ROYAL GLOBAL UNIVERSITY
GUWAHATI

ROYAL SCHOOL OF BIO SCIENCES

(RSBSC)

DEPARTMENT OF MICROBIOLOGY

Course Structure and Syllabus

Based on National Education Policy -2020

FOR

B.Sc. Microbiology

4 Year Single Major

W.E.F. 2025-26

W.E.F. 2025-26

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Preamble

The National Education Policy (NEP) 2020 conceives a new vision for India's higher education system. It recognizes that higher education plays an extremely important role in promoting equity, human as well as societal well-being and in developing India as envisioned in its Constitution. It is desired that higher education will significantly contribute towards sustainable livelihoods and economic development of the nation as India moves towards becoming a knowledge economy and society.

If we focus on the 21st century requirements, the higher education framework of the nation must aim to develop good, thoughtful, well-rounded, and creative individuals and must enable

an individual to study one or more specialized areas of interest at a deep level, and also develop character, ethical and Constitutional values, intellectual curiosity, scientific temper, creativity, spirit of service, and twenty-first- century capabilities across a range of disciplines including sciences, social sciences, arts, humanities, languages, as well as professional, technical, and vocational subjects. A quality higher education should be capable enough to enable personal accomplishment and enlightenment, constructive public engagement, and productive contribution to the society. Overall, it should focus on preparing students for more meaningful and satisfying lives and work roles and enable economic independence. Towards the attainment of holistic and multidisciplinary education, the flexible curricula of the University will include credit-based courses, projects in the areas of community engagement and service, environmental education, and value-based education. As part of holistic education, students will also be provided with opportunities for internships with local industries, businesses, artists, crafts persons, and so on, as well as research internships with faculty and researchers at the University, so that students may actively engage with the practical aspects of their learning and thereby improve their employability.

The undergraduate curriculums are diverse and have varied subjects to be covered to meet the needs of the programs. As per the recommendations from the UGC, introduction of courses related to Indian Knowledge System (IKS) is being incorporated in the curriculum structure which encompasses all of the systematized disciplines of Knowledge which were developed to a high degree of sophistication in India from ancient times and all of the traditions and practises that the various communities of India—including the tribal communities—have evolved, refined and preserved over generations, like for example Vedic Mathematics, Vedangas, Indian Astronomy, Fine Arts, Metallurgy, etc

The NEP highlights that the following fundamental principles that have a direct bearing on the curricula would guide the education system at large, viz.

i. Recognizing, identifying, and fostering the unique capabilities of each student to promote her/his holistic development.

ii. Flexibility, so that learners can select their learning trajectories and programmes, and thereby choose their own paths in life according to their talents and interests.

iii. Multidisciplinary and holistic education across the sciences, social sciences, arts, humanities, and sports for a multidisciplinary world.

iv. Emphasis on conceptual understanding rather than rote learning, critical thinking to encourage logical decision-making and innovation; ethics and human & constitutional values, and life skills such as communication, teamwork, leadership, and resilience.

v. Extensive use of technology in teaching and learning, removing language barriers, increasing access for Divyang students, and educational planning and management.

vi. Respect for diversity and respect for the local context in all curricula, pedagogy, and policy.

vii. Equity and inclusion as the cornerstone of all educational decisions to ensure that all students can thrive in the education system and the institutional environment are responsive to differences to ensure that high-quality education is available for all.

viii. Rootedness and pride in India, and its rich, diverse, ancient, and modern culture, languages, knowledge systems, and traditions

Abbreviations

1. Major - Core Courses of a Discipline
2. Minor - May/may not be related to Major.
3. SEC - Skill Enhancement Course
4. VAC - Value Addition Course
5. AEC - Ability Enhancement Course
6. GEC - Generic Elective Course
7. IKS - Indian Knowledge System
8. AICTE - All India Institute of Technical Education
9. CBCS - Choice Based Credit System
10. HEIs - Higher Education Institutes
11. MSDE - Ministry of Skill Development and Entrepreneurship
12. NAC - National Apprenticeship Certificate
13. NCrF - National Credit Framework
14. NCVET - National Council for Vocational Education and Training
15. NEP - National Education Policy
16. NHEQF - National Higher Education Qualification Framework
17. NSQF - National Skill Qualifications Framework
18. NTA - National Testing Agency
19. SDG - Sustainable Development Goals

20. UGC - University Grants Commission
21. VET - Vocational Education and Training
22. ME-ME - Multiple Entry Multiple Exit
23. OJT - On Job Training
24. NCH - Notional Credit Hours

Introduction

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

Choice Based Credit System (CBCS) By UGC Under the CBCS system, the requirement for awarding a degree or diploma or certificate is prescribed in terms of number of credits to be earned by the students. This framework is being implemented in several universities across States in India. The main highlights of CBCS are as below

• The CBCS provides flexibility in designing curriculum and assigning credits based on the course content and learning hours.

• The CBCS provides for a system wherein students can take courses of their choice, learn at their own pace, undergo additional courses and acquire more than the required credits, and adopt an interdisciplinary approach to learning.

Definitions

Academic Credit: An academic credit is a unit by which a course is weighted. It is fixed by the number of hours of instructions offered per week. As per the National Credit Framework, 1

Credit = 30 NOTIONAL CREDIT HOURS (NCH) Yearly Learning Hours = 1200 Notional Hours (@40 Credits x 30 NCH)

1 Credit = 30 NOTIONAL CREDIT HOURS (NCH) Yearly Learning Hours = 1200 Notional Hours (@40 Credits x 30 NCH)

30 Notional Credit Hours		
Lecture/Tutorial	**Practicum**	**Experiential Learning**
1 Credit = 15 -22 Lecture Hours	**10-15 Practicum Hours**	**0-8 Experiential Learning Hour**

Course of Study: Course of study indicate pursuance of study in a particular discipline/programme. Discipline/Programmes shall offer Major Courses (Core), Minor Courses, Skill Enhancement Courses (SEC), Value Added Courses (VAC), Ability Enhancement Compulsory Courses (AECCs) and Interdisciplinary courses.

Disciplinary Major: The major would provide the opportunity for a student to pursue in-depth study of a particular subject or discipline. Students may be allowed to change major within the broad discipline at the end of the second semester by giving her/him sufficient time to explore interdisciplinary courses during the first year. Advanced-level disciplinary/interdisciplinary courses, a course in research methodology, and a project/dissertation will be conducted in the seventh semester. The final semester will be devoted to seminar presentation, preparation, and submission of project report/dissertation. The project work/dissertation will be on a topic in the disciplinary programme of study or an interdisciplinary topic.

Disciplinary/interdisciplinary minors: Students will have the option to choose courses from disciplinary/interdisciplinary minors and skill-based courses. Students who take a sufficient number of courses in a discipline or an interdisciplinary area of study other than the chosen major will qualify for a minor in that discipline or in the chosen interdisciplinary area of study. A student may declare the choice of the minor at the end of the second semester, after exploring various courses.

Courses from Other Disciplines (Interdisciplinary): All UG students are required to undergo 3 introductory-level courses relating to any of the broad disciplines given below.

These courses are intended to broaden the intellectual experience and form part of liberal arts and science education. Students are not allowed to choose or repeat courses already undergone at the higher secondary level (12th class) in the

proposed major and minor stream under this category. i. Natural and Physical Sciences: Students can choose basic courses from disciplines such as Natural Science, for example, Biology, Botany, Zoology, Biotechnology, Biochemistry, Chemistry, Physics, Biophysics, Astronomy and Astrophysics, Earth and Environmental Sciences, etc. ii. Mathematics, Statistics, and Computer Applications: Courses under this category will facilitate the students to use and apply tools and techniques in their major and minor disciplines. The course may include training in programming software like Python among others and applications software like STATA, SPSS, Tally, etc. Basic courses under this category will be helpful for science and social science in data analysis and the application of quantitative tools. iii. Library, Information, and Media Sciences: Courses from this category will help the students to understand the recent developments in information and media science (journalism, mass media, and communication) iv. Commerce and Management: Courses include business management, accountancy, finance, financial institutions, fintech, etc., v. Humanities and Social Sciences: The courses relating to Social Sciences, for example, Anthropology, Communication and Media, Economics, History, Linguistics, Political Science, Psychology, Social Work, Sociology, etc. will enable students to understand the individuals and their social behaviour, society, and nation. Students be introduced to survey methodology and available large- scale databases for India. The courses under humanities include, for example, Archaeology, History, Comparative Literature, Arts & Creative expressions, Creative Writing and Literature, language(s), Philosophy, etc., and interdisciplinary courses relating to humanities. The list of Courses can include interdisciplinary subjects such as Cognitive Science, Environmental Science, Gender Studies, Global Environment & Health, International Relations, Political Economy and Development, Sustainable Development, Women's, and Gender Studies, etc. will be useful to understand society.

Ability Enhancement Courses (AEC): Modern Indian Language (MIL) & English language focused on language and communication skills. Students are required to achieve competency in a Modern Indian Language (MIL) and in the English language with special emphasis on language and communication skills. The courses aim at enabling the students to acquire and demonstrate the core linguistic skills, including critical reading and expository and academic writing skills, that help students articulate their arguments and present their thinking clearly

and coherently and recognize the importance of language as a mediator of knowledge and identity. They would also enable students to acquaint themselves with the cultural and intellectual heritage of the chosen MIL and English language, as well as to provide a reflective understanding of the structure and complexity of the language/literature related to both the MIL and English language. The courses will also emphasize the development and enhancement of skills such as communication, and the ability to participate/conduct discussion and debate.

Skill Enhancement Course (SEC): These courses are aimed at imparting practical skills, hands-on training, soft skills, etc., to enhance the employability of students and should be related to Major Discipline. They will aim at providing handson training, competencies, proficiency, and skill to students. SEC course will be a basket course to provide skill-based instruction. For example, SEC of English Discipline may include Public Speaking, Translation & Editing and Content writing. A student shall have the choice to choose from a list, a defined track of courses offered from 1st to 3rd semester.

Value-Added Courses (VAC): i. Understanding India: The course aims at enabling the students to acquire and demonstrate the knowledge and understanding of contemporary India with its historical perspective, the basic framework of the goals and policies of national development, and the constitutional obligations with special emphasis on constitutional values and fundamental rights and duties. The course would also focus on developing an understanding among student-teachers of the Indian knowledge systems, the Indian education system, and the roles and obligations of teachers to the nation in general and to the school/community/society. The course will attempt to deepen knowledge about and understanding of India's freedom struggle and of the values and ideals that it represented to develop an appreciation of the contributions made by people of all sections and regions of the country, and help learners understand and cherish the values enshrined in the Indian Constitution and to prepare them for their roles and responsibilities as effective citizens of a democratic society. ii. Environmental science/education: The course seeks to equip students with the ability to apply the acquired knowledge, skills, attitudes, and values required to take appropriate actions for mitigating the effects of environmental degradation, climate change, and pollution, effective waste management, conservation of biological diversity, management of biological resources, forest and wildlife conservation, and sustainable development and living. The course will also deepen the knowledge and understanding of India's environment in its totality, its interactive processes, and its effects on the future quality of people's lives.
iii. Digital and technological solutions: Courses in cutting-edge areas that are fast gaining prominences, such as Artificial Intelligence (AI), 3-D machining, big data analysis, machine learning, drone technologies, and Deep learning with important applications to health, environment, and sustainable living that will be woven into undergraduate education for enhancing the employability of the youth. iv. Health & Wellness, Yoga education, sports, and fitness: Course components relating to health and wellness seek to promote an optimal state of physical, emotional, intellectual, social, spiritual, and environmental well- being of a

person. Sports and fitness activities will be organized outside the regular institutional working hours. Yoga education would focus on preparing the students physically and mentally for the integration of their physical, mental, and spiritual faculties, and equipping them with basic knowledge about one's personality, maintaining self-discipline and self-control, to learn to handle oneself well in all life situations. The focus of sports and fitness components of the courses will be on the improvement of physical fitness including the improvement of various components of physical and skills-related fitness like strength, speed, coordination, endurance, and flexibility; acquisition of sports skills including motor skills as well as basic movement skills relevant to a particular sport; improvement of tactical abilities; and improvement of mental abilities. These are a common pool of courses offered by different disciplines and aimed towards embedding ethical, cultural and constitutional values; promote critical thinking. Indian knowledge systems; scientific temperament of students.

