccharides, proteins, Toxoids. Recombinant vector vaccines, DNA vaccines, Development of vaccines and antibodies in plants. Vaccines

against AIDS and Tropical Infectious Diseases – Leprosy, malaria and TB. Vaccines for control of fertility , Anti – HCG Vaccines and Anti – sperm antigen vaccine. Immunization – Active and Passive. Therapy for immunological diseases. Immuno therapy for cancer. Strategies of vaccine production. Gene silencing.

Total: 60 Lecture Hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Learn the molecular basis of microbial pathogens.

CO2: Understand the Innate and Acquired immune responses against microbial pathogens

CO3: Learn various disease caused by immune response.

CO4: Learn immune diagnostic tests and assays against pathogens.

CO5: Understand the vaccines preparations and its clinical uses.

TEXTBOOK:

Mark Peakman, Basic and Clinical Immunology; Churchill Livingstone. 2nd Ed., 2009.

REFERENCE BOOKS:

1. Talwar GP, Rao KVS and Chauhan VS, Recombinant and Synthetic Vaccines; Narosa, New Delhi. 1994.
2. Benjamini E, Coico R and Sunskise G,;Immunology – A short course, Wiley – Liss Publication, NY. Ed.4; 2000.
3. Kuby J, Immunology, WH Freeman and Co. NY. Ed.4; 1997.
4. Clark WR, The Experimental Foundations of Modern Immunology; John Wiley and Sons Inc. New York. 1991.
5. Leslie Hudson and Frank C. Hay., Practical Immunology. Wiley. Ed.3; 1989.
6. Noel R. Rose, Herman Friedman, John L. Fahey., Manual of Clinical *Laboratory Immunology. ASM. Ed.3;* 1986.

18CMIM33 CC10: Practical - Vaccine Technology 0 0 6 3

Course Objective: The candidate will gain hands-on knowledge and acquire adequate skill required to prepare bacterial antigens and raise antisera, evaluate the antisera.

1. Crude preparation of bacterial antigens and Immunization
2. Crude preparation of bacterial vaccines.
3. Efficacy tests for vaccines.
4. Toxoid preparation
5. Raising polyclonal antisera.
6. Repetitive Bleeding Technique – Antiserum Preparation; Antibody Titration – Agglutination
7. Bacterial Agglutination Assay
8. Antiprotease Assay
9. Visit to Regional Vaccine Institutes

Total Hours: 90 Practical Hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Acquire technical skills on antigen preparation

CO2: Know how to prepare bacterial vaccines

CO3: Gain the basic skill on toxoid prepartion

CO4: Skilled in testing of efficacy of vaccines

CO5: Gain the knowledge on raising polyclonal Abs.

18CMIM32 CC11: Applied Microbiology (Theory) 4 0 0 4

Course Objective: The candidate will gain knowledge about the role of microorganisms in soil; plant pathology and biogeochemical cycles; microorganisms and foods – preservation, spoilage, canning, HACCP,GMP; microbiology of air and effluent treatment.

UNIT I SOIL MICROBIOLOGY 15 Lecture Hours

Various types of soil microbes and their importance. Organic matter – sources and decomposition. Soil enzymes and soil sickness. Plant microbes interaction – rhizosphere, phyllosphere, root nodules (*Rhizobium, Frankia),* stem nodules and mycorrhiza. Nitrogen fixation – symbiotic (*Rhizobium, Azolla, Anabena*) free living (*Azotobacter*, BGA) and associative (Azospirillum).Preparation, application and advantage of Biofertilizer – Nitrogen fixer – *Rhizobium, Azotobacter, Azospirillum, Azolla-Anabena, Nostoc,* Phosphate solubilising –*Phosphobacterium* and mycorrhizal biofertilizer. Biopesticide-Bacterial, fungal and viral.

UNIT II NUTRIENT CYCLES 10 Lecture Hours

Plant pathology – Host - pathogen interaction. Transmission of plant pathogen. Various symptoms of plant diseases. Biogeochemical cycles. Importance of biogeochemical cycle in environment. A brief account of carbon cycle, sulphur cycle and iron cycle.

UNIT III FOOD MICROBIOLOGY 12 Lecture Hours

Microorganisms important in food microbiology- molds, yeasts and bacteria. Factors influencing microbial growth and survival in foods – intrinsic and extrinsic factors. Principles of food preservation – Asepsis, Removal of microbes, maintenance of anaerobic conditions. Methods – physical- heat-processing, low temperature- chilling, freezing, high pressure, controlled and modified atmosphere, drying, irradiation. Chemical methods- use of preservatives, food additives. Canning process. Food Sanitation- Controlling microbiological quality of foods- sampling schemes, control at source, GMPs, HACCP, Personal Hygiene. Quality Systems – BS 5750, ISO 9000 series.

UNIT IV DAIRY MICROBIOLOGY 11 Lecture Hours

Microbiology of milk and dairy products- contamination, spoilage and preservation of dairy products. Fermented dairy products – cheese and its types. Food safety and quality assurance. Food hazards, Significance of food-borne diseases, Incidence and Risk factors. Bacterial and

non-bacterial food borne infections and intoxications. Methods of microbiological examination of foods- indicator organisms, direct examination, cultural techniques.

UNIT V ENVIRONMENTAL MICROBIOLOGY 12 Lecture Hours

Microbiology of air; droplet, droplet nuclei, aerosol, infectious dust. Assessment of air quality. Laboratory hazards of air microbes, air borne diseases, air sanitation. Aquatic Microbiology- aquatic ecosystems. Potability of water, assessment of water quality, purification of drinking water. Water borne diseases- pathogenesis, prevention and control.Waste treatment – BOD and COD. Biodegradation of xenobiotic compounds. Bioaccumulation of heavy metals, biomagnification, biocorrosion, bioleaching and biomining. Bioremediation.

Total: 60 Lecture Hours

Course outcome:

CO1: Acquire knowledge about microorganisms and their role in soil and applications as biofertilizers.

CO2: Understand the role of plant pathogens and nutrient cycling in soil.

CO3: Comprehend microbial food spoilage and preservation of foods.

CO4: Gain knowledge about microorganisms in dairy applications and food borne diseases.

CO5: Understand the significance of microbes in air, water, waste disposal, and biodegradation.

TEXTBOOK:

Arumugam.N.; Microbiology – Basic and Applied Microbiology. Saras Publication. 2014.

REFERENCE BOOKS:

1. Subba Rao N.S.; Soil Microorganisms and Plant Growth, Oxford and IBH publication Co. Pvt. Ltd. New Delhi. 2002.
2. Mitchell.R.; Introduction to Environmental Microbiology, Prentice – Hall. Inc. Cliffs - New Jersey. 2003.
3. N.S. Subba Rao, Biofertilizer in Agriculture and Forestry, Oxford and IBH publication. 3rd edn, 2005.

4. Lynch , J.M. and Poole, Microbial Ecology. A Concept Approach, BI scientific publication London. 2005.
5. Sivasankar, B, Food Processing and Preservation; Prentice Hall of India Pvt. Ltd. 2002.
6. Ananthakrishnan CP, Singh RB, Padmanabhan PN, Dairy Microbiology; Sri Lakshmi Publications, Chennai. 1994.
7. Robinson RK, Dairy Microbiology; Wiley and Sons. New York. 2002.
8. Salle, A.J., Fundamental Principles of Bacteriology, Tata-McGraw Hill Publishing Company Ltd. Ed.7; 2001.
9. Ronald. M. Atlas, Richard Bartha, Microbial Ecology. Fundamental and application, An imprint of Addison Wesley Longman Inc. 4th ed, 1998.
10. Mitchell.R., Introduction to Environmental Microbiology; Prentice Hall. Inc. Cliffs - New Jersey. 2003;
11. Rheinheimer, Aquatic Microbiology, John Wiley and sons, Chichester. Ed.2; 2003.

18PMIM34 CC12: Applied Microbiology (Practical) 0 0 6 3

Course Objective: The candidate will gain hands-on knowledge and acquire adequate skill required to observe the growth of microbes in various foods and environments. Requisite skills and basic knowledge about the use of microbes in fermentation and product formation.

1. Isolation and identification of bacteria and fungi from spoiled food. Enumeration of bacteria in spoiled foods.
2. Dye Reduction Tests for milk – MBRT and Resazurin tests. Litmus Milk Reactions.
3. Evaluation of quality of Dairy products (milk and curd) by SPC. Isolation of microorganisms from Dairy products (curd/ yoghurt) – *S. aureus, Lactobacillus* species and yeasts.
4. Production of Sauerkraut
5. Enumeration of microbes in air- settle plate method, air sampling methods.
6. Physical, chemical and microbial assessment of water- color, pH, alkalinity, acidity, BOD, COD, anions, cations. MPN analysis of water.
7. Enumeration of microbes using membrane filter.
8. Isolation of Bacteria, Fungi, Algae and Actinomycetes from soil.I solation and study of *Rhizobium, Azotobacter, Azospirillum,* Phosphate solubilising organism, BGA – *Nostoc, Anabena.*
9. Isolation of plant pathogens – Bacteria – *Xanthomonas, Pseudomonas spp. Alcaligens spp*, Fungi- *Fusarium, Helminthosporium, Cercospora.*
10. Preparation of media for animal cell culture. Primary culture of chick embryo fibroblasts. Primary culture of chick organ - spleen and kidney cells. Demonstration of inclusion bodies.
11. Ethanol production.Cultivation of SCP – *Spirulina*, Fodder yeast.
12. Production of acetic acid. Production of lactic acid.
13. Visit to any Microbial / Biotech Industries.