Summer Internship /Apprenticeship: The intention is induction into actual work situations. All students must undergo internships / Apprenticeships in a firm, industry, or organization or Training in labs with faculty and researchers in their own or other HEIs/research institutions during the summer term. Students should take up opportunities for internships with local industry, business organizations, health and allied areas, local governments (such as panchayats, municipalities), Parliament or elected representatives, media organizations, artists, crafts persons, and a wide variety of organizations so that students may actively engage with the practical side of their learning and, as a by-product, further improve their employability. Students who wish to exit after the first two semesters will undergo a 4-credit work-based learning/internship during the summer term to get a UG Certificate

Indian Knowledge System: In view of the importance accorded in the NEP 2020 to rooting our curricula and pedagogy in the Indian context all the students who are enrolled in the four-year UG programmes should be encouraged to take an adequate number of courses in IKS so that the total credits of the courses taken in IKS amount to at least five per cent of the total mandated credits (i.e. min. 8 credits for a 4 yr. UGP & 6 credits for a 3 yr. UGP). The students may be encouraged to take these courses, preferably during the first four semesters of the UG programme. At least half of these mandated credits should be in courses in disciplines which are part of IKS and are related to the major field of specialization that the student is pursuing in the UG programme. They will be included as a part of the total mandated credits that the student is expected to take in the major field of specialization. The rest of the mandated credits in IKS can be included as a part of the mandated Multidisciplinary courses that are to be taken

by every student. All the students should take a Foundational Course in Indian Knowledge System, which is designed to present an overall introduction to all the streams of IKS relevant to the UG programme. The foundational IKS course should be broad-based and cover introductory material on all aspects. Wherever possible, the students may be encouraged to choose a suitable topic related to IKS for their project work in the 7/8th semesters of the UG programme. "Guidelines for Incorporating Indian Knowledge in Higher Education Curricula", University Grants Commission, March 2023 for further details) 1.3.11. Experiential Learning: One of the most unique, practical & beneficial features of the National Credit Framework is assignment of credits/credit points/ weightage to the experiential learning including relevant experience and professional levels acquired/ proficiency/ professional levels of a learner/student. Experiential learning is of two types: a. Experiential learning as part of the curricular structure of academic or vocational program. E.g., projects/OJT/internship/industrial attachments etc. This could be either within the Program-internship/ summer project undertaken relevant to the program being studied or as a part time employment (not relevant to the program being studied- up to certain NSQF level only). In case where experiential learning is a part of the curricular structure the credits would be calculated and assigned as per basic principles of NCrF i.e., 40 credits for 1200 hours of notional learning.

b. Experiential learning as active employment (both wage and self) post completion of an academic or vocational program. This means that the experience attained by a person after undergoing a particular educational program shall be considered for assignment of credits. This could be either Full or Part time employment after undertaking an academic/ Vocation program. In case where experiential learning is as a part of employment the learner would earn credits as weightage. The maximum credit points earned in this case shall be double of the credit points earned with respect to the qualification/ course completed. The credit earned and assigned by virtue of relevant experience would enable learners to progress in their career through the work hours put in during a job/employment

Nature and extent of the B.Sc. Programme in microbiology

The structure and duration of undergraduate programmes of study offered by the University as per NEP 2020 include: 2.1. Undergraduate programmes of 4-year duration with Single Major, with multiple entry and exit options, with appropriate certifications:

UG Certificate:

Students who opt to exit after completion of the first year and have secured 40 credits will be

awarded a UG certificate if, in addition, they complete one vocational course of 4 credits during the summer vacation of the first year. These students are allowed to re-enter the degree programme within three years and complete the degree programme within the stipulated maximum period of seven years.

UG Diploma:

Students who opt to exit after completion of the second year and have secured 80 credits will be awarded the UG diploma if, in addition, they complete one vocational course of 4 credits during the summer vacation of the second year. These students are allowed to re-enter within a period of three years and complete the degree programme within the maximum period of seven years.

3-year UG Degree:

Students who will undergo a 3-year UG programme will be awarded UG Degree in the Major discipline after successful completion of three years, securing 120 credits and satisfying the minimum credit requirement.

4-year UG Degree (Honours): A four-year UG Honours degree in the major discipline will be awarded to those who complete a four- year degree programme with 160 credits and have satisfied the credit requirements as given in Table 6 in Section 5.

4-year UG Degree (Honours with Research): Students who secure 75% marks and above in the first six semesters and wish to undertake research at the undergraduate level can choose a research stream in the fourth year. They should do a research project or dissertation under the guidance of a Faculty Member of the University. The research project/dissertation will be in the major discipline. The students who secure 160 credits, including 12 credits from a research project/dissertation, will be awarded UG Degree (Honours with Research)

(Note: UG Degree Programmes with Single Major: A student must secure a minimum of 50% credits from the major discipline for the 3-year/4-year UG degree to be awarded a single major. For example, in a 3- year UG programme, if the total number of credits to be earned is 120, a student of Mathematics with a minimum of 60 credits will be awarded a B.Sc. in Mathematics with a single major. Similarly, in a 4-year UG programme, if the total number of credits to be earned is 160, a student of Chemistry with a minimum of 80 credits will be awarded a B.Sc. (Hons./Hon. With Research) in Chemistry in a 4-year UG programme with single major. Also the 4-year Bachelor's degree programme with Single Major is considered as the preferred option since it would allow the opportunity to experience the full range of holistic and multidisciplinary education in addition to a focus on the chosen major and minors as per the choices of the student.)

SI No.	Type	Year	Credits	Additional Credits	Re-entry allowed within (years)	Completion on tenure (years)
1	UG Certificate	**1**	**40**	**4**	**3**	**7**
2	UG Diploma	**2**	**80**	**4**	**3**	**7**
3	3 year UG Degree (major)	**3**	**120**			
4	4 year UG Degree (honours)	**4**	**160**			
5	4 year UG Degree (honours with research)	**4**	**160**	**Students who secure 75 % marks & above in the first 6 semesters**		

Credit, Credit Points & Credit hours for different types of courses

'Credit' is recognition that a learner has completed a prior course of learning, corresponding to a qualification at a given level. For each such prior qualification, the student would have put in a certain volume of institutional or workplace learning, and the more complex a qualification, the greater the volume of learning that would have gone into it. Credits quantify learning outcomes that are subject achieving the prescribed learning outcomes to valid, reliable methods of assessment. The credit points will give the learners, employers, and institutions a mechanism for describing and comparing the learning outcomes achieved. The credit points can be calculated as credits attained multiplied with the credit level. The workload relating to a course is measured in terms of credit hours. A credit is a unit by which the coursework is measured. It determines the number of hours of instruction required per week over the duration of a semester (minimum 15 weeks). Each course may have only a lecture component or a lecture and tutorial component or a lecture and practicum component or a lecture, tutorial, and practicum component, or only practicum component. Refer to the Section 1.3.1 A course can have a combination of lecture credits, tutorial credits, practicum credits and experiential learning credits. The following types of courses/activities constitute the programmes of study. Each of them will require a specific number of hours of teaching/guidance and laboratory/studio/workshop activities, field-based learning/projects, internships, and community engagement and service.

• **Lecture courses:** Courses involving lectures relating to a field or discipline by an expert or qualified personnel in a field of learning, work/vocation, or professional practice.

• **Tutorial courses:** Courses involving problem-solving and discussions relating to a field or discipline under the guidance of qualified personnel in a field of learning, work/vocation, or professional practice. Should also refer to the Remedial Classes, flip classrooms and focus on both Slow and Fast Learners of the class according to their merit

Practicum or Laboratory work: A course requiring students to participate in a project or practical or lab activity that applies previously learned/studied principles/theory related to the chosen field of learning, work/vocation, or professional practice under the supervision of an expert or qualified individual in the field of learning, work/vocation or professional practice.

• **Seminar:** A course requiring students to participate in structured discussion/conversation or debate focused on assigned tasks/readings, current or historical events, or shared experiences guided or led by an expert or qualified personnel in a field of learning, work/vocation, or professional practice. • **Internship:** A course requiring students to participate in a professional activity or work experience, or cooperative education activity with an entity external to the education institution, normally under the supervision of an expert of the given external entity. A key aspect of the internship is induction into actual work situations. Internships involve working with local industry, government or private organizations, business organizations, artists, crafts persons, and similar entities to provide opportunities for students to actively engage in on-site experiential learning. •

Studio activities: Studio activities involve the engagement of students in creative or artistic activities. Every student is engaged in performing a creative activity to obtain a specific outcome. Studio-based activities involve visual- or aesthetic-focused experiential work.

• **Field practice/projects:** Courses requiring students to participate in field-based learning/projects generally under the supervision of an expert of the given external entity.

• **Community engagement and service:** Courses requiring students to participate in field-based learning/projects generally under the supervision of an expert of the given external entity. The curricular component of 'community engagement and service' will involve activities that would expose students to the socio-economic issues in society so that the theoretical learnings can be supplemented by actual life experiences to generate solutions to real-life problems.

Table-1: Course wise Distribution of Credits

Broad Category ofCourse	**Minimum Credit Requirement**	
	3-year UG	**4-Year UG**
Major (Core)	60	80
Minor Stream	24	32
Interdisciplinary	9	9

Ability Enhancement Courses (AEC)	8	8
Skill Enhancement Courses (SEC)	9	9
Value Added Coursescommon for all UG	6	6
*MOOCs/SWAYAM	12	12
Summer Internship	4	4
Research Project /Dissertation	NA	12
Total	**132**	**172**

Table 2: Credit Distribution for 3-year Course

Semester	**Course Credits**							
	Major	**Minor**	**ID**	**AEC**	**SEC**	**VAC**	**SI**	**Total**
I	6	3	3	2	3	3	0	**23**
II	6	3	3	2	3	3	0	**23**
III	8	4	3	2	3	0	0	**23**
IV	12	6	0	2	0	0	0	**23**
V	12	4	0	0	0	0	4	**20**
VI	16	4	0	0	0	0	0	**20**
	60	**24**	**9**	**8**	**9**	**6**	**4**	**132**

Table 3: Credit Distribution for 4-year Course

Semester	**Course Credits**	**Total**

	Major	Minor	ID	AEC	SEC	VAC	SI	RP	
I	6	3	3	2	3	3	0	0	**23**
II	6	3	3	2	3	3	0	0	**23**
III	8	4	3	2	3	0	0	0	**23**
IV	12	6	0	2	0	0	0	0	**23**
V	12	4	0	0	0	0	4	0	**20**
VI	16	4	0	0	0	0	0	0	**20**
VII	16	4	0	0	0	0	0	0	**20**
VIII	4	4	0	0	0	0	0	12	**20**
	80	**32**	**9**	**8**	**9**	**6**	**4**	**12**	**172**

NHEQF levels

The NHEQF levels represent a series of sequential stages expressed in terms of a range of learning outcomes against which typical qualifications are positioned/located. NHEQF level 4.5 represents learning outcomes appropriate to the first year (first two semesters) of the undergraduate programme of study, while Level 6 represents learning outcomes appropriate to Bachelor's Degree (Honours/ Honours with Research). Programme duration: Four years (eight semesters).

NHEQF level	Examples of higher education qualifications located within each level	Credit Requirements
Level 4.5	Undergraduate Certificate. Programme duration: First year (first two semesters) of the undergraduate programme, followed by an exit 4-credit skills-enhancement course(s).	40
Level 5	Undergraduate Diploma. Programme duration: First two years (first four semesters) of the undergraduate programme, followed by an exit 4-credit skills-enhancement course(s) lasting two months	80
Level 5.5	Bachelor's Degree. Programme duration: First three years (Six semesters) of the four-year undergraduate programme.	120
Level 6	Bachelor's Degree (Honours/ Honours with Research). Programme duration: Four years (eight semesters).	160

Graduate Attributes in Microbiology

The Learning Outcomes Descriptors and Graduate Attributes

Sl.no.	Graduate Attribute	The Learning Outcomes Descriptors *(The graduates should be able to demonstratethe capability to:)*
GA1	Disciplinary Knowledge	acquire knowledge and coherent understanding of the chosen disciplinary/interdisciplinary areasof study.
GA 2	Complex problem solving	solve different kinds of problems in familiar and non-familiar contexts and apply the learning to real-life situations.
GA 3	Analytical & Critical thinking	apply analytical thought including the analysis and evaluation of policies, and practices. Able to identify relevant assumptions or implications. Identify logical flaws and holes in the argumentsof others. Analyse and synthesize data from a variety of sources and draw valid conclusions and support them with evidence and examples.
GA 4	Creativity	create, perform, or think in different and diverse ways about the same objects or scenarios and deal with problems and situations that do not have simple solutions. Think ‘out of the box’ and generate solutions to complex problems in unfamiliar contexts by adopting innovative, imaginative, lateral thinking, interpersonal skills,and emotional intelligence.
GA 5	Communication Skills	listen carefully, read texts and research papers analytically, and present complex information in a clear and concise manner to different groups/audiences. Express thoughts and ideas effectively in writing and orally and communicate with others using appropriate media.

GA 6	Research-related skills	develop a keen sense of observation, inquiry, and capability for asking relevant/ appropriate questions. Should acquire the ability to problematize, synthesize and articulate issues and design research proposals, define problems, formulate appropriate and relevant research questions, formulate hypotheses, test hypotheses using quantitative and qualitative data, establish hypotheses, make inferences based on the analysis and interpretation of data, and predict cause-and-effect relationships. Should develop the ability to acquire the understanding of basic research ethics and skills in practicing/doing ethics in the field/ in personal research work.
GA 7	Collaboration	work effectively and respectfully with diverse teams in the interests of a common cause and work efficiently as a member of a team.
GA 8	Leadership readiness/qualities	plan the tasks of a team or an organization and setting direction by formulating an inspiring vision and building a team that can help achieve the vision.
GA 9	Digital and technological skills	use ICT in a variety of learning and work situations. Access, evaluate, and use a variety ofrelevant information sources and use appropriate software for analysis of data.
GA10	Environmental awareness andaction	mitigate the effects of environmental degradation, climate change, and pollution. Should develop the technique of effective waste management, conservation of biological diversity,management of biological resources and biodiversity, forest and wildlife conservation, and sustainable development and living

Programme Learning Outcomes (PLO)

Sl.no.	**Programme Learning Outcomes**
PLO1	The student will acquire knowledge and a coherent understanding about the Microbiology.
PLO 2	Development of different kinds of complex problem-solving skills related to microbiology.