Total: 90 hrs

Course Outcome

At the end of the course, learners will be able to:

CO1: Acquire technical skills on isolation microbes from spoiled foods

CO2: Know how to perform quality checking of milk and dairy products

CO3: Gain the basic skill on microbial quality checking of air, water.

CO4: Skilled on study of microbes in Biofertilizers

CO5: Gain the knowledge on animal cell cultures.

DISCIPLINE SPECIFIC ELECTIVES (DSE)

18DMIM11 DSE1: Medical Microbiology (Theory) 4 0 0 4

Course Objective: The candidate will gain knowledge about pathogenesis, diagnosis, control and treatment of medically important – viral diseases; bacterial diseases; fungal diseases; and parasitic infections.

UNIT I VIROLOGY 12 Lecture Hours

General properties of viruses Structure, cultivation, pathogenesis and various diagnosis techniques. Antiviral agents, chemotherapy and vaccines. Viroids, prions, virusoids and satellite RNA. General properties, antigenic structure, pathogenesis, clinical findings, lab diagnosis, prevention, control and treatment of - HIV, HAV, HBV, Rabies, Influenza, Dengue, Yellow Fever, Measles, Mumps, Rubella, Polio, Oncogenic Viruses.

UNIT II BACTERIOLOGY 12 Lecture Hours

Normal flora of human body. General attributes and virulence factors of bacteria causing infections – invasiveness and toxigenicity. Pathogens, pathogenesis, clinical manifestations, lab diagnosis, epidemiology, chemotherapy and prevention of diseases caused by– *Staphylococcus, Streptococcus, C. diphtheriae, Cl. tetani, Cl. botulinum, B.pertussis, M. tuberculosis, N. gonorrhea, S. typhi, V. cholera , S. dysentriae, T. pallidum*. Y. *pestis, Leptospira interrogans.*

UNIT III INFECTION 12 Lecture Hours

Epidemiology and control of community infections. Nosocomial infections – factors that influence hospital infection, hospital pathogens, routes of transmission, investigation, prevention and control. Hospital waste management.

UNIT IV MYCOLOGY 12 Lecture Hours

Detection and recovery of fungi from clinical specimens. Molecular and advanced diagnostic methods for mycological infections. Antifungal agents- testing methods and quality control. Yeasts of medical importance – *Candida, Cryptococcus sp.* Fungi of medical importance – Dermatophytes and Superficial mycoses, systemic mycoses, opportunistic mycoses, Dimatiaceous fungi, Eumycotic mycetoma.

UNIT V **PARASITOLOGY** **12 Lecture Hours**

Introduction to parasitology, Host–parasite relationship, mechanism of pathogenesis, transmission and life cycle of the Protozoan – *Entamoeba, Toxoplasma, Cryptosporidium, Leishmania, Giardia, Trypanosoma, Trichomonas, Balantidium* and *Plasmodium*. Helminthes – Cestodes – *Taenia solium* and *T.saginata, Echinococcus*. Trematodes – *Fasciola hepatica, Fasciolopsis buski, Paragonium, Schistosomes*. Nematodes – *Ascaris, Ankylostoma, Trichuris, Trichinella, Enterobius, Wucheriria*.

Total: 60 Lecture Hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Study about the properties, pathogenicity, lab diagnosis of pathogenic viruses.

CO2: Know about the normal microbial flora of human and Learn about the characters, pathogenicity, lab diagnosis of bacteria pathogens.

CO3: Get knowledge on nosocomial infections. Gain knowledge hospital waste management

CO4: Get in-depth knowledge on fungal pathogens.

CO5: Learn about pathogenic protozoans and helminths

TEXTBOOK:

Jawetz. E, Melnick J.L, Adelberg E.A , Review of Medical Microbiology, Lange Medical Publications, ELBS, London. Ed. 28; 2013.

REFERENCE BOOKS:

1. Ananthnarayanan. R & C. K. Jeyaram Panicker, Textbook of Microbiology,;Orient Longman. Ed.8; 2006.
2. David Greenwood, Richard B. Slack John F. Peutherer Medical Microbiology, Churchill Livingstone, London. 16th Edn., 2002.
3. Baron EJ, Fine Gold S.M; Diagnostic Microbiology. Blackwell Scientific Systems. 1995.

4. J.G. Colle, A.Simmons, A.G. Fraser, B.P. Marmion, Mackie & McCartney Practical Medical Microbiology, Elsevier.Ed.14; 2006.
5. Topley & Wilson, Topley & Wilson's Principles of Bacteriology, Virology & Immunity, Vol III; Bacterial Diseases, Edward Arolla, London. Ed.8; 1990.
6. Jagadish Chandar, 1996; A Textbook of Medical Mycology; Interprint, New Delhi.
7. Alexopoulos C.J, Introductory Mycology; John Wiley & Sons Inc, N.Y. 1992.
8. H.C. Dube , Introduction to Fungi, Vikas Publishing House. Ed.3; 2005.
9. D.R. Arora & B.R. Arora Medical Parasitology, CBS Publishers & Distributors, New Delhi. 1st Edn., 2002.
10. Subhas Chandra Parija, Medical Parasitology, 2nd Edn., 2009.

18DMIM12 DSE2: Industrial and Pharmaceutical Microbiology (Theory) 4 0 0 4

Course Objective: The candidate will gain knowledge about industrially important organisms, strain improvement; production of major products involving microbes; biogas, biofuels; Antimicrobials production; Immobilisation and sterilization.

UNIT I INTRODUCTION 12 Lecture hours

Introduction to industrial microbiology. Study of industrially important microbes- yeast, *Lactobacillus*, *Hansenula*, *Spirulina*, *Streptomyces*, *Penicillium.* Methods for the improvement of microbial strains having industrial value. Fermenter- basic function, design and components, types of fermenter, types of fermentation.

UNIT II PRODUCTION 12 Lecture hours

Production of organic acids- vinegar, citric acid, vitamins- riboflavin, cyanocobalamine, amino acid- glutamic acid, lysine, enzymes- cellulases, amylases, pectinases, proteases. Mushroom cultivation, production of SCP (Spirulina, yeast). Production of fermented food- dairy and non-dairy products.

UNIT III EFFLUENT TREATMENT 12 Lecture Hours

Production of biogas, biofuel. Production of non-microbial products through microbes- insulin, interferon, B-cell growth factor. A brief mention about effluent treatment in industries using microbes. Petroleum Microbiology- organisms involved. Introduction to antibiotics. Mode of action of antibiotic-cell wall, cell membrane, nucleic acids, protein synthesis, enzyme inhibition.

UNIT IV DRUG 12 Lecture Hours

Important microbes producing antimicrobial agents, synthetic antimicrobial agents, antifungal agents and antitumor agents. Drug targeting, drug delivery system in gene therapy. Resistant to antibiotics-bacteria, yeast. Sterilisation of pharmaceutical products, contamination and spoilage of pharmaceutical products. Other pharmaceutical products produced by microbes (streptokinase, streptodornase, Botox).

UNIT V PHARMACEUTICAL APPLICATIONS 12 Lecture Hours

Immobilisation procedure for pharmaceutical applications (lipososmes), biosensors in pharmaceuticals. Applications of microbial enzymes in pharmaceuticals. Regulatory aspects of quality control. Sterilisation, control and sterility testing (Heat sterilization, D-value, Z-value, radiation, Gaseous and filter sterilization), chemical and biological indicators used.

Total: 60 Lecture Hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Gain knowledge on industrially important microbes. Understanding a fermenter, its structure & types.

CO2: Assimilate knowledge on industrial production of microbial -Organic acids, Amino acids and enzymes.

CO3: Gain knowledge on production of Biofuel, Biogas, Insulin and petroleum microbiology.

CO4: Understand microbial production of antimicrobial agents, antifungal agents, antitumour agents and pharmaceuticals.

CO5: Gain knowledge on application of biosensors and Grasp information on regulatory aspects of quality control.

TEXTBOOK:

Arnold .L, Demain and Davis. J. E., Manual of Industrial Microbiology and Biotechnology; ASM Press. Washington DC. 1999.

REFERENCE BOOKS:

1. Stanbury. P .F, Whitaker. A. Hall. S. J, Principles of Fermentation Technology; Pergamon Press. 1995.
2. Reed. G, Prescott and Dunn’s Industrial Microbiology; Macmillan Publishers. 1982.
3. W.B. Hugo and A. D. Russell, Pharmaceutical microbiology, Blackwell scientific Publications; Ed. 6; 2002.

4. Fredrick Kavanagh, Analytical microbiology, Vol I & II;Academic press, New York. 2003.

5. Murray. S. Cooper, Quality control in pharmaceutical industry, Vol 2; Academic press, New York. 2001.

6. S.P.Vyas, V.K. Dixit, Pharmaceutical Biotechnology; CBS publishers and Distributors, New Delhi. 2004.

7. Rajesh Bhatia, Ratanlal Ihhpunjani, Quality assurance in Microbiology; CBS publishers and distributors, New Delhi. 2005.

18DMIM21 DSE3:Immunotechnology(Theory) 4 0 0 4

Course Objective: The candidate will gain knowledge about antigens, antiboby, Ag-Ab reactions; antigen preparation; antibody and genetic engineering in mmunology; immune cells and blood systems.

UNIT I ANTIGEN-ANTIBODY REACTIONS 12 Lecture Hours

Antigen-Antibody reactions- Precipitation- types-immunodiffusion methods-Agglutination-types-immunofluorescent techniques-principles- typical protocol -types- RIA-principles-typical protocol-ELISA-different types-Ag coating-Ab coating-linking of enzymes to Abs-substrates. Immunoelectrophoresis- immunoblotting.

UNIT II ANTIBODY 12 Lecture Hours

Preparation of antigens-bacterial, fungal, viral pathogens-different methods. Standardization of antigens-quantification. Raising of polyclonal antibodies in animals-different routes of inoculation- immunization protocol- purification of immunoglobulins of different classes-quantification.

UNIT III MOLECULAR ENGINEERING 12 Lecture Hours

Molecular engineering methods – improve and modify immunological specificities and reactions. Antigen engineering for better immunogenicity and use for vaccine development. Antibody engineering – development of monoclonal antibodies and fragments using cellular and molecular technologies- cloning methods, production, purification and characterization of mAbs. Production of human monoclonal antibodies and their applications. Antibodies for diagnosis and therapy.

UNIT IV IMMUNE CELLS 12 Lecture Hours

Separation of immune cells-T cells- B cells- Macrophages- density gradient-lymphocyte stimulation test- flow cytometry-T cell subset analysis- B cell analysis. Delayed Type Hypersensitivity estimation methods- macrophage migration inhibition assays- purification and assay of interleukins.

UNIT V IMMUNOHAEMATOLOGY 12 Lecture Hours

Immunohaematology-blood groups- methods of blood grouping- reverse grouping- uses in forensic science-coombs test- blood banking. HLA typing- Tissue typing.

Total: 60 Lecture Hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Basic Understanding of various immunological techniques

CO2: Understand the polyclonal, monoclonal and humanized antibodies and production of these.

CO3: Learn various types of molecular engineering methods and their applications for diagnosis and therapy.

CO4: Understand the evaluating effect of immune cells.

CO5: Understanding of the principles of immunohaematology methods and their use in diagnostics, medicine, biotechnology, and scientific research.

TEXTBOOK:

D.P. Stites, JD Stobo, H.H. Fudenberg, J.V. Wells; Basic and Clinical Immunology. Lange Medical Publications. Ed.8; 2006.

REFERENCE BOOKS:

1. Pravash Sen. Gupta, Clinical Immunology; Oxford University Press. 2003.
2. Noel R. Rose, Herman Friedman, John L. Fahey, Manual of Clinical Laboratory Immunology. ASM. III edition; 1986.
3. Leslie Hudson and Frank C. Hay, Practical Immunology, Blackwell Scientific Publication. Ed.3; 1989.
4. Goding J.W., Monoclonal Antibodies: Principle and Practice; Academic Press. 2001.
5. Carl A. K. Borrebacck, Antibody Engineering, Oxford University Press. Ed.2; 1995.

6. Leonore A. Herzenberg, Donald M. Weir, Leonard A. Herzenberg, Caroline Blackwell, Weir's Handbook of Experimental Immunology, Vol. I – IV; Blackwell Science. 1996.

7. Stefan H.E. Kaufmann and Dieter Kabelitz, Immunology of Infection. Methods in Microbiology. Vol. 25; Academic Press. 1998.

8. Sringer, T.A, Hybridoma Technology in the Biosciences and Medicine; Plenum Press. New York. 2004.

9. Garrison Fathman. C., Fitch, F.W., Isolation, Characterization and Utilization of T lymphocyte clones; Academic Press. 2003.

10. G.P.Talwar and S.K.Gupta., A Handbook of Practical and Clinical Immunology, Vol.I-II; CBS Publishers and Distributors. Delhi. 1993.

18DMIM22 DSE4: Cloning Strategies and Nanomicrobiology (Theory) 4 0 0 4

Course Objective: The candidate will gain knowledge about genetic engineering; gene transfer mechanisms and related phenomena; various cloning strategies; nanomicrobiology and nanotechnologies.

UNIT I GENETIC ENGINEERING 12 Lecture Hours

An overview of Genetic engineering- Isolation and purification of DNA from cells – Total, plasmid and phage DNA. PCR, Pulse field electrophoresis for large DNA. Restriction enzymes, DNA ligases, DNA modifying enzymes, Eukaryotic and Prokaryotic hosts for cloning. Characteristics of an ideal vector, cloning vectors – Plasmids, phages, Cosmids, Phagemids, Artificial chromosomal vectors, Shuttle vectors, choice of vectors for *E. coli*, fungi, higher plants and mammalian cells.

UNIT II GENE TRANSFER 12 Lecture Hours

Methods of gene transfer- Electroporation, transduction, and liposome mediated gene transfer. Direct transfer of DNA- Microinjection, particle bombardment. Screening of recombinants- Insertional inactivation and complementation, blue-white screening, immunodetection and radioactive probes.

UNIT III STRATEGIES 12 Lecture Hours

Strategies for obtaining the clone of choice- Direct selection – selection from gene library. Construction of cDNA libraries. Uses of cloning in medicine, agriculture, forensic science and industries. Socio-economic ethics of cloning, NIH guidelines, GEO, GMF, future of cloning techniques.

UNIT IV NANOMICROBIOLOGY 12 Lecture Hours

Basics of Nanomicrobiology- introduction, landmarks in nanomicrobiology- Techniques: microarrays- nanoarrays- protein nanoarray- microfluidics and nanofluidics. Atomic force microscopy- operation- advantages of AFM, Magnetic resonance force microscopy. Nanoparticles- Quantum dots, Gold nanoparticles, Silica nanoparticles, Fluorescent nanoparticles, cubosomes, Dendrimers, nanoparticle synthesis.

UNIT V NANOBIOTECHNOLOGY 12 Lecture Hours

Bacterial structures relevant to nanobiotechnology- Nanostructures on bacterial cell surface-bacterial magnetic particles- DNA nanotubes. Applications in Biology- NanoSystems Biology-Quantum dots for cell labeling and study of apoptosis- Nanofabricated structures for DNA separation- Nanopore sequencing- Nanomotor from DNA (Molecular motor). Nanoprobes for Analytical Applications-A new Methodology in medical diagnostics and Biotechnology-Nanosensors. Nanomicrobiology in drug delivery- viruses as nanomaterials for drug delivery-Bacteria mediated drug delivery-Dendrimers- Cubosomes- Gold nanoparticles- cyclodextrin.

Total: 60 Lecture Hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Gain knowledge about various aspects in genetic engineering, strategies in obtaining clone and cloning vectors.

CO2: Learn about the gene transfer methods and screening of clones.

CO3: Study about the cloning and expression of gene of interest.

CO4: Acquire knowledge on nanoparticles and their characterization.

CO5: Learn about the nanomicrobiology, nanobiotechnology and microbial mediated drug delivery system.

TEXTBOOKS:

1. L.E.Foster, Nanotechnology-Science, Innovation and Opportunity,

Person education Inc, 2007.

2. Sardul Singh Sandhu; Recombinant DNA Technology;I K International Publishing House. 2010.

REFERENCE BOOKS:

1. T.A. Brown, Gene cloning and DNA analysis- An introduction, Blackwell Science Publishers. Ed.4; 2001.
2. Old, R.S and Primrose SB, Principles of Gene manipulation: An introduction to Genetic engineering , Blackwell Scientific publications. Ed.5; 1995.
3. Glick B.R and Pasternak JJ, Molecular Biotechnology. ASM Press, Washington DC. 1994.
4. Clover D.M , DNA cloning series (Vol I-IV); IRL Press, Oxford. 1987.
5. Winnacker E L, From Genes to clones: Introduction to Gene technology; VCH Weinheim. 1987.
6. Satyanarayana. U, Biotechnology; Uppala- Author Publishers Linkers. 2005.
7. Tuan R.S , Recombinant Gene Expression Protocols; Humana Press. 1997.
8. M.Ratner and D.Ratner, Nanotechnology –A Gentle Introduction to The Next Big Idea, Pearson Education. 2007.
9. Charles P. Poole, Jr. and Frank J. Owens, Introduction to Nanotechnology; Wiley – Interscience. 2003.
10. Guozhong Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Applications; Imperial College Press. 2004.
11. David S. Goodsell, Bionanotechnology: Lessons from Nature; Wiley-Liss, Inc. Hoboken, New Jersey. 2004.

18DMIM07 DSE5: Biofertilizers (Theory) 4 0 0 4

Course Objective: The candidate will gain knowledge about significance of biofertilizers; various beneficial microbes like nitrogen fixers, Mycorrizhal associations and organic farming.