PLO3	Critical thinking and microbiological data Analyse collected from the variety of sources and draw valid conclusions.

PLO4	Innovative thinking and generating a solution to overcome complex Problems in the area of microbiology.
PLO 5	Express thoughts and ideas effectively in writing and orally and also ability to communicate with the scientific community.
PL06	Develop a keen sense of observation, inquiry, andcapability for asking relevant/ appropriate questions as well as designing research proposals related to microbiological research
PLO7	Development of effective ways of working and learning to work in a team.
PLO 8	Implementation of the Plan and setting direction by formulating an inspiring vision and building a team that can help achievethe vision.
PLO 9	Use of ICT(Information and communicating technology) in a variety of learning and complex microbial work situations. and use a variety of relevant information sources and appropriate software.
PL010	Understanding of environmental issues, climate change, pollution, and development of the microbiological technique for effective waste management, conservation of biological diversity,management of biological resources, biodiversity and sustainable development

The Qualification

Specifications : NHEQF

Qualification specifications

Qualification type	Purpose of the qualification
Undergraduate Certificate	The students will be able to apply technical and theoretical concepts and specialized knowledge and skills in a broad rangeof contexts to undertake skilled or paraprofessional work and/or to pursue further study/learning at higher levels.
Undergraduate Diploma	The students will be able to apply specialized knowledge in a range of contexts to undertake advanced skilled or paraprofessional work and/or to pursue further learning/studyat higher levels.
Bachelor's degree	The students will be able to apply a broad and coherent body of knowledge and skills in a range of contexts to undertakeprofessional work and/or for further learning.

Bachelor's degree (Honours/ Honours with Research)	The students will be able to apply the knowledge in a specific context to undertake professional work and for research and further learning.
	The students will be able to apply an advanced body of knowledgein a range of contexts to undertake professional work and apply specialized knowledge and skills for research and scholarship, and/or for further learning relating to the chosen field(s) of learning, work/vocation, or professional practice.

STRUCTURE OF THE SYLLABUS FOR 4 YEAR UG PROGRAMME

SCHOOL NAME - **Royal School of Biosciences (RSBSC)**

DEPARTMENT NAME - **Department of Microbiology**

PROGRAMME NAME - **Undergraduate programme (UG)**

1st SEMESTER					
COMPONENT	**COURSE CODE**	**COURSE TITLE**	**LEVEL**	**CREDIT**	**L-T-P**
Major (Core)	MIB152M101	Fundamentals of Microbiology	100	3	3-0-0
Major (Core)	MIB152M111	Practical on Fundamental Microbiology	100	3	0-0-6
Minor	MIB152N101	Introduction and Scope of Microbiology	100	3	3-0-0
Interdisciplinary (IDC)	IKS992K101	Indian Knowledge System-1	100	3	3-0-0
Ability Enhancement course (AEC-1)	CEN982A101	Communicative English-1	100	1	1-0-0
AEC-2	BHS982A102	Behavioural Science-1	100	1	1-0-0
Skill Enhancement Course (SEC)	MIB152S111	Microbial Quality Control in Water and Food	100	3	3-0-0

Value Added Course (VAC)	VAC-1	VAC- (To choose from a pool ofcourses)	100	3	3-0-0
*MOOCs	MOOCs 1	*MOOCs/online course will be identified by the dept. from the list of courses available on the MOOC online platform/SWAYAM portal	100	3	
TOTAL CREDIT FOR 1st SEMESTER				**23**	**17-0-6**
2nd SEMESTER					
COMPONENT	**COURSE CODE**	**COURSE TITLE**	**LEVEL**	**CREDIT**	**L-T-P**
Major (Core)	MIB152M201	Bacteriology	100	3	3-0-0
Major (Core)	MIB152M211	Practical on Bacteriology	100	3	0-0-6
Minor	MIB152N201	Introductory Virology	100	3	3-0-0
IDC	IKS992K201	Indian Knowledge System-2	100	3	3-0-0
AEC-1	CEN982A201	Communicative English-2	100	1	1-0-0
AEC-2	BHS982A202	Behavioural Science-2	100	1	1-0-0
SEC	MIB152S211	Fermentation Technology and Application	100	3	0-0-3
VAC	VAC-2	VAC- (To choose from a pool ofcourses)	100	3	3-0-0
*MOOCs	MOOCs 1	*MOOCs/online course will be identified by the dept. from the list of courses available on the MOOC online platform/SWAYAM portal	100	3	
TOTAL CREDIT FOR 2nd SEMESTER				23	14-0-9
3rd SEMESTER					

COMPONENT	COURSE CODE	COURSE TITLE	LEVEL	CREDIT	L-T-P
Major (Core)	MIB152M301	Biochemistry	200	3	3-0-0
Major (Core)	MIB152M311	Practical on Biochemistry	200	1	0-0-2
Major (Core)	MIB152M302	Cell Biology	200	3	3-0-0
Major (Core)	MIB152C312	Practical on cell Biology	200	1	0-0-2
Minor	MIB152N301	Plant Pathology and plant-microbe interaction	200	4	4-0-0
IDC	MIB152K301	Indian Knowledge System-3	200	3	3-0-0
AEC-1	CEN982A301	Communicative English-3	200	1	1-0-0
AEC-2	BHS982A302	Behavioural Science-3	200	1	1-0-0
SEC	MIB152S311	Biofertilizer and Biopesticide	200	3	1-0-4
*MOOCs	MOOCs 1	*MOOCs/online course will be identified by the dept. from the list of courses available on the MOOC online platform/SWAYAM portal	100	3	
TOTAL CREDIT FOR 3rd SEMESTER				23	16-0-8
4th SEMESTER					
COMPONENT	**COURSE CODE**	**COURSE TITLE**	**LEVEL**	**CREDIT**	**L-T-P**
Major (Core)	MIB152M401	Immunology	200	4	4-0-0
Major (Core)	MIB152M402	Microbial Genetics	200	4	4-0-0
Major (Core)	MIB152M411	Practical on Immunology and Microbial Genetics	200	4	0-0-8
Minor-1	MIB152N401	Biosafety and Intellectual property rights	200	3	3-0-0
Minor-2	MIB152N402	Microbial Biotechnology	200	3	3-0-0
AEC-1	CEN982A401	Communicative English-IV	200	1	1-0-0

AEC--2	BHS982A402	Behavioural Science-IV	200	1	1-0-0
*MOOCs	MOOCs 1	*MOOCs/online course will be identified by the dept. from the list of courses available on the MOOC online platform/SWAYAM portal	100	3	
TOTAL CREDIT FOR 4th SEMESTER				23	16-0-8
5th SEMESTER					
COMPONENT	**COURSE CODE**	**COURSE TITLE**	**LEVEL**	**CREDIT**	**L-T-P**
Major (Core)	MIB152M501	Molecular Biology	300	3	3-0-0
Major (Core)	MIB152M511	Practical on Molecular Biology	300	3	0-0-6
Major (Core)	MIB152M502	Phycology Mycology and Virology	300	3	3-0-0
Major (Core)	MIB152M512	Practical on Phycology Mycology and Virology	300	3	0-0-6
Minor	MIB152N501	Medical Microbiology	300	4	4-0-0
Internship	MIB152I501	6 weeks Internship after 4th sem exam	300	4	0-0-8
TOTAL CREDIT FOR 5th SEMESTER				20	10-0-20
6th SEMESTER					
COMPONENT	**COURSE CODE**	**COURSE TITLE**	**LEVEL**	**CREDIT**	**L-T-P**
Major (Core)	MIB152M601	Genetic engineering	300	4	4-0-0
Major (Core)	MIB152M602	Pharmaceutical Microbiology	300	4	4-0-0
Major (Core)	MIB152M603	Inheritance Biology	300	4	4-0-0
Major (Core)	MIB152M604	Practical on Genetic engineering	300	4	0-0-8
Minor	MIB152N601	Food Microbiology	300	4	4-0-0
TOTAL CREDIT FOR 6th SEMESTER				20	16-0-8

7th SEMESTER					
COMPONENT	**COURSE CODE**	**COURSE TITLE**	**LEVEL**	**CREDIT**	**L-T-P**
Major (Core)	MIB152M701	Industrial and food Microbiology	400	4	4-0-0
Major (Core)	MIB152M702	Environmental and Agricultural Microbiology	400	4	4-0-0
Major (Core)	MIB152M703	Microbial Physiology & Metabolism	400	4	4-0-0
Major (Core)	MIB152M704	Practical on Food and Environmental Microbiology	400	4	0-0-8
Minor	MIB152N701	Environmental Microbiology	400	4	4-0-0
TOTAL CREDIT FOR 7th SEMESTER				20	16-0-8
8th SEMESTER					
COMPONENT	**COURSE CODE**	**COURSE TITLE**	**LEVEL**	**CREDIT**	**L-T-P**
Major (Core)	MIB152M801	Research Methodology and Scientific Writing	400	4	4-0-0
Minor	MIB152N801	Agriculture Microbiology	400	4	4-0-0
Project / Dissertation			400	12	0-0-12
or					
Advanced Microbiology course to be taken in lieu of Dissertation/Research Project	MIB152M802	Microbial enzyme: Current trend in industry and healthcare	400	4	
	MIB152M803	Parasitology, Medical and Veterinary Microbiology	400	4	
	MIB152M804	Microbiome's role in human and plants health	400	4	
TOTAL CREDIT FOR 8th SEMESTER				20	8-0-12

SYLLABUS (1ST SEMESTER)

Paper I: Fundamentals of Microbiology		**Subject code: MIB152M101**
Course Level-100	**Credit-3**	**L-T-P-C :2-1-0-3**

Course Objective:

This course is designed with the objective to provide basic information about the history of microbiological development, Classification of the living system, and basic instruments used for the observation of microbes. Further, this course also designs to provide information about different culture media used for growing microbes, sterilization techniques and distribution of microbes in different environments along with their application in industries.

Course Outcomes

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the contribution made by prominent scientists in this field along with identifying different systems of classifying living organisms.	**BT 1**
CO 2	**Understand** the basic tool and techniques use for the microorganism growth and indetification..	**BT 2**
CO 3	**Apply** the knowledge gained in solving of problems associated with the topic.	**BT 3**
CO 4	**Analyze** the components of the cellular structure in prokaryotes, eukaryotes and its potential application	**BT 4**

Detailed Syllabus:

Modules	Topics (if applicable) & Course Contents	Periods
I.	**Introduction to Microbial World** . Development of microbiology as a discipline. Spontaneous generation *vs*. Biogenesis; Microbes in nature; Role of microbes in the fields of agriculture & environment, industry, medicine, astrobiology History of microbiological development with special reference to the works of: Anton von Leeuwenhoek, Joseph Lister, Edward Jenner, Louis Pasteur, Robert Koch, Martinus W. Beijerinck, Sergei N. Winogradsky, Alexander Fleming and Elie Metchnikoff.	**15**
II.	Binomial Nomenclature. Whittaker's five kingdom and Carl Woese's three domain concept of classification and their utility. Basics of Bergeys manual of systematic bacteriology. General characteristics of acellulars (Viruses, Viroids, Virusoid and Prions) and cellular microorganisms (Bacteria, Algae, Fungi and Protozoa) with emphasis on their distribution and occurrence, morphology, mode of reproduction and economic importance.	**15**
III.	Principle and application of light (bright and dark field), phase contrast, fluorescent, electron microscope (SEM & TEM), staining, and fixation in microbiology. Sterilization: Physical and chemical methods of sterilization; mode of action of chemotherapeutic agents. Culture media: types of media, classification and importance; pure culture methods, preservation of pure cultures. .	**15**
IV	Microorganisms of Soil: Diversity of soil microflora and factors affecting their distribution. Brief account of microbial interactions in soil- symbiosis, mutualism, commensalism, competition and synergism and parasitism. PGPR and Microbes in the Rhizosphere and their importance. Microorganisms of Water, Microorganisms of Air, Source and distribution of airborne and waterborne microorganisms. Microbes in the phyllosphere and their importance. Microbial Application in Industry: Food preservation (chemical and physical) methods, Microbial deterioration of food products. Fermented food products. Application of bacteria, yeast and molds in food industry.	**15**
	TOTAL	**60**

Textbooks:

1. Pelczar MJ, Chan ECS and Krieg NR. (2010). *Microbiology*. 8th edition. McGraw Hill Book Company.
2. Sharma PD. (2005). *Microbiology.* 4th edition (reprint). Rastogi Publication, Meerut.

References:

1. Atlas RM. (2005). *Principles of Microbiology*. 4th edition. WMT. Brown Publishers.
2. Cappucino J and Sherman N. (2010). *Microbiology: A Laboratory Manual*. 9th edition. Pearson Education limited.
3. Frazier WC and Westhoff DC. (2005). *Food Microbiology*. 5th edition. Tata McGraw-Hill Publishing Company Ltd, New Delhi, India.
4. Martin A. (1977). *An Introduction to Soil Microbiology*. 2nd edition. John Wiley & Sons Inc. New York & London.