UNIT I INTRODUCTION 12 Lecture Hours

Introduction; General account about the microbes used as biofertilizer – Rhizobium – isolation, identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis.

UNIT II NITROGEN FIXERS 12 Lecture Hours

Azospirillum Isolation and mass multiplication – carrier based inoculant, associative, effect of different microorganisms. Azotobacter: classification, characteristics – crop response to Azotobacter inoculum, maintenance and mass multiplication.

UNIT III ASSOCIATIONS 12 Lecture Hours

Cyanobacteria (blue green algae); *Azolla* and *Anabaena*- azollae association, nitrogen fixation, factors affecting growth, blue green algae and *Azolla* in rice cultivation.

UNIT IV MYCORRHIZA 12 Lecture Hours

Mycorrhizal association Types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants.

UNIT V ORGANIC FARMING 12 Lecture Hours

Organic farming Green manuring and organic fertilizers,Recycling of biodegradable, municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – field application.

Total: 60 Lecture Hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Gain knowledge about the role and importance and significance of biofertilizers and mass production.

CO2: Study about the nitrogen fixer such as Azospirillum, Azotobacter and the mass multiplication, maintenance of these biofertilizers.

CO3: Achieve information about blue green algae and its association with nitrogen fixation.

CO4: Gain knowledge in the mycorrhizal taxonomy, occurrence, distribution and types of mycorrhizal associations.

CO5: Achieve knowledge in green manuring Gain knowledge in recycling of biodegradable municipal, agricultural and industrial wastes.

TEXTBOOK:

P.C.Trivedi, Biofertilizers; Neha Publishers. 2008.

REFRENCE BOOKS:

1. Dubey, R.C., A Text book of Biotechnology S.Chand & Co, New Delhi. 2005.
2. Kumaresan, V., Biotechnology, Saras Publications, New Delhi. 2005.
3. John Jothi Prakash, E., Outlines of Plant Biotechnology. Emkay Publication,
4. New Delhi. 2004.
5. Sathe, T.V., Vermiculture and Organic Farming. Daya Publishers.2004. Subha Rao, N.S. Soil Microbiology, Oxford & IBH Publishers, New Delhi.2000.
6. Vayas,S.C, Vayas, S. and Modi, H.A. Bio-fertilizers and or ganic Farming Akta Prakashan, Nadiad.1998.
7. H.C.Lakshmi, Biofertilizers & Biopesticides; Neha Publishers. 2014.

18DMIM32 DSE6: Cell Culture and Fermentation Technology (Theory) 4 0 0 4

Course Objective: The candidate will gain knowledge about fermentation types and kinetics, fermenters; media formulation and characteristics; industrial type/ scale sterilization, GLISP; animal culture; animal cell culture systems and applications.

UNIT I FERMENTATION 12 Lecture Hours

General consideration of fermentation process. Types of fermentation-submerged, solid state, batch, fed batch, continuous, single, dual, multiple. Design of fermenter. Types of fermenter-Air lift, cylindro conical, fluidized bed, stirred, Tower fermenter, growth kinetics of batch and continuous culture-chemostat and turbidostat. Primary and secondary metabolites-product fermentation kinetics.

UNIT II MEDIA FORMULATION 12 Lecture Hours

Media formulation- Strategy involved - aeration and agitation. Factors affecting oxygen transfer – Determination of K_{La} Values-Newtonian and non Newtonian fluids. Physical and chemical environmental sensors, fermentation control systems-manual and automatic.

UNIT III PRODUCTS 12 Lecture Hours

Sterilization-Types of sterilization, batch and continuous, Insitu and exsitu. Sterilisation of media, bioreactor and accessories, fed additives. Sterilisation kinetics – del factor, TDT, 12 D concepts, asepsis and containment – GMP, GILSP, HACCP, IPR, TRIPS, GATT. Screening and selection of industrially important cultures. Inoculum development, scale up process and downstream processing. Commercial fermentation products – enzymes – protease, amylase, lipase, cellulase, organic solvents – ethanol, butanol, Acids-Acetic acid and lactic acid, SCP-BGA, Vitamins – Vit B12, Vit C. Amino acids-Glutamic and threonine. Non microbial products produced through microbes – Hormones – GH, IFN, TPA, B-cell growth factor.

UNIT IV ANIMAL CELL CULTURE 12 Lecture Hours

Structure and Organization of animal cell; Equipments and materials for animal cell culture technology; Primary and established cell line cultures. Brief discussion on the chemical, physical and metabolic functions of different constituents of culture medium. Measurement of viability and cytotoxicity and Growth.

UNIT V CELL CULTURE TECHNIQUES 12 Lecture Hours

Basic techniques of mammalian cell culture in vitro; disaggregation of tissue and primary culture, maintenance of cell culture; cell separation. Cell synchronization; Cell cloning and micromanipulation; Cell transformation; Application of animal cell culture; Scaling-up of animal cell culture. Stem cell cultures, embryonic stem cells and their applications; Cell culture based vaccines, Somatic cell genetics.

Total: 60 Lecture Hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Gain knowledge on the fermentation process and types of fermenters and growth and fermentation kinetics.

CO2: Acquire knowledge on the strategy involved in the Media formulation and fermentation process control

CO3: Gain knowledge about sterilization, screening, scale up, downstream processing and commercially important products

CO4: Know about the cell culture basics, techniques involved in animal cell culture and its maintenance

CO5: Know about stem cell cultures, ES cell application, vaccines and somatic cell genetics

TEXTBOOK:

1. Mukhopadhyay S., Process Biotechnology Fundamentals, Ed.2; Viva Books Pvt. Ltd. 2004.

REFERENCE BOOKS:

1. Glyn Stacey, Medicines from Animal Cell Culture; John Wiley and Sons Ltd. 2007.
2. Ralf Portner, Animal Cell Biotechnology: Methods and Protocols (Methods in Biotechnology); Humana Press Inc., U.S. 2007.

3. Joanna Picot, Human Cell Culture Protocols (Methods in Molecular Medicine); Humana Press Inc., U.S. 2004.

4. Jan-Thorsten Schantz and Kee Woei Ng., A Manual for Primary Human Cell Culture ;World Scientific Publication. 2004.

5. Sadettin Ozturk and Wei-Shou Hu, Cell Culture – Technology for Pharmaceutical and Cell – Based Therapies (Biotechnology and Bioprocessing); Taylor and Francis. 2004.

6. Butler, M., Animal Cell Culture and Technology: The Basics; Garland Science. 2003.

7. Davis. J.M., Basic Cell Culture: A Practical Approach ; Oxford University Press. 2002.

8. John R.W. Masters, Animal Cell Culture: A Practical Approach, Ed.3; Oxford University Press. 2000.

9. Stanbury PF, Whitaker A, Hall SJ, Principles of Fermentation Technology; Pergamon Press. 1995.

10. Anton Moser, Bioprocess Technology – Kinetics and Reaction; Springer Verlag, New York. 1998.

11. El-Mansi, EMT., Fermentation Microbiology and Biotechnology; Taylor and Francis Publishers. 2005.

12. Balasubramanian, D., Bryce CFA, Dharmalingam, K., Green J., Kunthala Jayaraman., Concepts of Biotechnology; University Press. 2004.

18DMIMXX DSE7: Microbial Biochemistry (Theory) 4 0 0 4

Course Objective: The candidate will gain knowledge about microbial ultrastructure and biomolecules, biochemical cycles; energy molecule formation; fermentations and transport mechanisms.

UNIT I ULTRASTRUCTURE 13 Lecture Hours

Ultra structure of bacteria, algae, protozoa, fungi and virus. Types of Linkages in biomolecules; configuration and forms of sugars, amino acids (biologically active forms).Chemistry of Carbohydrates, Proteins and Lipids; Enzymes – factors affecting enzyme activity.

UNIT II CYCLES 14 Lecture Hours

Photosynthesis in bacteria, Cyanobacteria. Electron transport and respiration in bacteria - aerobic and anaerobic; and eukaryotes. Adaptive response in bacteria- metabolic stress, temperature, pH, oxygen. Osmotic stress, extremophiles. C1 metabolism. EMP, ED Pathway; HMP Shunt, TCA cycle.

UNIT III ENERGY PRODUCTION 10 Lecture Hours

Energy production–Substrate-level phosphorylation; oxidative phosphorlation. Membrane - potential – chemiosmotic theory, conformational change hypothesis; mechanisms to generate and maintain membrane potential. ATP Synthesis. Biosynthesis of fatty acids.

UNIT IV FERMENTATION 12 Lecture Hours

Fermentation – Propionate, Acetate, Lactate, Mixed Acid, Butyrate and Butanediol. Assimilation and dissimilation of nitrogen and sulphate. Nitrogen fixation – nitrogen fixation process; components of nitrogenase system. Endospore formation, Life cycle of *Myxobacteria*, Life cycle of *Caulobacter*.

UNIT V TRANSPORT 11 Lecture Hours

Mechanism of locomotion by bacteria, Homeostasis in bacteria, Transport across membranes – Chaperons, Leader Sequence. Bacterial cell division. Biosynthesis of nucleic acids. Exotoxins, endotoxins and quorum sensing.

Total: 60 Lecture Hours

Course Outcome

At the end of the course, learners will be able to:

CO1: In depth knowledge about the ultrastructure of various groups of microbes and details related to biomolecules – carbohydrates, proteins and lipids plus mechanism of action of enzyme

CO2: A thorough understanding of different metabolic cycles related to photosynthesis, ETC, stress response and adaptations to different conditions by bacteria including the various methods of carbohydrate breakdown and utilization.

CO3: Fine understanding of the ways for formation of ATP as well as fatty acid synthesis.

CO4: Complete grasp of various fermentation cycles, N2 and Sulphur utilization; endospore formation and two life-cycles.

CO5: Knowledge regarding bacterial locomotion, homeostasis, cell division and transport of molecules.

TEXTBOOK:

J.L. Jain, Fundamentals of Biochemistry; Chand Publications. 2006.

REFERENCE BOOKS:

1. Albert G.Moat, John W. Foster, Michael P.Spector, Microbial Physiology, John Wiley and Sons. Ed. 4; 2006.
2. David White, The Physiology and Biochemistry of Prokaryotes; Oxford University Press. 1995.
3. Michael T. Madigan, John M Martinko, Brock's Biology of Microorganisms, Pearson-Prentice Hall. Ed. 11; 2006.
4. Alberts B.Dray, J Lewis, M Raff, K Roberts, JD Watson, Molecular Biology of The Cell, Garland Publishing. Ed. 3; 1994.
5. Gottschalk G, Bacterial Metabolism, Springer-Verlag. Ed. 2; 1996.
6. Kates M, D Kushner, AT Matthews, The Biochemistry of Archae; Elseiver. 1993.

7. Topley and Wilson's : Principles of Bacteriology, Virology, and Immunology, Edward Arnold. Ed. 9; 2002.
8. Harper's Biochemistry; Robert.K. Murray Lance International Publication, 26th edition, 2005.
9. M.N. Chatterjee, Text Book of Medical Biochemistry; Jaypee Publication. 6th edition, 2006
10. U. Sathyanarayana, Biochemistry; Books and Allied (P) Ltd. 3rd edition, 2006.

18DMIMXX DSE8: Medical Parasitology (Theory) 4 0 0 4

Course Objective: The candidate will gain knowledge about the structure of protozoa and helminths; life-cycle patterns, pathogenesis, identification, and treatment.

UNIT I INTRODUCTION 11 Lecture Hours

Introduction to parasitology, Classification, Host – parasite relationship, Lab diagnosis of parasitic infections.

UNIT II PROTOZOOLOGY 12 Lecture Hours

Protozoology- pathogenic mechanism, transmission, life cycle, lab diagnosis of Protozoans – *Entamoeba, Giardia, Trichomonas, Balantidium.*

UNIT III HAEMOFLAGELLATES 12 Lecture Hours

Haemoflagellates- *Leishmania, Trypanosomes- Trypanosoma and Sporozoites-Plasmodium. Toxoplasma, Cryptosporidium.*

UNIT IV CESTODES 12 Lecture Hours

Helminthes – Cestodes – *Taenia solium and saginata, Echinococcus.* Trematodes – *Fasciola hepatica, Fasciolopsis buski, Paragonium, Trematodes- Schistosomes, Trichinella*.

UNIT V NEMATODES 13 Lecture Hours

Nematodes – *Ascaris, Ancylostoma, Trichuris, Strongyloides, Enterobius, Filarial worms- Wucheriria, Brugia, Loa Loa, Dracunculus, Onchocerca;* and other parasitic infections in immunocompromised hosts and AIDS associated parasites.

Total: 60 Lecture Hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Gain knowledge about the basic information of parasites

CO2: Acquire knowledge on complete study of protozoans

CO3: Complete knowledge on plant pathogenic interaction.

CO4: Get detailed view of haemoflagellates

CO5: Knowledge on cestodes and nematodes.

TEXTBOOK:

Chatterjee; Medical Parasitology. CBS Publishers. 2008.

REFERENCE BOOKS:

1. D.R. Arora & B.R. Arora Medical Parasitology, CBS Publishers & Distributors, New Delhi. 1st Edn., 2002.
2. Subhas Chandra Parija, Medical Parasitology, 2nd Edn., 2009.
3. Jayaram Panicker, Textbook of Parasitology, C.K. Jaypee Brothers, New Delhi. 2006.
4. Gerald D. Schmidt & Larry S. Roberts. Foundations of Parasitology, 6th Edn., 2008.

18DMIMXX DSE9: Research Methodology (Theory) 4 0 0 4

Course Objective: The candidate will gain knowledge about research methodology; biostatistics; biomolecules; and various biotechniques.

UNIT I RESEARCH METHODOLOGY 12 Lecture Hours

Research methodology- Meaning, Course Objective and types of research. Different research designs- Experimental and Non- experimental. Review of literature- preparation of research report. Guidelines for preparing an article. Criteria of good research-problem encounters in research in India.

UNIT II BIOSTATISTICS 12 Lecture Hours

Biostatistics- collection, classification and presentation of data-graphical and diagrammatic presentation, measure of central tendencies (mean, median, mode), measure of dispersion (range, mean deviation, standard deviation) and qualitative methods of data analysis. Simple linear correlation and regression analysis- testing of hypothesis using t- test, chi-square test, analysis of variances and covariance- ANOVA.

UNIT III BIOMOLECULES 12 Lecture Hours

Nucleic acid blotting methods-PCR-principles-instrumentation –applications- primer design-Nucleic acid sequencing methods- direct PCR sequencing- automated fluorescent DNA sequencing. Protein estimation- UV-lowry method- Bradford- Kjeldahl analysis- purification methods- cell disruption- crude extract- fractionation methods. Enzyme assays-spectrophotometric and manometric methods. Immobilization of enzymes- physical and chemical methods.

UNIT IV CENTRIFUGATION 12 Lecture Hours

Centrifugation techniques- principles- types of centrifuges and their uses-Refrigerated- High speed- Continuous flow- Preparative Ultracentrifuge- Differential- Density gradient and Analytical Ultracentrifuge. Spectroscopic techniques-Principles- Instrumentation – Applications- UV-Vis Spec- Spectrofluorimetry- Atomic absorption spectroscopy - Turbidometry and Nephelometry- Luminometry-NMR.

UNIT V **BIOSEPARATION** **12 Lecture Hours**

Electrophoretic techniques-principles-Electrophoresis of proteins-SDS-PAGE- Native gels- Gradient gels- Isoelectric focusing gels- Two dimensional PAGE- Cellulose acetate electrophoresis-western blotting. Electrophoresis of Nucleic acids- Agarose gel- Pulse – field gel and Capillary electrophoresis.Chromatographic techniques- principles – materials and applications. Column-TLC-Low pressure column chromatography- HPLC- Adsorption – Partition and affinity chromatography- GLC.

Total: 60 Lecture Hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Gain knowledge about the objective, types of research and guidelines for article writing.

CO2: Acquire knowledge about use of biostatistics and tools in research.

CO3: Learn about the types, and properties of major biomolecules.

CO4: Achieve knowledge about the basic molecular techniques – PCR, blotting, Nucleic acid sequencing, Centrifugation, NMR, fluorescent DNA sequencing and Enzyme assays.

CO5: Gain knowledge about the bioseparation techniques.

TEXTBOOK:

Kothari CR; Research Methodology; New Age International Publishers, New Delhi. 2nd Edition; 2005.

REFERENCE BOOKS:

1. Keith Wilson and John Walker; Practical Biochemistry- principles and techniques, Cambridge University Press. 5th Edition, 2003.
2. John G. Webster; Bioinstrumentation. Student Edition, John Wiley and Sons Ltd. 2004.
3. Palanivev, P; Analytical Biochemistry and Separation Techniques- A laboratory manual, 2nd Edition. 2001.

4. Asokan P; Analytical Biochemistry (Biochemical techniques), 2001.
5. Gurumani N; Research Methodology for Biological sciences, MJP publishers, Chennai. 2006.
6. Wayne W Daniel; Biostatistics- A foundation for analysis in the health sciences. 7th Edition, John Wiley and Sons Ltd. 2000.

18DMIMXX **DSE10: Biostatistics (Theory)** **4 0 0 4**

Course Objective: The candidate will gain knowledge about biostatistics; collection of data, data correlation; regression analysis and variability.

UNIT I **INTRODUCTION** **12 Lecture Hours**

Introduction to biostatistics – Definition, statistical methods, biological measurement, kinds of biological data, functions of statistics and limitation of statistics.

UNIT II **DATA** **12 Lecture Hours**

Collection of data, sampling and sampling design, classification and tabulation, types of representations, graphic – bar diagrams, pie diagrams and curves.

UNIT III **CORRELATION** **12 Lecture Hours**

Correlation – different types of correlation – positive, negative, simple, partial, multiple, linear and non-linear correlation. Methods of studying correlations.

UNIT IV **REGRESSION** **12 Lecture Hours**

Regression, types and methods of analysis. Regression line, Regression equations, Deviation taken from arithmetic mean of X on Y, Deviation taken from the assumed mean.