Paper II: Practical on Fundamental Microbiology		**Subject code: MIB152M111**
Course Level-100	**Credit-3**	**L-T-P-C: 0-0-6-3**

Course Objective:

This course is design with the introduction of basic instruments used in microbiological study and preparation of media use for growing different microbes. This course also cover different technique involve in the isolation and study of microbes from different samples. Further this course also introduces the qualitative and quantitative analysis of important biomolecules from the samples.

Course Outcomes

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** Biosafety protocol and other laboratory ethics	**BT 1**
CO 2	**Understand** the principle and applications of important instruments (biological safety cabinets, autoclave, incubator, hot air oven, light	**BT 2**

CO 3	**Apply** the knowledge of practical to study microorganism in surrounding environment	**BT 3**
CO 4	**Analyze** problem associated with microbes and its impact	**BT 4**

Detailed Syllabus:

Modules	**Topics (if applicable) & Course Contents**	**Periods**
I.	1. Microbiological laboratory standards and safety protocols. 2. To study the principles and applications of important instruments (biological safety cabinets, autoclave, incubator, hot air oven, light microscope, pH meter), and colony counter used in the microbiology laboratory. 3. Preparation of common microbial media (PDA, LB, LBA, NA) & sterilization techniques	**23**
II.	4. Isolation and characterization of microorganisms from soil, water, and air and motility tests. 5. Isolation of pure cultures of bacteria by streaking method and staining process. 6. Bacterial growth study and plotting of the bacterial curve. 7. Study of the protozoans (*Amoeba*, *Entamoeba*, *Paramecium*, and *Plasmodium)* using permanent mounts/photographs.	**22**
III.	8. Preparation of Stock Solution, Normal, Molar and Millimolar solutions **9.** Tests of carbohydrates, proteins and amino acids- both quantitative and qualitative.	**23**
IV	10. Study of the following genera through temporary and permanent slides: *Volvox, Coleochaete, Vaucheria, Ectocarpus, Polysiphonia* and *Nostoc*	**22**

	11. Study of the vegetative and reproductive structures of following genera through temporary and permanent slides: *Mucor, Saccharomyces, Penicillium, Agaricus* and *Alternaria*	
TOTAL		**90**

Recommended Texts:

1. Atlas, R.M. 1984. Basic and practical microbiology. Mac Millan Publishers, USA.987pp.

2. Black, J.G. 2008. Microbiology principles and explorations. 7th edition. John Wiley and Sons Inc., New Jersey. 846pp.

3. Dubey, R.C. and Maheshwari, D.K. 1999. A Textbook of Microbiology, 1st edition, S. Chand & Company Ltd

Minor : Introduction and Scope of Microbiology		**Subject code: MIB152N101**
Course level-100	**Credit-3**	**L-T-P-C-2-1-0-3**

Course Objective:

This course is design with an objective to provide the basic information about the history of microbiological development, Classification of living system and basic instruments used for observation of microbes. Further, this course also designs to provide information about different culture media used for growing microbes, sterilization technique and distribution of microbes in different environment along with their application in industries.

Course Outcome:

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the development of the microbiology and the contribution made by prominent scientists in this fields	**BT 1**
CO 2	**Understand** microbe diversity, distribution s and their economic importance	**BT 2**
CO 3	**Apply** the knowledge to Illustrate the characteristics of different types of microorganisms	**BT 3**

CO 4	**Analyze** their interaction with other organisms and surrounding environment	**BT 4**

Detailed Syllabus:

Modules	Topics (if applicable) & Course Contents	Periods
I.	**Introduction to Microbial World** Development of microbiology as a discipline, Spontaneous generation vs. biogenesis. Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming Role of microorganisms in fermentation, Germ theory of disease, Development of various microbiological techniques and golden era of microbiology, Development of the field of soil microbiology: Contributions of Martinus W. Beijerinck, Sergei N. Winogradsky, Selman A.Waksman Establishment of fields of medical microbiology and immunology through the work of Paul Ehrlich, Elie Metchnikoff, Edward Jenner	**15**
II.	General characteristics of different groups: Acellular microorganisms (Viruses, Viroids, Prions) and Cellular microorganisms (Prokarya: Archaea and Bacteria, Eukarya : Algae, Fungi and Protozoa),Sterilization: Physical and chemical methods of sterilization; mode of action of chemotherapeutic agents.	**15**
III.	Principle and application of light (bright and dark field), phase contrast, fluorescent, electron microscope, staining and fixation in microbiology. Culture media: classification and importance; pure culture methods, preservation of pure cultures	**15**
IV	Microorganisms of Soil: Diversity of soil microflora and factors affecting their distribution. Brief account of microbial interactions in soil- symbiosis, mutualism, commensalism, competition and synergism and parasitism. Microbes in the Rhizosphere and their importance. Microorganisms of Water, Microorganisms of Air, Source and distribution of airborne and waterborne microorganisms. Microbes in the phyllosphere and their importance. Microbial Application in Industry: Food preservation (chemical and physical) methods, Microbial deterioration of food products. Fermented food products. Application of bacteria, yeast and molds in food industry.	**15**
	TOTAL	**60**

Textbooks:

3. Pelczar MJ, Chan ECS and Krieg NR. (2010). *Microbiology*. 8th edition. McGraw Hill Book Company.
4. Sharma PD. (2005). *Microbiology.* 4th edition (reprint). Rastogi Publication, Meerut.

References:

5. Atlas RM. (2005). *Principles of Microbiology*. 4th edition. WMT. Brown Publishers.
6. Cappucino J and Sherman N. (2010). *Microbiology: A Laboratory Manual*. 9th edition. Pearson Education limited.
7. Frazier WC and Westhoff DC. (2005). *Food Microbiology*. 5th edition. Tata McGraw-Hill Publishing Company Ltd, New Delhi, India.
8. Martin A. (1977). *An Introduction to Soil Microbiology*. 2nd edition. John Wiley & Sons Inc. New York & London.

SEC-I: Microbial Quality Control in water and food	**Subject code: MIB152S111**
Course level-100	**L-T-P-C-0-0-6-3**

Course Objective:

This course is design with an objective to provide an overview to students about different methods and techniques and practical aspect of microbiological safety in water and food industries. The course will also provide a basic understanding about industries oriented microbiological work.

Course Outcome: On completion of the course the students will be expected to

Course Outcomes

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** different aspect of food safety and method used in industry.	**BT 1**
CO 2	**Understand about the** practical aspects of microbiological safety	**BT 2**
CO 3	**Apply** various detection methodologies and use of different microbiological media in food industries.	**BT 3**

CO 4	**Analyze** problems associated with drinking water and food industries	**BT 4**

Detailed Syllabus:

Modules	**Topics (if applicable) & Course Contents**	**Periods**
I.	1. To understand Good laboratory practices, Good microbiological practices. Biosafety cabinets – Working of biosafety cabinets 2. To Discard biohazardous waste – Methodology of Disinfection, Autoclaving & Incineration	**22**
II.	1. Determination of micro-organism in Food / water Samples: coliform load in water samples, Standard plate count, Most probable numbers, Direct microscopic counts, Biochemical test 2. Sterility testing for pharmaceutical products, Ascertaining microbial quality of milk by MBRT, Rapid detection methods of microbiological quality of milk	**23**
III.	1. Detection of specific microorganisms - on XLD agar, Manitol salt agar, EMB agar, McConkey Agar, Saboraud Agar, Enrichment culture technique.	**23**
	2. Hazard analysis of critical control point (HACCP) - Principles, flow diagrams, limitations Microbial Standards for Different Foods and Water – BIS standards for common foods and drinking water	**22**
TOTAL		**90**

Reference Books:

1. Quality Control in the Food Industry V1, S Herschdoerfer,ISBN: 9780323152068,: Academic Press, 1967
2. Principles of Sensory Evaluation of Food- 1965 MA Amerine, RM, Pangborn and EB Roessler, Elsevier.
3. Harrigan WF (1998) Laboratory Methods in Food Microbiology, 3rd ed. Academic Press.

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

SYLLABUS (2 nd SEMESTER)

Paper I: Bacteriology	**Subject code: MIB152M201**
Course Level: 100	**L-T-P-C:2-1-0-3**

Course Objective:

This course is design with an objective to provide the basic features of bacteria and their growth and adaptation. The primary objective of the course is to build a strong foundation in the area of bacterial cell structure, division, survival and propagation.

Course Outcome: On completion of the course the students will be expected to

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the morphological features, cell arrangement and structural components of bacterial cell in detail; will be able to differentiate	**BT 1**
CO 2	**Understand** the nutritional requirements of bacteria and various media used for growth and development.	**BT 2**
CO 3	**Apply** the knowledge gained in solving of problems associated with the topic.	**BT 3**
CO 4	**Analyze** the bacterial potential for human well fare	**BT 4**

Detailed Syllabus:

Modules	Topics (if applicable) & Course Contents	Periods
I.	**Cell organization** Cell size, shape and arrangement, glycocalyx, capsule, flagella, endoflagella, fimbriae and pili. Cell-wall: Composition and detailed structure of Gram-positive and Gram-negative cell walls, Archaebacterial cell wall; Gram and acid-fast staining mechanisms, lipopolysaccharide (LPS), sphaeroplasts, protoplasts, and L-forms; Effect of antibiotics and enzymes on the cell wall. Cell Membrane: Structure, function and chemical composition of bacterial and archaeal cell membranes. Cytoplasm: Ribosomes, mesosomes, inclusion bodies, nucleoid, chromosome and plasmids. Endospore: Structure, formation, stages of sporulation.	**15**
II.	**Important archaeal and eubacterial groups** Archaebacteria: General characteristics, phylogenetic overview, genera belonging to Nanoarchaeota (Nanoarchaeum), Crenarchaeota and Euryarchaeota [Methanogens, thermophiles and Halophiles] Eubacteria: Morphology, metabolism, ecological significance and economic importance of following groups: (a) Gram Negative: Non proteobacteria: General characteristics with suitable examples.Alpha-,Beta-, Gamma- Delta- and Zeta proteobacteria: General characteristics with suitable examples. (b) Gram Positive: Low (Firmicutes) and High (Actinobacteria) G+C: General characteristics with suitable examples. (c) Cyanobacteria: An Introduction.	**15**
III.	**Growth and nutrition** Nutritional requirements in bacteria and nutritional categories. Culture media: components of media, natural and synthetic media, chemically defined media, complex media, selective, differential, indicator, enriched and enrichment media Physical methods of microbial control: heat, low temperature, high pressure, filtration, desiccation, osmotic pressure, radiation. Chemical methods of microbial control: disinfectants, types and mode of action	**15**
IV	**Reproduction in Bacteria** Asexual methods of reproduction, logarithmic representation of bacterial populations, phases of growth, calculation of generation time and specific growth rate **Bacterial Systematics**	**15**

	Aim and principles of classification, systematics and taxonomy, Concept of species, taxa, strain; conventional, molecular and recent approaches to polyphasic bacterial taxonomy, evolutionary chronometers, rRNA oligonucleotide sequencing, signature sequences, and protein sequences. Differences between eubacteria and archaebacteria	
TOTAL		**60**

Textbooks:

1. Pelczar MJ, Chan ECS and Krieg NR. (2010). *Microbiology*. 8th edition. McGraw Hill Book Company.
2. Sharma PD. (2005). *Microbiology.*4th edition (reprint). Rastogi Publication, Meerut.

Reference Books:

1. Atlas RM. (1997).Principles of Microbiology.2nd edition.WM.T.Brown Publishers.
2. Srivastava S and Srivastava PS. (2003). Understanding Bacteria. Kluwer Academic Publishers, Dordrecht.
3. Stanier RY, Ingraham JL, Wheelis ML and Painter PR. (2005). General Microbiology. 5th edition McMillan.

Major: Practical on Bacteriology **Subject code: MIB152M211**

Course level-100 **L-T-P-C-0-0-6-3**

Course Objective:

This course is design to enable students to prepare different Medias for culturing bacteria and different techniques used for isolation of pure culture of bacteria. This course is also design to help students identify microbes based on different staining method and also learn basic structure of virus.

Course Outcomes

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** different staining techniques	**BT 1**
CO 2	**Understand** cell division through practical	**BT 2**

CO 3	**Apply** the knowledge of practical to study microorganism in surrounding environment	**BT 3**
CO 4	**Analyze** problems associated with microbes detection and growth in lab	**BT 4**

Detailed Syllabus:

Modules	Topics (if applicable) & Course Contents	Periods
I.	1. To study staining techniques in Bacteria: Simple staining, Negative staining, Gram's staining, Acid fast staining, Capsule staining and Endospore staining 2. To study motility of bacteria by hanging drop method, swimming and twitching motility	**22**
II.	3. Isolation of pure cultures of bacteria by streaking method; Estimation of CFU count by spread plate method/pour plate method 4. Estimation of Coliform loads in drinking water	**23**
III.	5. Study of cytopathic effects of viruses using photographs 6. Assessment of microbiological quality of water	**22**
IV	7.Different Biochemical test for bacteria 8.Plasmid isolation from *E. coli* 9- Antibiotic sensitivity test	**23**
TOTAL		**90**

Textbooks:

1-De Robertis, E. D. P. and De Robertis R. E. 2009. Cell and Molecular Biology, 8th edition. Lippincott Williams and Wilkins, Philadelphia.