UNIT V **VARIABILITY** **12 Lecture Hours**

Measures of dispersion and variability, changes. Deviations – Quartile deviation, mean deviation, standard deviation, coefficient of variation, Lorenzen's curve.

Total: 60 Lecture Hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Understand the concepts of Biostatistics.

CO2: Grasp the information on kinds of biological data and collection of data.

CO3: Obtaining in-depth information on Correlation.

CO4: Assimilate knowledge on Regression and types.

CO5: Gain the knowledge on Deviations and graphic representations.

TEXTBOOK:

Khan, Fundamentals of Biostatistics, Uhaaz Publications, 1994.

REFERENCE BOOKS:

1. Palanisamy. S. and Manoharan, M. Statistical methods for Biologists (Biostatistics). Palani Paramount Publications, TamilNadu. 1994.
2. Arora, P.N. and Malhan, P.K. Biostatistics. Himalaya Publishing House, Mumbai. 1996.
3. Stanton. A.Clantz. Primer of Biostatistics – The McGraw Hill Inc. New York.1997.
4. Sokal and Rohlf. Introduction to Biostatistics – Toppan Co. Japan. 1973.
5. A. K. Vashisth. Encyclopedia of Biostatistics; Neha Publishers & Distributors. 2007.

18DMIMXX DSE11: Animal Cell Culture (Theory) 4 0 0 4

Course Objective: The candidate will gain knowledge about structure of animal cells; culture media and cultivation of animal cells; quantitation of cells and their applications.

UNIT I STRUCTURE 12 Lecture Hours

Structure and Organization of animal cell; Equipment and materials for animal cell culture technology; Primary and established cell line cultures; Introduction to the balanced salt solutions and simple growth medium.

UNIT II CULTURE MEDIUM 12 Lecture Hours

Brief discussion on the chemical, physical and metabolic functions of different constituents of culture medium. Role of carbon dioxide. Role of serum and supplements; Serum and protein free defined media and their application.

Unit III QUANTITATION 12 Lecture Hours

Measurement of viability and cytotoxicity; Biology and characterization of the cultured cells, measuring parameters of growth;

UNIT IV CELL CULTURE 12 Lecture Hours

Basic techniques of mammalian cell culture in vitro; disaggregation of tissue and primary culture, maintenance of cell culture; cell separation.

UNIT V APPLICATIONS 12 Lecture Hours

Cell synchronization; Cell cloning and micromanipulation; Cell transformation; Application of animal cell culture; Scaling-up of animal cell culture. Stem cell cultures, embryonic stem cells and their applications; Cell culture-based vaccines, Somatic cell genetics.

Total: 60 Lecture Hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Gain knowledge about the structure and organization of animal cells and cell cultures.

CO2: Learn about the culture media used in animal cell culture.

CO3: Get knowledge about the biology and characterization of the cultured cells.

CO4: Achieve knowledge about the maintenance of cell culture.

CO5: Get knowledge about the cell synchronization.

TEXTBOOK:

Mishra Bina, Animal Cell Culture.Studium Press. 2011.

REFERENCE BOOKS :

1.Basanth Kumar Sinha, Rinesh Kumar; Principles of animal Cell Culture. IBDC Press.2008.

2.Kumaresan, V., Biotechnology, Saras Publications, New Delhi. 2005.

3.John Masters, Animal Cell Culture: A Practical Approach. Oxford University Presss. 2000.

4.Ian Freshney.R, Culture of Animal Cells: A Manual of Basic Technique and Specialized Application. Wiley-Blackwell.2010.

18DMIMXX DSE12: Good Manufacturing Practices (Theory) 4 0 0 4

Course Objective: The candidate will gain knowledge about quality control and GMP; statistical basis for GMP; quality control systems and quality assurance.

UNIT I INTRODUCTION 12 Lecture Hours

Introduction to quality control History – Definition – quality in manufacturing and service system – Philosophy of quality management (Deming, Juran, Croshy and others) Red bead and funnel experiment.

UNIT II QUALITY CONTROL 12 Lecture Hours

Laboratory and quality control: Personnel training – Sampling procedures – Sample submittal – Receipt and handling of samples – Analytical methods and method validation – equipment calibration and maintenance – Data validation and interpretation – reporting – documentation and sample retention – corrective action.

UNIT III STATISTICS 12 Lecture Hours

Statistical quality control: Descriptive statistics – confidence intervals – tests of mean – correlation – regression – ANOVA – x chart. HACCP, GMP, cGMP, GILSP, SSOP. Writing QA manual, Biosafety manual – SOPs – Inter laboratory QC program.

UNIT IV QUALITY SYSTEMS 12 Lecture Hours

International quality systems: Introduction to ISO family – ISO – 9001; ISO – 17025 – regulatory bodies of quality – Good laboratory practice. Six sigma concept. Quality frame work.

UNIT V QUALITY AUDITING 12 Lecture Hours

Quality auditing: Audit definition and fundamentals of auditing – preparation – performance – reporting – closure-post script – internal system audit - procedure- auditing check list.

Total: 60 Lecture Hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Gain knowledge about basics of quality management

CO2: Study about the basics of quality control measures

CO3: Learn about the sampling, analysis, validation and documentation.

CO4: Get knowledge on using statistical models in quality control.

CO5: Gain knowledge international quality system and quality auditing.

TEXTBOOK:

HACCP: A Systematic Approach to Food Safety. A Comprehensive Manual for Developing and Implementing a Hazard Analysis and Critical Control Point Plan. Virginia N. Scott and Kenneth E. Stevenson, Editors, Food Products Association, Fourth Edition, 2006.

REFERENCE BOOKS:

1. Shayne Cox Gad. Pharmaceutical Manufacturing Handbook, Published by John Wiley and Sons, Inc., 2008
2. Good manufacturing practices for pharmaceutical products. In: *WHO Expert Committee on Specifications for Pharmaceutical Preparations. Thirty-seventh report*. Geneva, World Health Organization, 2003 (WHO Technical Report Series, No. 908), Annex 4.
3. Validation of analytical procedures used in the examination of pharmaceutical materials. In: *WHOExpert Committee on Specifications for Pharmaceutical Preparations. Thirty-second report*. Geneva,World Health Organization, 1992 (WHO Technical Report Series, No. 823), Annex 5.
4. *EudraLex* – Volume 4. *Good manufacturing practice (GMP) Guidelines. European Commission*. (http://ec.europa.eu/health/documents/eudralex/vol-4/ index_en.htm).

GENERIC ELECTIVES (GE)

18PGECXX GE1: Introduction and Scope of Microbiology (Theory) 2 0 0 2

Course Objectives: The candidates will understand the development of microbiology, diversity of microorganisms,Microscopy and other microbiological concepts.

UNIT I HISTORY OF DEVELOPMENT OF MICROBIOLOGY 6 Lecture Hours

Development of microbiology as a discipline, Spontaneous generation *vs*. biogenesis. Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming. Role of microorganisms in fermentation, Germ theory of disease,

UNIT II DIVERSITY OF MICROORGANISMS 6 Lecture Hours

Systems of classification : Binomial nomenclature, Whittaker's five kingdom and Carl Woese's three kingdom classification systems and their utility. General characteristics of different groups: Acellular microorganisms and Cellular microorganisms giving definitions and citing examples.

UNIT III MICROSCOPY 6 Lecture Hours

Bright Field Microscope, Dark Field Microscope, Phase Contrast Microscope, Fluoresence Microscope,Transmission Electron Microscope, Scanning Electron Microscope.

Unit IV STERILIZATION 6 Lecture Hours

Moist Heat, Autoclave, Dry Heat, Hot Air Oven, Tyndallization, Filteration. Microorganisms as food (SCP), microorganisms in food fermentations (dairy and non dairy based fermented food products) and probiotics.

Unit V MICROBES IN HUMAN HEALTH AND ENVIRONMENT 6 Lecture Hours

Medical microbiology and immunology: List of important human diseases and their causative agents of various human systems. **Environmental microbiology**: Definitions and examples of important microbial interactions – mutualism, commensalism- parasitism

Total: 30 Lecture Hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Learn basics of microbiology

CO2: Learn about the significance of classification and features of microbes.

CO3: Able to suitably address the ways to view microbes and the role of fermentations in human activity.

CO4: Gain knowledge regarding control of microbes, uses and impact of microorganisms regarding food.

CO5: Comprehend the role of microorganisms in health and environment.

TEXTBOOK:

Ananthnarayanan. R & C. K. Jeyaram Panicker; TEXTBOOKS of Microbiology, Orient Longman. 2010.

REFERENCE BOOKS:

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

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

3. Cappucino J and Sherman N., Microbiology: A Laboratory Manual. PearsonEducation Limited. 9th edition. 2010.

4.Wiley JM, Sherwood LM and Woolverton CJ. Prescott's Microbiology. McGrawHill International. 9th Edition. 2013.

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

6. Pelczar MJ, Chan ECS and Krieg NR., Microbiology. McGraw Hill Book Company. 5th edition. 1993.

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

18PGECXX GE2: Bacteriology and Virology (Theory) 2 0 0 2

Course Objectives: The candidates will understand the cell organization, bacterial growth and control, bacterial systematic and classification of viruses.