2. Cooper G. M. Hausman R. E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press and Sunderland, Washington D. C.; Sinnauer Academic Press.

3. Becker W. M., Kleinsmith L.J. and Bertni G. P. 2009. The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San fransisco.

Minor: Introductory Virology		**Subject code: MIB152N201**
Course level -100	**Credit units: 3**	**L-T-P-C-2-1-0-3**

Course Objective:

This course will give an overview of medically important viruses and their genome organization, replication strategies within the host cell. The course is also design to provide information about different transmission mode and prevention strategies to control of viral diseases. Common human viral infection will be the main focus of this course giving emphasis on virus - host interaction in understanding the diversity of viruses and viral diseases.

Course Outcome: On completion of the course the students will be expected to

Course Outcome:

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the origin, structure, medically important viruses and their genome organization, replication strategies within the host cell	**BT 1**
CO 2	**Understand** the infectious nature and their role in causing diseases.	**BT 2**

CO 3	**Apply** the knowledge to understant different viral strategies to evade host immune and cellular factors	**BT 3**
CO 4	**Analyze** the knowledge to develope different preventive measures to against viral diseases and develope vaccine and other antiviral drugs	**BT 4**

Detailed Syllabus:

Modules	**Topics (if applicable) & Course Contents**	**Periods**
I.	**General Characteristics of Viruses** Nature and general properties of viruses, concept of viroids, virusoids/satellite viruses and Prions. Theories of viral origin. Structure of Viruses: Capsid symmetry, enveloped and non-enveloped viruses. Isolation, purification and cultivation of viruses	**15**
II.	**Viral nucleic acids Replication and maturation** Salient features of viral Nucleic acid, Viral multiplication and replication strategies: Interaction of viruses with cellular receptors and entry of viruses. Replication strategies of viruses, Assembly, maturation and release of virions	**15**
III.	**Bacteriophages and medically important virus** Bcteriophage(lytic and lysogenic life cycle), clinically important viruses - Rota virus, Corona virus(***SARS***-CoV2***)***, Hepadnavirus(Hepatitis B, C & D), Human Papilloma virus(HPV), Ebolla virus, Human immunodeficiency virus (HIV).	**15**
IV.	**Viral Transmission, Prevention & control of viral diseases** Modes of viral transmission: Persistent, non-persistent, vertical and horizontal. Antiviral compounds and their mode of action. Interferon and their mode of action. General principles of viral vaccination; Applications of Virus (Phage therapy).	**15**
	TOTAL	**60**

<u>Text books</u>

1. Dimmock, NJ, Easton, AL, Leppard, KN (2007). Introduction to Modern Virology. 6th edition BlackwellPublishing Ltd.
2. Carter J and Saunders V (2007). Virology: Principles and Applications. John Wiley and Sons.

Reference Books:

1. Mathews. (2004). Plant Virology. Hull R. Academic Press, New York.
2. Nayudu MV. (2008). Plant Viruses. Tata McGraw Hill, India.
3. Bos L. (1999) Plant viruses-A text book of plant virology by. Backhuys Publishers.
4. Versteeg J. (1985). A Color Atlas of Virology.Wolfe Medical Publication.

SEC II: Fermentation technology and application **Subject code: MIB152S211**

Course level-100 **L-T-P-C: 0-0-6-3**

Course Objective: This course is design to enable students learn about fermentation process alongwith different fermented food items obtained from microbiological activities.. This course is also design to help students learn about different useful microbes that are use in fermentation process and also learn about the production of fermented food items

Course Outcome: On completion of the course the students will be expected to

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** microorganisms in the preparation specific fermented food items and the preparation of inoculum.	**BT 1**
CO 2	**Understand** the general laboratory safety measures and maintain the same.	**BT 2**
CO 3	**Apply** the knowledge for the preparation of various chemicals.	**BT 3**
CO 4	**Analyze** the source of probiotic in fermented foods and their health benefits	**BT 4**

Detailed Syllabus:

Modules	Topics (if applicable) & Course Contents	Periods
I.	1. Production of ethyl alcohol from fruit juice or sugar sources. 2. Estimation of protein in fermented food 3. To understand different Fermented Foods and its advantages and health benefits	**15**
II.	4. To study Milk Based Fermented Foods: Dahi, Yogurt: Preparation of inoculums, types of microorganisms and production process	**15**
III.	5. To study Grain Based Fermented Foods: Bread, Idli and Dosa: Microorganisms and production process	**15**
IV	6. To study vegetable Based Fermented Foods: Pickels, Saeurkraut: Microorganisms and production process	**15**
	TOTAL	**60**

Textbooks:

1.Hui YH, Meunier-Goddik L, Josephsen J, Nip WK, Stanfield PS (2004) Handbook of food and fermentation technology, CRC Press

2. Holzapfel W (2014) Advances in Fermented Foods and Beverages, Woodhead Publishing.

SYLLABUS (3rd SEMESTER)

Paper: Biochemistry		**Subject code: MIB152M301**
Course Level: 100	**Credit units: 3**	**L-T-P-C-3-0-0-3**

Course Objective:

This course is designed to generate fundamental concepts among students about different biomolecules present inside biological organisms. The course will develop the foundation for all other courses like microbial physiology and metabolism.

Course Outcomes:

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** various biomolecules and interactive forces that are required for the development and functioning of a bacterial cell.	**BT 1**
CO 2	**Understand** the structure, properties, and function of carbohydrates and lipids.	**BT 2**
CO 3	Apply Amino acid-related information to resolve the structure and folding pattern as well as the separation of proteins.	**BT 3**
CO 4	Analyze biocatalytic activity of enzyme kinetics, and calculate Vmax, Km, and Kcat values along with purification of the enzyme.	**BT 4**

Detailed Syllabus:

Modules	**Topic & Course Contents**	**Periods**
I.	Structure of atoms, molecules, and chemical bonds; Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.); Principle of biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics, colligative properties).	**12**
II.	Carbohydrate (chemistry) Classification and nomenclature -- Aldoses and Ketoses; optical activity, stereoisomerism, enantiomers, racemic mixture, Dia stereoisomers, epimers, anomers; hemiacetal and hemiketal; optical rotation; polysaccharide (homopolysaccharide, heteropolysaccharide); carbohydrate synthesis (C3, C2, C4 and CAM). Lipid (fat, oil, wax), Fatty acid (saturated and unsaturated fatty acid); Δ- and ω-nomenclature of fatty acid; derived lipid (phospholipid, glycolipid) and types; acid value, saponification value, iodine value.	**18**

III.	Classification, properties, and structure of Amino acids; Conformation of proteins (primary, secondary, tertiary, quaternary structure), domains, motif and folds; Ramachandran plot.	**15**
IV	Principle of catalysis, enzymes and enzyme kinetics, classification of enzyme; enzyme regulation, mechanism of enzyme catalysis; enzyme inhibition; cofactors, coenzyme, prosthetic group; bi-substrate reaction; allosteric enzyme; isozymes, allozyme, ribozyme; enzyme isolation and purification.	**15**
	TOTAL	**60**
Pedagogy: Lectures, Assignments, Seminar		

Credit distribution:		
Theory	**Practical**	**Experiential Learning**
60 Hours	zero	30 (Problem solving, Presentation, Project, Seminar, Internship, Workshop, Field Trip)

Text books:

1. Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*. 8th edition. McGraw Hill Higher Education.
2. Nelson D L, Cox M. M. Lehningers. (2004). Principle of Biochemistry. 4th ed. Freeman and company, New York, USA.
3. Harper, 1999. Biochemistry, McGraw Hill, NewYork
4. Lodish, H.T. Baltimore, A. Berck B.L. Zipursky, P. Mastsydaire and J. Darnell. 2004. Molecular Cell Biology, Scientific American Books, Inc. Newyork

Reference book:

1. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN: 13: 978-1-4641-0962-1 / ISBN: 10:1-4292-3414-8.
2. Biochemistry (2011) 4th ed., Donald, V. and Judith G.V., John Wiley & Sons Asia Pvt.Ltd. (New Jersey), ISBN: 978-1180-25024.
3. Fundamentals of Enzymology (1999) 3rd ed., Nicholas C.P. and Lewis S., Oxford University Press Inc. (New York), ISBN:0 19 850229 X

Paper: Practicals on Biochemistry		**Subject code: MIB152M311**
Course Level: 100	**Credit units: 1**	**L-T-P-C-0-0-2-1**

Course Objective:

This course is designed to generate fundamental concepts among students about different biomolecules present inside biological organisms. The course will develop a foundation for all other courses like cell biology, microbial physiology, and metabolism.

Course Outcomes:

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Reminisce** synthesis of solution and pH from isolates.	**BT 1**
CO 2	**Understand** the basic principles of quantitative biochemical tests.	**BT 2**
CO 3	**Identify the** enzyme production ability of isolated microbes.	**BT 3**
CO 4	**Analyse** protein structures and their functions	**BT 4**

Detailed Syllabus:

Modules	**Topics & Course Contents**	**Periods**
I.	Preparation of molar, normal, molal, percentage, and ppm solution, Preparation of buffers solution, Estimation of pH of plant juice, water, and soil sample, Handling of micropipettes and checking their accuracy.	**15**
II.	Qualitative tests for organic acids (oxalic, citric, tartaric,), carbohydrates (reducing, non-reducing), lipids, and proteins from laboratory samples	**15**
III.	Estimation of catalase activity, hydrolysis of starch, gelatin liquefaction, hydrolysis of casein	**15**
IV	Study of protein secondary and tertiary structures with the help of models. Study of enzyme kinetics – calculation of Vmax, Km, Kcat values	**15**

		TOTAL	**60**
Pedagogy: Lectures, Assignments, Seminar			
Credit distribution:			
Theory	**Practical**	**Experiential Learning**	
zero	60 Hours	Problem solving, Presentation, Project, Seminar, Internship, Workshop, Field Trip)	

Text books:

1. Campbell, MK (2012) Biochemistry, 7th ed., Published by Cengage Learning

2. Campbell, PN and Smith AD (2011) Biochemistry Illustrated, 4th ed., Published by Churchill Livingstone

3. Tymoczko JL, Berg JM and Stryer L (2012) Biochemistry: A short course, 2nd ed., W.H.Freeman

4. Berg JM, Tymoczko JL and Stryer L (2011) Biochemistry, W.H.Freeman and Company

Reference book:

1. Nelson DL and Cox MM (2008) Lehninger Principles of Biochemistry, 5th Edition., W.H. Freeman and Company.

2. Willey MJ, Sherwood, LM &Woolverton C J (2013) Prescott, Harley and Klein's Microbiology by. 9th Ed., McGrawHill

3. Voet,D. and Voet J.G (2004) Biochemistry 3rd edition, John Wiley and Sons

Paper: Cell Biology	**Subject code:** MIB152M302	
Course level-300	**Credit units: 3**	**L-T-P-C-4-0-0-4**

Course Objective:

This course is designed to provide the basic features of living cells, particularly emphasizing more on the prokaryotic cells and detailed information about the cell components along with their role in maintaining the cell's structure and functions.

Course Outcomes:

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the various components of the cell and their function.	**BT 1**
CO 2	**Understand** the function of the cells and their roles.	**BT 2**
CO 3	**Apply** the knowledge gained in solving of problems associated with the topic.	**BT 3**
CO 4	**Analyze** the components of the cellular structure in prokaryotes, eukaryotes and archaea.	**BT 4**

Detailed Syllabus:

Modules	Topics & Course Contents	Periods
I.	**Introduction to cell** Cell theory, Structural organization of the prokaryotic cell, eukaryotic cells and their function. Comparative characters of prokaryotes and eukaryotes. Plasma membrane**:** Structural organization of cell membrane, plasma membrane, and their function. Mechanism of transport across the plasma membrane.	**15**
II.	**Cell organelles; structure & function** The endoplasmic reticulum, Golgi complex, lysosome, peroxisome, ribosomes and vacuoles, mitochondria; role of mitochondria in oxidative reactions and electron transport chain. Chloroplast and its role in photosynthesis.	**15**
III.	**Nucleus** Nucleus- Structure, organization and function, Nuclear envelope, role of nuclear pore in transport across the envelope, nucleoplasm and nucleolus, Chromatin structure and organization.	**15**

IV	**Cytoskeleton, Cell cycle & cell division** Microtubule and microfilaments: Intermediate filaments and Extracellular matrix. Cell cycle and its phase, Cell divisions (Mitosis & Meiosis), Apoptosis, Cell cycle control and its association with cancer.	**15**
TOTAL		**60**

Credit distribution:		
Theory	**Practical**	**Experiential Learning**
60Hours	zero	**30 Hours-** Problem solving, Presentation, Project, Seminar, Internship, Workshop, Field Trip

Textbooks:

1. Bruce Albert*set al*. *Molecular Biology of cell*. Garland Publications
2. Daniel. *Molecular Cell Biology*. Sceintific American Books.
3. Jack D. Bruke. *Cell Biology*. The William Twilkins Company.
4. Old and Primrose. *Principles of Gene Manipulations*. Black Well Scientific Publications.
5. Ambrose and Dorouthy M Hasty. *Cell Biology*. ELBS Publications.
6. Sharp. *Fundamentals of Cytology*. McGraw Hill Company.

Reference Books:

1. Wilson and Marrision. *Cytology*. Reinform Publications
2. Smith. *Molecular Biology*. Faber and Faber Publications
3. EDP Roberties and EMF Roberties. *Cell and Molecular Biology*. Sauder College.
4. Gardener EJ, Simmons MJ and Snustad DP. *Principles of Genetics*. John Wiley and Sons Publications.

Paper: Practicals on cell Biology **Subject code: MIB152M312**

L-T-P-C-0-0-8-4 **Credit units: 1** **Scheme of evaluation: (P)**

Course Objective:

The Cell Biology practical paper aims to provide students with a comprehensive understanding of cellular structures, functions and processes through hands-on experimentation. Students will acquire proficiency in essential laboratory techniques including microscopy, staining, and enabling them to investigate cellular dynamics and interactions.

Course Outcomes:

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** different staining techniques.	**BT 1**
CO 2	**Understand** cell division through practicals	**BT 2**
CO 3	**Apply** the knowledge of practical to study microorganisms in surrounding environment	**BT 3**
CO 4	**Analyze** problems associated with microbes' detection and growth in the lab	**BT 4**

Detailed Syllabus:

Modules	Topics & Course Contents	Periods
I.	1.Study the phenomenon of plasmolysis and deplasmolysis 2.To study the motility of bacterial cells by hanging drop method, swimming, and twitching motility	**15**
II.	3. Study of different stages of mitosis by temporary preparation/ permanent slides of onion root tips. 4. Study of meiosis in onion bud cell or grasshopper testis by temporary preparation /permanent slides	**15**
III.	5. Isolation of DNA from blood cells. 6. Cytochemical staining of proteins by Bromophenol blue. .	**15**

IV	7. Karyotyping and Ideogram of metaphase plate of human 8.Linear differentiation of human chromosomes through G-banding and C-banding	**15**
TOTAL		**60**

Credit distribution:		
Theory	**Practical**	**Experiential Learning**
zero	60	Problem solving, Presentation, Project, Seminar, Internship, Workshop, Field Trip

Books:

1-De Robertis, E. D. P. and De Robertis R. E. 2009. Cell and Molecular Biology, 8th edition. Lippincott Williams and Wilkins, Philadelphia.

2. Cooper G. M. Hausman R. E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press and Sunderland, Washington D. C.; Sinnauer Academic Press.

3. Becker W. M., Kleinsmith L.J. and Bertni G. P. 2009. The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San fransisco.

Paper: Plant Pathology and Plant-microbe Interaction		**Subject code: MIB152N301**
L-T-P-C-4-0-0-4	**Credit units: 4**	**Scheme of evaluation:(T)**

Course Objective:

The course is developed with the following objectives: To enable the students to develop a proper understanding of the interaction taking place among the microorganism along with another organism. This course also includes the microbes present in the soil environment and their impacts on different plants. Furthermore, this course also includes plant pathogens and the social impact of plant diseases.

Course Outcome: On completion of the course the students will be expected to

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** about the plant immune system along with the causation of diseases in plants by different types of microorganisms namely bacterial, fungal and viral	**BT 1**
CO 2	**Understand** plant diseases, their etiology, salient characteristics and control measures.	**BT 2**
CO 3	**Apply** the knowledge to Identify different soil pathogens associated with plant diseases.	**BT 3**
CO 4	**Analyze** the diseased plant samples in the laboratory and are able to identify the salient features of the disease-causing microbe and the lesions produced on the plant parts.	**BT 4**

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	**Introduction to Plant-Microbial interactions:** Mutualism, synergism, commensalism, competition, parasitism, endophytic association, Symbiotic and non-symbiotic interaction, lichen symbiosis	**15**
II	**Communication among rhizobia:** Insights into Rhizobia-Plant Communication, Rhizosphere; Non – rhizosphere; R: S ratio; Rhizosphere effect; Phyllo sphere effect; Spermosphere effect; Plant growth promoting rhizobacteria; epiphytic and endophytic microbiomes and their significance.	**15**
III	**Microbial Interactions and Plant Health:** Basal Resistance and PAMP-Triggered Immunity (PTI); Pathogen-Induced Resistance and Effector-triggered immunity (ETI); Effectors; Resistance Proteins; Avr/R Protein Interaction	**15**
IV	**Microbesas Plant Pathogens**: Concept of plant disease- definitions of disease, disease cycle & pathogenicity, symptoms associated with microbial plant diseases, types of plant pathogens. Biocontrol	**15**

	mechanisms and ways, Microorganisms used as biocontrol against plant pathogens and disease.	
Total		**60**

Credit distribution:		
Theory	**Practical**	**Experiential Learning**
60Hours	zero	**30 Hours-** Problem solving, Presentation, Project, Seminar, Internship, Workshop, Field Trip

Textbooks:

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

2. Singh RS. (1998). Plant Diseases Management.7th edition.Oxford& IBH, New Delhi.

3. Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. 8th edition. McGraw Hill Higher Education.

4. Pelczar MJ, Chan ECS and Krieg NR. (2010). Microbiology. 8th edition. McGraw Hill Book Company.

Reference books:

1. Singh DP, Singh HB, Prabha R (2017). Plant-Microbe Interactions in Agro-Ecological Perspectives. Vol. 1. Springer.
2. Boland GJ and Kuykendall LD (1998). Plant-microbe Interactions and Biological Control Books in Soils, Plants, and the Environment. CRC Press.

Paper I: Biofertilizers and Biopesticides		**Subject code: MIB152S311**
Course Level-200	**Credit units: 3**	**L-T-P-C: 0-0-6-3**

Course Objective:

This course is designed to provide basic information about the history of microbiological development, Classification of the living system, and basic instruments used for the observation of microbes. Further, this course is also designed to provide information about different culture media used for growing microbes, sterilization techniques, and distribution of microbes in different environments along with their application in industries.

Course Outcomes

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the contribution made by prominent scientists in this field along with identifying different systems of microorganisms in different kinds of biofertilizers and biopesticides.	**BT 1**
CO 2	**Understand** the basic tools and techniques used for the microorganism growth and application of biofertilizers and biopesticides.	**BT 2**
CO 3	**Apply** the knowledge gained in solving problems associated with the topic such as organic farming and industry.	**BT 3**
CO 4	**Analyze** the components of the cellular structure in prokaryotes, and eukaryotes and its analysis through sophisticated techniques.	**BT 4**

Detailed Syllabus:

Modules	**Topics & Course Contents**	**Periods**

I.	**Brief history and development of Biofertilizer and Biopesticide:** History and concept of Biofertilizer and Biopesticides. Definitions, Importance, scope and potential of biofertilizer and biopesticide. classification of biopesticides viz. pathogen, botanical pesticides.	**15**
II.	**Production of Biofertilizer and Biopesticides:** Rhizobia Inoculants, mineral solubilizers, mass production and method of application. Mechanism of phosphate solubilization and phosphate mobilization, K solubilization. Biopesticide: Viral, Bacterial, and Fungal biopesticide, Mode of application, Mass production.	**15**
III.	**Quality Control of Biofertilizer and Biopesticide:** Quality Control, BIS Norms of Biofertilizer and Biopesticide, Environmental impact of Biofertilizer and Biopesticide.	**15**
IV	**Application of Biofertilizer and Biopesticide:** Organic Farming, Different application of Biofertilizer and Biopesticide in Agriculture, Case study of Biofertilizer and Biopesticide.	**15**
TOTAL		**60**

Credit distribution:		
Theory	**Practical**	**Experiential Learning**
Zero	60 Hours	**30 Hours-** Problem solving, Presentation, Project, Seminar, Internship, Workshop, Field Trip

Textbooks:

1. Borkar,S.G. (2015). *Beneficial Microbes as Biofertilizers and its Production Technology* , 1st edition, Woodhead Publisher, India,New Delhi.

2. M T Madigan, and J M Martinko (2014). Biology of Microorganisms 14th Edn. Tata McGrow Hill Education Pvt. Ltd.

References:

1. Pearson.M J Pelczer (1998) Microbiology 5th Edn. Tata McGrow Hill Education Pvt. Ltd.
2. Strainer, R, (1987) General Microbiology. Palgrave Macmillan.Edward Alchano, 2002. Introduction to Microbiology. Jones and Bartlett hearing.
3. R P Singh, (2007) General Microbiology. Kalyani Publishers.
4. J Heritage, E G V Evans, R A Killington, (2008) Introductory Microbiology. Cambridge University press P. date. 6. Pelczar, jr. M.J.E.C.S.Chan and Krieg, N.R. 1996. Microbiology. Mc Graw Hill Publishers,

SYLLABUS (4th SEMESTER)

Paper: Immunology		**Subject code: MIB152M401**
Course Level-200	**Credit units: 4**	**L-T-P-C-3-1-0-4**

Course Objective:

This course is designed to provide knowledge about the immune response in the body along with the basic structure of antigens and antibodies. Further, the syllabus also includes the application of antigens and antibodies in the different serological tests.

Course Outcome: On completion of the course the students will be expected to

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the basic concepts about the innate and adaptive immune	**BT 1**
CO 2	Understanding of the antigen, antibody structure, and working mechanism of the Immune system.	**BT 2**
CO 3	**Apply** the knowledge of antigen, antibody, RIA, and other techniques in HLA typing and related research	**BT 3**
CO 4	**Analyze** the immune system-related disease and other related issues.	**BT 4**

Detailed Syllabus:

Modules	Topics & Course Contents	Periods
I.	History of immunology, Types of immunity: Innate and Acquired immunity; Cells and Organs of the immune system.	**15**
II.	Antigen – Antigenicity, Immunogenicity, Epitopes, Haptens, Adjuvants; MHC self-antigen – Class and structure. Antibodies- Structure, classes and function, Isotype, Allotype, and Idiotype; Genetic diversity of antibody class, Antigen and antibody interaction, affinity and avidity, cross-reactivity, precipitation, and agglutination reaction; Cytokines.	**15**
III.	Complement system. Allergy and Hypersensitivity – type – I, II, III, and IV their clinical manifestation; Autoimmune disorders, Immunity to the microbes	**15**
IV	Transplantation – Allograft rejection, Graft vs Host rejection, Immunosuppressor drugs. Demonstration of Single Radial Immuno-diffusion, Principle and applications of RIA and ELISA, Tumor immunology.	**15**
TOTAL		**60**

Credit distribution:		
Theory	**Practical**	**Experiential Learning**
60Hours	zero	**30 Hours-** Problem solving, Presentation, Project, Seminar, Internship, Workshop, Field Trip

Text Books:

1. Nelson D L, Cox M. M. Lehningers. (2004). Principle of Biochemistry. 4th ed. Freeman and company, New York, USA.
2. Janis Kuby. (2013). Immunology. 7th Edition, WH Freeman.

Reference Books:

1. Kuby J, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman,2002.
2. Janeway et al., Immunobiology, 4th Edition, Current Biology publications., 1999.
3. Paul, Fundamental of Immunology, 4th edition, Lippencott Raven, 1999.

Paper I: Microbial Genetics		**Subject code:** MIB152M402
Course Level-200	**Credit units: 4**	**L-T-P-C-4-0-0-4**

Course Objective:

The purpose of this course is to introduce the student to the advanced concepts of genetics micro-organisms, The Student will gain an understanding of molecular mechanisms of DNA transfer and mutation in prokaryotes and lower eukaryotes.

Course Outcome: On completion of the course the students will be expected to

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**remember** the core concept of genetic material and its transmission	**BT 1**

CO 2	**Understand** the genome organization in bacteria and the mechanism of DNA transfer	**BT 2**
CO 3	**Apply** the concepts of genetic material transmission, and recombination as a molecular biology tool and explain various levels of gene regulation in prokaryotic system	**BT 3**
CO 4	**Analyze** the process of genetic information flow and its regulation to understand the evolution process and antibiotic resistance development.	**BT 4**

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Genetic material**,** vertical and horizontal gene transfer**,** Bacterial chromosomes and plasmids, types of plasmid, megaplasmid, organization of the genome in prokaryotes, Mechanisms behind the information flow, central dogma of life.Archaeal genomes and their differences with other prokaryotic and eukaryotic organisms.	**15**
II	Meselson and Stahl experiment, Hershey and Chase experiment, exon and intron isolation of bacterial mutants, Nutritional mutants, prototroph, and auxotroph. Transformation, conjugation, one gene-one enzyme hypothesis.	**15**
III	Mutation, types, rate, cause of mutation, Mutagenic agents, base analogues, Assay of mutagenic agents, Molecular basis of mutation, heavy metal/drug resistance in bacteria, Ames test.	**15**
IV	Genetics of Bacteriophages - General characteristics of the viral genome, T4 virulent Phage- Structure- life cycle. Lambda temperate phage- Structure – Transduction and its types. Lysogenic and Lytic cycle.	**15**
Total		**60**

Credit distribution:		
Theory	**Practical**	**Experiential Learning**
60Hours	zero	**30 Hours-** Problem solving, Presentation, Project, Seminar, Internship, Workshop, Field Trip

Text Books:

1. James D Watson *et al*. (2009). Molecular biology of the gene. 5th Edition, Pearson.
2. Karp, G. (2010);*Cell and Molecular Biology: Concepts and Experiments*, 6th edition,

. John Wiley &Sons.Inc.
3. Stanley R Maloy. Microbial Genetics. 5th Edition, Narosa publishing house.
4. Daniel J Fairbanks. Genetics: The Continuity of Life, Wadsworth Publishing, ISBN-10: 0534252796

References:

1. Peter J Russel. Genetics. Pearsons Education India, ISBN-10: 9332571627.
2. William Klug, Michael Cummings, Charlotte A Spencer, Michael A Palladino. Concept of Genetics, 10th edition, Pearsons.