UNIT I CELL ORGANIZATION 6 Lecture Hours

Cell size, shape and arrangements, capsule, flagella and pili, Composition and detailed structure of gram- positive and gram- negative cell wall and archaeal cell wall structure.

Unit II BACTERIAL GROWTH AND CONTROL 6 Lecture Hours

Culture media: Components of media, Synthetic or defined media, Complex media, enriched media, selective media, differential media, enrichment culture media. Pure culture isolation: Streaking, serial dilution and plating methods.

Unit III BACTERIAL SYSTEMATICS AND TAXONOMY 6 Lecture Hours

Taxonomy, nomenclature, systematics, types of classifications. Morphology, ecological significance and economic importance of the following groups: Archaea: methanogens, thermophiles and halophiles.

Unit IV INTRODUCTION TO VIRUSES 6 Lecture Hours

Properties of viruses; general nature and important features. Subviral particles; viroids, prions and their importance. Isolation and cultivation of viruses.

Unit V STRUCTURE OF VIRUSES 6 Lecture Hours

Description of important viruses: salient features of the viruses infecting different hosts - Bacteriophages (T4 & Lambda); Plant (TMV & Cauliflower Mosaic Virus), Human (HIV & Hepatitis viruses).

Total: 30 Lecture Hours Course Outcome

At the end of the course, learners will be able to:

CO1: Get a wide knowledge on cell structure.

CO2: Have a wide knowledge on cultivation of microorganisms.

CO3: Gain a deep knowledge on taxonomy and types of classification systems.

CO4: : Knowledge of properties of viruses.

CO5: Learn the details of viral structure.

TEXTBOOK:

Ananthnarayanan. R & C. K. Jeyaram Panicker; TEXTBOOKS of Microbiology, Orient Longman. 2010.

REFERENCE BOOKS:

1. Atlas RM., Principles of Microbiology. WM.T.Brown Publishers. 2nd edition.1997.

2. Madigan MT, Martinko JM, Dunlap PV and Clark DP, Brock Biology of

Microorganisms. Pearson Education, Inc. 14th edition. 2014.

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

4. Carter J and Saunders V, Virology; Principles and Applications. John Wiley and Sons. 2007.

5. Flint SJ, Enquist, LW, Krug, RM, Racaniello, VR Skalka, AM, Principles of Virology,Molecular Biology, Pathogenesis and Control. ASM Press. 2nd ed. 2004

6. Shors Teri, Understanding Viruses; Jones and Bartlett Learning Burlington USA. 2nd edition, 2013.

7. Pelczar Jr MJ, Chan ECS, and Krieg NR., Microbiology. Tata McGraw Hill. 5th edition, 2004.

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

9. Willey JM, Sherwood LM, and Woolverton CJ., Prescott's Microbiology. McGraw Hill Higher Education. 9th edition. 2013.

10. Dimmock, NJ, Easton, AL, Leppard, KN, Introduction to Modern Virology. Blackwell Publishing Ltd. 6th edition, 2007.

11. Cann AJ, Principles of Molecular Virology, Academic Press Oxford UK. 2012.

18PGECXX GE3: Microbial Metabolism (Theory) 2 0 0 2

Course Objectives: The candidates will understand the microbial growth, nutrient uptake and transport, chemoheterotrophic metabolism, anaerobic respiration and fermentation, chemolithotrophic and phototrophic metabolism.

UNIT I MICROBIAL GROWTH 6 Lecture Hours

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

UNIT II NUTRIENT UPTAKE AND TRANSPORT 6 Lecture Hours

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

UNIT III CHEMOHETEROTROPHIC METABOLISM 6 Lecture Hours

Concept of aerobic respiration, anaerobic respiration and fermentation. Sugar degradation pathways i.e. EMP, ED, Pentose phosphate pathway, TCA cycle

UNIT IV ANAEROBIC RESPIRATION AND FERMENTATION 6 Lecture Hours

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

UNIT V CHEMOLITHOTROPHIC AND PHOTOTROPHIC METABOLISM

6 Lecture Hours

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 and Cyanobacteria.

Introduction to biological nitrogen fixation - Ammonia assimilation; Assimilatory nitrate reduction.

Total: 30 Lecture Hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Gain knowledge about the microbial growth and nutritional categories of microorganisms.

CO2: Understand various nutritional uptake and transport mechanism.

CO3: Learn about the chemo heterotrophic metabolism and types of respiration and fermentation.

CO4: Learn anaerobic respiration and types of fermentation

CO5: Understand chemolithotrophic and phototrophic metabolisms

TEXTBOOK:

Ananthnarayanan. R & C. K. Jeyaram Panicker; TEXTBOOKS of Microbiology, Orient Longman. 2010.

REFERENCE BOOKS:

1. Madigan MT, and Martinko JM, Brock Biology of Microorganisms. Prentice Hall International Inc.14th edition. 2014.
2. Moat AG and Foster JW., Microbial Physiology. John Wiley & Sons. 4th edition.2002.
3. Reddy SR and Reddy SM., Microbial Physiology. Scientific Publishers India. 2005.
4. Gottschalk G., Bacterial Metabolism. Springer Verlag. 2nd edition. 1986.

5. Stanier RY, Ingrahm JI, Wheelis ML and Painter PR., General Microbiology. McMillan Press. 5th edition, 1987.

6. Willey JM, Sherwood LM, and Woolverton CJ., Prescott's Microbiology. McGraw Hill Higher Education. 9th edition. 2013.

18PGECXX GE4: Industrial and Food Microbiology (Theory) 2 0 0 2

Course Objectives: The candidates will understand the development of food microbiology, microbial fermentation processes, food preservation and food-borne diseases.

UNIT I INTRODUCTION 6 Lecture Hours

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.

UNIT II MICROBIAL FERMENTATION PROCESSES 6 Lecture Hours

Ingredients used in fermentation medium - molasses, corn steep liquor, whey & Yeast extract. Downstream processing - filtration, centrifugation, cell disruption, solvent extraction. Microbial production of industrial products - citric acid, ethanol and penicillin. Industrial production and uses of the enzymes - amylases, proteases, lipases and cellulases

UNIT III FOOD AS A SUBSTRATE FOR MICROBIAL GROWTH 6 Lecture Hours

Intrinsic and extrinsic parameters that affect microbial growth in food. Microbial spoilage of food – seafoods, fruits and vegetables, milk, egg, bread and canned foods

UNIT IV PRINCIPLES AND METHODS OF FOOD PRESERVATION 6 Lecture Hours

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

UNIT V DAIRY PRODUCTS, PROBIOTICS AND FOOD-BORNE DISEASES

6 Lecture Hours

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

Total: 30 Lecture Hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Realize the importance of microbes in the production of many useful products

CO2: Understand fermenters and fermentation processes.

CO3: Gain knowledge in downstream processing and industrial production of various products.

CO4: Understand the relationship between foods and microbes and its impact on human health

CO5: Assimilate information on Microbial production of foods and food sanitation

TEXTBOOK:

Frazier WC and Westhoff DC., Food Microbiology. Tata McGraw-Hill Publishing Company Ltd, New Delhi, India. 3rd edition. 1992.

REFERENCE BOOKS:

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

9. Jay JM, Loessner MJ and Golden DA., Modern Food Microbiology. CBS Publishers and Distributors, Delhi, India. 7th edition, 2005.

18PGECXX GE5: Microbes in Environment (Theory) 2 0 0 2

Course Objectives: The candidates will understand the microorganisms and their habitats, microbial interactions, biogeochemical cycling and waste management.

UNIT I MICROORGANISMS AND THEIR HABITATS 6 Lecture Hours

Structure and function of ecosystems. Terrestrial Environment: Soil profile and soil microflora. Aquatic Environment: Microflora of fresh water and marine habitats. Atmosphere: Aeromicroflora and dispersal of microbes.

UNIT II MICROBIAL INTERACTIONS 6 Lecture Hours

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

UNIT III BIOGEOCHEMICAL CYCLING 6 Lecture Hours

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.

UNIT IV WASTE MANAGEMENT 6 Lecture Hours

Solid Waste management: Sources and types of solid waste, Methods of solid waste disposal (composting and sanitary landfill). Liquid waste management: Composition and strength of sewage (BOD and COD).

UNIT V MICROBIAL BIOREMEDIATION 6 Lecture Hours

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

Total: 30 Lecture Hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Learn about the structure and functions of ecosystem and role of microbes in the environment.

CO2: Obtain knowledge about microbial interactions – symbiosis, antagonism, synergism, commensalism, amensalism, parasitism, and predation.

CO3: Gain knowledge in the importance of biogeochemical cycling in the ecosystems.

CO4: Obtain knowledge on microbiological aspects and management of waste water.

CO5: Learn about the microbial bioremediation of pesticides, hydrocarbons, oil spills.

TEXTBOOK:

Pradipta.K.M., TEXTBOOK of Environmental Microbiology; I.K.Publishing House; 2008.