Practicals on Immunology and Microbial Genetics	**Subject code:** MIB152M401	
Course level-200	**Credit units: 4**	**L-T-P-C- 0-0-8-4**

Course Objective:

- The objective of the course is to familiarize the student with basic practical knowledge regarding different tests related to immune cells and their responses

Course Outcome: On completion of the course the students will be expected to

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the basic concepts of blood grouping and other related tests.	**BT 1**
CO 2	Understanding of the antigen, antibody reaction, and working mechanism of the Immune system..	**BT 2**
CO 3	**Apply** the practical knowledge to confirm blood group and detection of infectious pathogen	**BT 3**
CO 4	**Analyze** the sample to understand the infection and disease.	**BT 4**

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	1: Demonstration of haemagglutination 2: Haemagglutination tests for identification of human blood groups 3: Demonstration of agglutination reaction concerning the Widal test and VDRL test.	**20**
II	5: Demonstration of ODD (Ouchtlerlony Double Diffusion) 6: Demonstration of Antigen-antibody reaction by ELISA.	**20**
III	7: Osmotic fragility of RBC 8: Estimation of Haemoglobin (Hb)	**20**
IV	**9:** Replica plating technique 10- Antibiotic **sensitivity test against Ampicillin and Gentamycin** 11-Genomic DNA Isolation from bacterial cell	**30**
Total		**90**

Credit distribution:		
Theory	**Practical**	**Experiential Learning**
zero	90 Hours	Problem-solving, Presentation, Project, Seminar, Internship, Workshop, Field Trip

Text Books:

1.Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*. 8th edition. McGraw Hill Higher Education.

2. Janis Kuby. (2013). Immunology. 7th Edition, WH Freeman.

References:

1. Kathleen park Talaro (2017). Foundations in Microbiology. 10th Edition, McGraw Hill. Science
2. White David (2000). Physiology and Biochemistry of Prokaryotes. 2nd ed. Oxford University Press, New York.

Biosafety and Intellectual property rights		**Subject code:** MIB152N401
Course level-200	**Credit units: 3**	**L-T-P-C-3-0-0-3**

Course Objective:

.This curriculum is structured to equip students with the essential principles of research methodologies, facilitating their comprehension and fostering familiarity with phenomena, as well as fostering fresh insights into the research journey. Moreover, it will establish a solid groundwork for subsequent courses on Intellectual Property Rights (IPR) and biosafety

Course Outcome: On completion of the course the students will be expected to

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the necessary preventive measures, handling of live bacteria.	**BT 1**
CO 2	**Demonstrate** the process how to dispose infectious waste, care of the equipment requiring safety audit.	**BT 2**
CO 3	**Apply** the theoretical knowledge for patent and copyright	**BT 3**
CO 4	**Analyze** the issue in patent filing and other related issue	**BT 4**

Modules	**Topics & Course Contents**	**Periods**

I.	**Biosafety:** Introduction; Biosafety issues in biotechnology; Biological Safety Cabinets & their types; Primary Containment for Biohazards; Biosafety Levels of the Microorganisms	**15**
II.	**Biosafety Guidelines:** Biosafety guidelines and regulations (National and International); GMOs/LMOs- Concerns and Challenges; Role of Institutional Biosafety Committees (IBSC), RCGM, GEAC etc. for GMO applications in food and agriculture.	**15**
III.	**IPR:** Introduction, Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, World Intellectual Property Rights Organization (WIPO). Geographical indication (GI)	**15**
IV	**Types of patent applications and Agreements**: Ordinary, PCT, Conventional, Divisional and Patent of Addition, GATT, TRIPS Agreements;	**15**
TOTAL		**60**

Credit distribution:		
Theory	**Practical**	**Experiential Learning**
60Hours	zero	**30 Hours-** Problem solving, Presentation, Project, Seminar, Internship, Workshop, Field Trip

Reference Books:

1. Indian Patent Act 1970 Acts & Rules, BAREACT, Universal Law Publishing Co. Pvt. Ltd., 2007

2. Genetic Patent Law & Strategy, 1st Edition, Kankanala C., Manupatra Information Solution Pvt. Ltd., 2007

3. N.S. Gopalakrishnan & T.G. Agitha, (2009) Principles of Intellectual Property Eastern Book Company, Lucknow.

4. Kerly's Law of Trade Marks and Trade Names (14th Edition) Thomson, Sweet & Maxweel.

5.B.L.Wadehra (2000) Law Relating to Patents, Trade Marks, Copyright, Designs & Geographical Indications; Universal law Publishing Pvt. Ltd., India.

Reference book:

1. Cr, K. (2020). Research methodology methods and techniques.

2. Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Age International.

3. P. Narayanan (2010) Law of Copyright and Industrial Designs; Eastern law House, Delhi

Paper: Microbial Biotechnology		**Subject code:** MIB152N402
Course level-200	**Credit units: 3**	**L-T-P-C-3-0-0-3**

Course Objective:

This course will provide detailed knowledge about Microbial biotechnology its scope and applications in therapeutics, environment, industries, etc. This course is also designed to build a strong foundation in the area of recombinant microbial production processes in pharmaceutical industries, biofuel production, and bioremediation.

Course Outcome: On completion of the course the students will be expected to

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	Remember how microbiology is relevant to technological developments for agriculture and the environment.	**BT 1**
CO 2	Understanding how microbiology is relevant to technology. developments for industries related to food and fermentations	**BT 2**
CO 3	Apply the knowledge on how the developments in recombinant DNA technology is juxtaposed with microbially-based technological developments for agriculture, industry, and the environment.	**BT 3**
CO 4	Analysis of the impact of microorganisms on the environment, industries human therapeutics etc.	**BT 4**

Detailed Syllabus:

Modules	**Topics / Course content**	**Periods**

I	Microbial biotechnology: Scope of Microbial biotechnology and applications in therapeutics, Human health, agriculture environmental issues, and food technology. Use of prokaryotic and eukaryotic microorganisms in biotechnological applications Genetically engineered microbes' application in industries.	**15**
II	Recombinant microbial production processes in pharmaceutical industries - Streptokinase, recombinant vaccines (Hepatitis B vaccine). Microbial polysaccharides and polyesters, Microbial production of bio-pesticides, bioplastic.	**15**
III	Microbial-based transformation of steroids and sterols. Bio-catalytic processes and their industrial applications: Production of high fructose syrup and production of cocoa butter substitute.	**15**
IV	Bioethanol and bio-diesel production: Commercial production from lignocellulosic waste and algal biomass, Biogas production: Methane and hydrogen production using microbial culture. Microorganisms' role in bioremediation	**15**
Total		**60**

Credit distribution:		
Theory	**Practical**	**Experiential Learning**
60Hours	zero	**30 Hours**- Problem solving, Presentation, Project, Seminar, Internship, Workshop, Field Trip

Textbooks:

1. Richard H. Baltz. Julian E Davies and Arnold L.DemainManual of Industrial Microbiology and Biotechnology. 3rd edition, ASM Press (2010).
2. Daniel Forciniti. Industrial Bioseperation: Principles and practice. 1st edition edition, Wiley-Blackwell (2008).
3. Reed. G. Prescott and Dunn's Industrial Microbiology. CBS Publishers. (1999).
4. Demain, A. L. Industrial Microbiology and Biotechnology. 2nd Edition. (2001).
5. EL Mansi. E.M.T., FermentationMicrobiologyand Biotechnology. 2ndEdition,CRC Taylor&Francis (2007).
6. Waites,M.J.,Morgan, N.L.,Rockey, J.S.andHigton,G.Industrial M i cr o b i o l o g y : An lntroduction. Blackwell SciencePublishers(2002).
7. Casida LE, Industrial Microbiology, J. Wiley, (1968).

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

SYLLABUS (5th SEMESTER)

Name of the Subject: Molecular Biology **Subject code:** MIB152M501

Course level-300 **Credit units: 4** **L-T-P-C-4-0-0-4**

Course Objective:

The purpose of this course is to introduce the student to the advanced concepts in molecular biology. Students will gain an understanding of molecular mechanisms of DNA replication, DNA repair, transcription, translation, and gene regulation in prokaryotic and eukaryotic organisms. The student will study the techniques and experiments used to understand these mechanisms.

Course Outcome: On completion of the course the students will be expected to

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the basic concept of gene, genome and nucleic acids.	**BT 1**
CO 2	**Understand** the structure of DNA and RNA, organization of eukaryotic genome	**BT 2**
CO 3	**Apply** the concepts of DNA repair mechanisms, and recombination as a molecular biology tool and explain various levels of gene regulation in both prokaryotic and eukaryotic organisms.	**BT 3**

CO 4	**Analyze** post-transcriptional processes, RNA editing, RNAi and miRNA along with translation mechanism in prokaryotes and eukaryotes, regulation of translation, and post-translational processing.	**BT 4**

Detailed Syllabus:

Modules	Topics (if applicable) & Course Contents	Periods
I.	**Basic concepts of Genetic Information** Nucleic acids as genetic information carriers, experimental evidences. Primary structure of nucleic acids and their properties. Highly repetitive, moderately repetitive and unique DNA sequences, Classes of RNA, secondary and tertiary structure. Secondary structures of nucleic acids, anti-parallel strands, base composition, base equivalence, base pairing and base stacking, types of DNA, structural characteristics, chirality and cot curve.	12
II.	**DNA Replication and Transcription** DNA replication in prokaryotes: Conservative, semiconservative and dispersive types, DNA polymerases, enzymes and protein factors involved in replication. Mechanism of replication in eukaryotes, inhibitors of replication. Transcription in prokaryotes and eukaryotes, RNA polymerases; promoters, differences in transcription termination,	12
III.	**Translation and Regulation of Gene Expression** Translation, post translational modifications. Genetic code: Basic features of genetic code, biological significance of degeneracy, Wobble hypothesis; gene within genes and overlapping genes, mechanism of translation in prokaryotes and eukaryotes, ribosome assembly. Regulation of Gene Expression in Prokaryotes and eukaryotes, Enzyme induction and repression, operon concept, Lac operon, Trp operon, eukaryotic gene arrangements.	12

IV	**Mutation and Repair** Mutation: molecular basis of mutation, types of mutation, dominant and recessive mutations, spontaneous and induced mutations. Mutagenicity testing: Correlation of mutagenicity and carcinogenicity: Ames testing, Random and site directed mutagenesis. DNA Repair- Types and evidences.	12
	TOTAL	48

TEXTBOOKS:

1. Glick, B.T and Pastermak J.J (1998) Molecular Biotechnology, Principles and application of recombinant DNA, Washington D.C. ASM press.
2. Howe.C. (1995) Gene Cloning and Manipulations, Cambridge University Press, USA
3. Lewin, B., Gene VI New York, Oxford University Press.
4. Rigby, P.W.J. (1987) Genetic Engineering, Academic Press Inc. Florida, USA.
5. Sambrooket al (2000) Molecular Cloning Volumes I, II, & III Cold spring Harbor Laboratory Press, New York, USA

Reference Books:

1. Walker J.M. and Gingold, E.B. (1983) Molecular Biology and Biotechnology (Indian Edition) Royal Society of Chemistry U.K
2. Karp.G (2002) Cell and Molecular Biology, 3rd Edition, John Wiley and Sons; INC
3.Cell and Molecular Biology- P.K. Gupta, Rastogi Publishers, Meerut.

Subject Name: Practical on Molecular Biology		**Subject Code:** MIB152M511
Course Level-300	**Credit-4**	**L-T-P-C: 0-0-8-4**

Course Outcome:

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the basic concepts in molecular biology.	**BT 1**
CO 2	**Demonstrate** the concepts in understanding the formation of various molecular events in life forms.	**BT 2**
CO 3	**Apply** the theoretical knowledge in carrying out practical assigned.	**BT 3**

CO 4	**Analyze** and **categorize** the various molecular reactions involved in mutations and DNA repair	**BT 4**

Modules	**Topics / Course content**	**Periods**
I	1. Isolation of genomic DNA from Bacterial cell 2. Agarose gel electrophoresis for the separation of DNA. 3. Quantification and purity determination of isolated genomic DNA by UV-spectrophotometry and agarose gel electrophoresis.	**24**
II	4. Primer designing for gene-specific DNA amplification 5. DNA amplification through PCR.	**24**
III	6. Quantification and purity determination of isolated genomic DNA by UV-spectrophotometry and agarose gel electrophoresis. 7. Extraction of RNA from Bacterial cell	**24**
IV	8. Restriction digestion of DNA 9.ORF Finding in the genome, blast, and phylogenic tree development with MEGA tools 10- Exploration of NCBI tools, PDB, Restriction site finder	**24**
Total		**96**

TEXTBOOKS:

1. Glick, B.T and Pastermak J.J (1998) Molecular Biotechnology, Principles and application of recombinant DNA, Washington D.C. ASM press.
2. Howe.C. (1995) Gene Cloning and Manipulations, Cambridge University Press, USA
3. Lewin, B., Gene VI New York, Oxford University Press.
4. Rigby, P.W.J. (1987) Genetic Engineering, Academic Press Inc. Florida, USA.
5. Sambrooket al (2000) Molecular Cloning Volumes I, II, & III Cold spring Harbor Laboratory Press, New York, USA

Reference Books:

1. Walker J.M. and Gingold, E.B. (1983) Molecular Biology and Biotechnology (Indian Edition) Royal Society of Chemistry U.K

2. Karp.G (2002) Cell and Molecular Biology, 3rd Edition, John Wiley and Sons; INC
3.Cell and Molecular Biology- P.K. Gupta, Rastogi Publishers, Meerut.