REFERENCE BOOKS:

1. Atlas RM and Bartha R. Microbial Ecology: Fundamentals & Applications. Benjamin/Cummings Science Publishing, USA. 4th edition. 2000.
2. Madigan MT, Martinko JM and Parker J. Brock Biology of Microorganisms. Pearson/ Benjamin Cummings. 14th edition. 2014.
3. Maier RM, Pepper IL and Gerba CP., Environmental Microbiology. Academic Press. 2nd edition, 2009.
4. Okafor, N, Environmental Microbiology of Aquatic & Waste systems. Springer, New York. 2011.
5. Singh A, Kuhad, RC & Ward OP, Advances in Applied Bioremediation. Volume 17, Springer-Verlag, Berlin Hedeilberg. 2009.
6. Barton LL & Northup DE, Microbial Ecology. Wiley Blackwell, USA2011.

18PGECXX GE6: Medical Microbiology and Immunology (Theory) 2 0 0 2

Course Objectives: The candidates will understand the concepts of normal flora organisms microbial diseases, antimicrobial agents and immune cells, and immune response and immunological disorders.

UNIT I NORMAL MICROFLORA AND SAMPLE COLLECTION 6 Lecture Hours

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.

UNIT II MICROBIAL DISEASES 6 Lecture Hours

List of diseases of various organ systems and their causative agents. List of diseases of various organ systems and their causative agents.List of diseases of various organ systems and their causative agents. Brief description of various types of mycoses.

UNIT III ANTIMICROBIAL AGENTS AND IMMUNE CELLS 6 Lecture Hours

Antibacterial agents: Five modes of action with one example each: Inhibitor of nucleic acid synthesis; Inhibitor of cell wall synthesis; Inhibitor of cell membrane function; Inhibitor of protein synthesis; Inhibitor of metabolism Antifungal agents: Structure, Functions and Properties of: Immune Cells – Stem cell, T cell, B cell, NK cell, Macrophage, Neutrophil, Eosinophil, Basophil, Mast cell, Dendritic cell.

UNIT IV IMMUNE ORGANS, ANTIGENS AND ANTIBODIES 6 Lecture Hours

Immune Organs – Bone; Marrow, Thymus, Lymph Node, Spleen. Characteristics of an antigen (Foreignness, Molecular size and Heterogeneity); Haptens; Epitopes (T& B cell epitopes), Adjuvants, Structure, Types and Functions of antibodies.

UNIT V IMMUNE RESPONSE AND IMMUNOLOGICAL DISORDERS 6 Lecture Hours

Primary and Secondary Immune Response; Generation of Humoral Immune Response (Plasma and Memory cells); Generation of Cell Mediated Immune Response. Types of Autoimmunity

and Hypersensitivity with examples; Immunodeficiencies - Animal models (Nude and SCID mice). Principles of Precipitation, Agglutination, Immunodiffusion, Immunoelectrophoresis, ELISA, ELISPOT.

Total: 30 Lecture Hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Realize the importance of normal microbial flora in human health and host pathogen interactions.

CO2: Assimilate knowledge on microbial diseases affecting various organ systems.

CO3: Understand the mechanisms of mode of action of different class of antibiotics.

CO4: Realize the role of immune cells in developing immunity against microbial diseases and Assimilate information on significant role of immune organs

CO5: Comprehend importance of immunological disorders.

TEXTBOOK:

Ananthanarayan R. and Paniker C.K.J. Textbooks of Microbiology. University Press Publication. 8th edition, 2009.

REFERENCE BOOKS:

1. Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A., Jawetz, Melnick and Adelberg's Medical Microbiology. McGraw Hill Publication. 26th edition. 2013.
2. Goering R., Dockrell H., Zuckerman M. and Wakelin D., Mims' Medical Microbiology. Elsevier. 4th edition., 2007.

18PGECXX GE7: Genetic Engineering and Biotechnology (Theory) 2 0 0 2

Course Objectives: The candidates will understand the development genetic engineering, vectors, DNA amplification and DNA sequencing, application of genetic engineering and biotechnology.

UNIT I INTRODUCTION TO GENETIC ENGINEERING 6 Lecture Hours

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.

UNIT II VECTORS 6 Lecture Hours

Cloning Vectors: Definition and Properties - Plasmid vectors: pBR and pUC series, Bacteriophage lambda and M13 based vectors, Cosmids, BACs, YACs. Expression vectors: *E.coli* lac and T7 promoter-based vectors, yeast YIp, YEp and YCp vectors, Baculovirus based vectors, mammalian SV40-based expression vectors.

UNIT III DNA AMPLIFICATION AND DNA SEQUENCING 6 Lecture Hours

PCR: Basics of PCR, RT-PCR, Real-Time PCR, Genomic and cDNA libraries: Preparation and uses, Genome sequencing - Sanger's method of DNA Sequencing: traditional and automated sequencing

UNIT IV APPLICATION OF GENETIC ENGINEERING 8 Lecture Hours

Gene delivery: Microinjection, electroporation, biolistic method (gene gun), liposome and viral mediated delivery, *Agrobacterium* - mediated delivery. Products of recombinant DNA technology: Products of human therapeutic interest - insulin, hGH, antisense molecules. Bt transgenic - cotton, brinjal, flavo savo tomato, Gene therapy, recombinant vaccine, protein engineering

UNIT V INTELLECTUAL PROPERTY RIGHTS 4 Lecture Hours

Patents, Copyrights, Trademarks.

Total: 30hrs

Course Outcome

At the end of the course, learners will be able to:

CO1: Gain knowledge about genetic engineering and enzymology.

CO2 Study about the various types of cloning vectors used in genetic engineering.

CO3: Learn about the DNA amplification and sequencing methods.

CO4: Acquire knowledge in gene transfer methods and also the applications of biotechnology.

CO5: Achieve knowledge about the intellectual property rights, patent, copyrights and. Trademarks.

TEXTBOOK:

Primrose SB and Twyman RM. Genomics: Applications in human biology. Blackwell Publishing, Oxford, U.K. 2008.

REFERENCE BOOKS:

1. Brown TA., Gene Cloning and DNA AnalysisBlackwell Publishing, Oxford, U.K. 6th edition. 2010.
2. Clark DP and Pasternik NJ. Biotechnology: Applying the Genetic Revolution. Elsevier Academic Press, USA. 2009.
3. Primrose SB and Twyman RM., Principles of Gene Manipulation and Genomics, Blackwell Publishing, Oxford, U.K. 7th edition. 2006.
4. Brown TA., Genomes-3. Garland Science Publishers. 2007.

18PGECXX GE8: Microbial Genetics and Molecular Biology (Theory) 2 0 0 2

Course Objectives: The candidates will understand the structures of DNA and RNA, replication of DNA and transcription, translation, gene regulation, mutations and genetic exchange.

UNIT I STRUCTURES OF DNA AND RNA 6 Lecture Hours

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

UNIT II REPLICATION OF DNA AND TRANSCRIPTION 6 Lecture Hours

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. Transcription: Definition, promoter - concept and strength of promoter.

UNIT III TRANSLATION AND GENE REGULATION 6 Lecture Hours

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

UNIT IV MUTATIONS AND GENETIC EXCHANGE 6 Lecture Hours

Mutations and mutagenesis: Definition and types of Mutations; Physical and chemical mutagens; Uses of mutations, DNA repair mechanisms. Transformation - Discovery, mechanism of natural competence. Conjugation - Discovery, mechanism, hfr and F’ strains. Transduction - Generalized transduction, specialized transduction.

UNIT V PLASMIDS AND TRANSPOSABLE ELEMENTS 6 Lecture Hours

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.

Total: 30 Lecture Hours

Course Outcome

At the end of the course, learners will be able to:

CO1: Attain knowledge about the structure of Nucleic acid.

CO2: Know about the mechanisms DNA replication, transcription and translation processes in organisms.

CO3: Gain knowledge in the mechanisms of gene expression and its regulations in organisms.

CO4: Achieve knowledge about the mutations and DNA repair mechanisms in organisms.

CO5: Realize knowledge about the transposable elements, types of plasmids and its applications.

TEXTBOOK:

Russell PJ. Genetics- A Molecular Approach. Benjamin Cummings.3rd Ed, 2009.

REFERENCE BOOKS:

1. Watson JD, Baker TA, Bell SP, Gann A, Levine M and Losick R, Molecular Biology of the Gene, Cold Spring Harbour Lab. Press, Pearson Publication. 6th edition, 2008.
2. Becker WM, Kleinsmith LJ, Hardin J and Bertoni GP, The World of the Cell, Pearson Benjamin Cummings Publishing, San Francisco. 7th edition, 2009.
3. De Robertis EDP and De Robertis EMFCell and Molecular Biology, Lippincott Williams and Wilkins, Philadelphia. 8th edition, 2006.
4. Karp G, Cell and Molecular Biology: Concepts and Experiments, John Wiley & Sons. Inc. 6th edition, 2010.
5. Krebs J, Goldstein E, Kilpatrick S (2013). Lewin's Essential Genes, Jones and Bartlett Learning
6. Gardner EJ, Simmons MJ, Snustad DP, Principles of Genetics. 8th Ed. Wiley-India. 3rd Ed., 2008.
7. Klug WS, Cummings MR, Spencer, C, Palladino, M, Concepts of Genetics, Benjamin Cummings. 10th Ed., 2011.

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 ares 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 forms 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, HE