Name of the subject: Phycology, Mycology, and virology	**Subject code: MIB152M502**	
Course Level: 100	**Credit units: 3**	**L-T-P-C-3-0-0-3**

Course Objective:

This course is design to make students learn about the characteristic features of algae, fungi and their classification. The course also includes the application of algae and fungi in different areas.

Course Outcome: On completion of the course the students will be expected to

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the cell structure, life cycles and economic importance of algae.	**BT 1**
CO 2	**Understand** the cell structure, life cycles and economic importance of fungi.	**BT 2**
CO 3	**Developing** the knowledge lichens and mycorrhiza.	**BT 3**
CO 4	**Understanding** viral origin, and structure of viroids, virusoids and prions and their mode of pathogenicity.	**BT 4**

Detailed Syllabus:

Modules	**Topics (if applicable) & Course Contents**	**Periods**
I.	**Phycology:** General characteristics; Ecology and distribution; Range of thallus organization and reproduction; Classification of algae; Alternation of Generation (Haplontic, Diplontic, haplo-diplo and Diplo-haplontic type); Diagnostic characters of Cyanophyceae, Rhodophyceae, Chlorophyceae, Charophyceae and Phaeophyceae; Life cycles of *Nostoc*, *Volvox*, *Chara*,	**18**

	Vaucharia, Oedogonium, Oscillatoria and *Polysiphonia* with special reference to alternation of generation; Role of algae in the environment, agriculture, biotechnology, and industry.	
II.	**Mycology**: General characteristics; Range of hyphal form and organization; Cell wall composition; Nutrition; Reproduction; Classification; Diagnostic characters of Oomycotina, Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina, Deuteromycotina; Life cycle of *Mucor, Saccharomyces*, *Rhizopus*, *Alternaria*, *Penicillium*, *Agaricus*; Economic Importance of fungi.	**15**
III.	**Lichens:** General characteristics; Reproduction and significance; **Mycorrhiza:** ectomycorrhiza and endomycorrhiza, and their significance in agriculture and forestry	**12**
IV	**Virology:** Introductions of viruses, discovery of viruses, biological status (nature) and general properties of viruses; Theories of viral origin. Forms and structure of viruses, capsid symmetry, enveloped and non-enveloped viruses. General concept of viroids, virusoids/satellite viruses and prions. Viral taxonomy: classification and nomenclature of different groups of viruses. Isolation, purification and cultivation of viruses.Introduction to oncogenic viruses. Types of oncogenic DNA and RNA viruses: Concepts of oncogenes and proto-oncogenes.	**15**
	TOTAL	**60**

Text Books:

1. Barasanti L and Guaaltieri P. (2006). Algae: Anatomy Biochemistry and Biotechnology. Taylor and Francis Group,New York

2. Dube HC. (1981). An Introduction to Fungi. Vikas Publishing House Pvt. Ltd.

3. Raham LE, Graham JM and Wilcox LW. (2009). Algae.2nd edition. Benjamin Cumming, New York.

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

5. Carter J and Saunders V (2007). Virology: Principles and Applications. John Wiley and Sons.
6. Flint SJ, Enquist, LW, Krug, RM, Racaniello, VR, Skalka, AM (2004). Principles of Virology, Molecular biology, Pathogenesis and Control.2nd edition. ASM press Washington DC

References:

1. Vashishta BR and Sinha AK. (2008). Fungi. S. Chand and Company Ltd.
2. Webster J. (1980). Introduction to Fungi.2nd edition. Cambridge University Press
3. Mathews. (2004). Plant Virology. Hull R. Academic Press, New York.
4. Nayudu MV. (2008). Plant Viruses. Tata McGraw Hill, India.

Paper: Practical on Phycology, Mycology and Virology		**Subject code: MIB152M512**
Course Level: 100	**Credit units: 1**	**L-T-P-C-0-0-2-1**

Course Objective:

This course is designed with the objective to generate fundamental concept among students about preparation and microscopic examination of algae, fungi, lichen and mycorrhiza. The course also provides fundamental idea of animal and plant viruses.

Course Outcomes

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Generate** idea about different classes of algae and their identification.	**BT 1**
CO 2	**Understand** fungal cell wall structure and structure of different group.	**BT 2**
CO 3	**Recognize** growth form of lichens and mycorrhiza.	**BT 3**
CO 4	**Develop** knowledge about plant, animal viruses and bacteriaphages.	**BT 4**

Detailed Syllabus:

Modules	Topics (if applicable) & Course Contents	Periods
I.	**Phycology:** 1. Study of vegetative and reproductive structures through temporary preparations of *Nostoc, Vaucharia, Volvox* and *Polysiphonia* 2. Study of vegetative and reproductive structures through permanent slides of *Nostoc, Vaucharia, Volvox, Oscillatoria, Coleochaete* and *Polysiphonia*	**15**
II.	**Mycology**: 1. Study of vegetative and reproductive structures through temporary preparations of *Mucor, Saccharomyces, Alternaria* and *Penicillium* 2. *Mucor, Saccharomyces* and *Penicillium*: Asexual stage from temporary mounts and sexual structures through permanent slides. 3. *Agaricus*: Specimens of button stage and full-grown mushroom; Sectioning of gills of *Agaricus*.	**15**
III.	**Lichens:** 1. Lichens: Study of growth forms of lichens (crustose, foliose, and fruticose) 2. Mycorrhiza: ecto-mycorrhiza and endo-mycorrhiza life cycle study (Photographs) 3. Isolation of mycorrhiza from soil	**05**
IV	**Virology:** 1. EMs/Models of -T-Phage 2. EMs/Models of -TMV 3.Isolation and enumeration of bacteriophages (PFU) from water/sewage sample	**05**
	TOTAL	**40**

Text books:

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

2. Carter J and Saunders V (2007). Virology: Principles and Applications. John Wiley and Sons.

3. Flint SJ, Enquist, LW, Krug, RM, Racaniello, VR, Skalka, AM (2004). Principles of Virology, Molecular biology, Pathogenesis and Control. 2nd edition. ASM press Washington DC.

4. Levy JA, Conrat HF, Owens RA. (2000). Virology. 3rd edition. Prentice Hall publication, New Jersey.

5. Wagner EK, Hewlett MJ. (2004). Basic Virology. 2nd edition. Blackwell Publishing.

Reference book:

1. Mathews. (2004). Plant Virology. Hull R. Academic Press, New York.

2. Nayudu MV. (2008). Plant Viruses. Tata McGraw Hill, India.

3. Bos L. (1999) Plant viruses-A text book of plant virology by. Backhuys Publishers.

4. Versteeg J. (1985). A Color Atlas of Virology. Wolfe Medical Publication.

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Paper: Medical microbiology		**Subject code:** MIB152N501
Course Level: 300	**Credit units: 4**	**L-T-P-C-3-1-0-4**

Course Objective:

This course is design with an objective to provide the basic information related to bacterial, viral, fungal and protozoan diseases and their diagnosis. Further, this course also provides up to date information regarding different serological and molecular based methods to detect the pathogens involve in causing disease

Course Outcome: On completion of the course the students will be expected to

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the basic concept of pathogenesis and transmission and life cycle.	**BT 1**
CO 2	Understanding of normal microflora of human body; role of resident flora. Host-parasite relationships, Infection type.	**BT 2**
CO 3	Apply the knowledge of antimicrobial agents and antibiotics as chemotherapeutic agents.	**BT 3**
CO 4	**Analyze**of the Emerging communicable diseases (Plague, Anthrax) and their control.	**BT 4**

Detailed Syllabus:

Modules	Topics (if applicable) & Course Contents	Periods
I.	**Normal microflora of the human body and host pathogen interaction** Normal microflora of the human body: Importance of normal microflora, normal microflora of skin, throat, gastrointestinal tract, urogenital tract. Host pathogen interaction: Definitions - Infection, Invasion, Pathogen, Pathogenicity, Virulence, Toxigenicity, Carriers and their types, Opportunistic infections, Nosocomial infections. Transmission of infection, Pathophysiologic effects of LPS	**15**
II.	**Importance of Diagnosis of Diseases** Bacterial, Viral, Fungal and Protozoan Diseases of various human body systems, Disease associated clinical samples for diagnosis.	**15**
III.	**Collection of Clinical Samples** Method of collecting clinical samples (oral cavity, throat, skin, Blood, CSF, urine and faeces) and precautions required. Method of transport of clinical samples to laboratory and storage.	**15**
IV	**Serological and Molecular Methods** Serological Methods-Agglutination, ELISA, immunofluorescence, Nucleic acid based methods - PCR, Nucleic acid probes. Testing for Antibiotic Sensitivity in Bacteria:Importance, Determination of resistance/sensitivity of bacteria using disc	**15**

	diffusion method; Determination of minimal inhibitory concentration (MIC) of an antibiotic by serial double dilution method.	
	TOTAL	**60**

Textbooks:

1. Ananthanarayan R and Paniker CKJ (2009)Textbook of Microbiology, 8th edition, Universities Press Private Ltd.
2. Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. (2013) Jawetz, MelnickandAdelberg's Medical Microbiology. 26th edition. McGraw Hill Publication

3. Tille P (2013) Bailey's and Scott's Diagnostic Microbiology, 13th edition, Mosby

References:

1. Collee JG, Fraser, AG, Marmion, BP, Simmons A (2007) Mackie and Mccartney Practical Medical Microbiology, 14th edition, Elsevier.
2. Randhawa, VS, Mehta G and Sharma KB (2009) Practicals and Viva in Medical Microbiology2nd edition, Elsevier India Pvt Ltd

SYLLABUS (6th SEMESTER)

Paper: Genetic Engineering	**Subject code:** MIB152M601	
Course Level-300	**Credit units: 4**	**L-T-P-C-4-0-0-4**

Course Objective:

This course is designed to provide the basic idea about genetic manipulation, the role of different enzymes used, and different techniques involved in the identification and amplification of specific DNA sequences. Further, this course also provides information regarding basic marker techniques used in DNA fingerprinting.

Course Outcome: On completion of the course the students will be expected to

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the basic concept of genome organization and omics approaches	**BT 1**
CO 2	Understanding of the replication, Transcription, and mechanism in the cell	**BT 2**
CO 3	apply the knowledge of genome organization in mutation and virulence gene study	**BT 3**
CO 4	Analysis of genetic material to correlate gene mutation and its impact on function	**BT 4**

Detailed Syllabus:

Modules	**Topics (if applicable) & Course Contents**	**Periods**
I.	Introduction to Genetic Engineering, Recombinant DNA technology (r-DNA technology), Restriction enzymes- Introduction, types and its functions; Restriction modification, DNA polymerases, Ligases, and DNA modifying enzymes, Cohesive and blunt end ligation. Linkers, adaptors, homopolymeric tailing.	**12**
II.	Cloning vectors: Plasmids, types of plasmids, cosmids, phagemids, artificial chromosome vectors (BAC, YAC), Phage biology Lytic and Lysogenic cycle, phage as a cloning vector, replacement and integrated vector.	**12**

III.	Hybridization techniques- Southern, Northern and Western Hybridization, DNA and RNA probes; Construction of libraries and its screening (genomic and c DNA libraries), PCR and its applications, types of PCR- Gradient, Reverse transcriptase, Real time PCR.	**12**
IV	Basics of marker methods in molecular biology: RAPD, RFLP, AFLP, microarrays, DNA fingerprinting. Introduction of DNA into mammalian cells, transfection techniques; vectorless DNA delivery. Synthetic biology definition, the subfield of synthetic biology (DNA synthesis, DNA-based bio circuits, minimal genome, protocells, Chemical synthetic biology), Genetic manipulation, Gene editing tools (CRISPER-CAS system, Tallen etc.)	**12**
	TOTAL	**48**

Reference Books:

1) S.B. Primrose, R.M. Twyman and R.W.Old; Principles of Gene Manipulation. 6th Edition, S.B.University Press, 2001.
2) J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL, 2001.

Suggested Readings:

1) J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols1-3, CSHL, 2001.
2) Campbell AM &Heyer LJ, Discovering Genomics, Proteomics & Bioinformatics, 2nd Edition. Benjamin Cummings 2007.
3) Singh, B.D. Biotechnology, Kalyani publishers, India.

4-N. Trun and J. Trempy, Fundamental Bacterial Genetics, Blackwell publishing, 2004.

5-Strachan T and Read A P, Human molecular genetics, 3rd Edition Wiley Bios, 2006. Mange E J and Mange A. P., Human genetics, 2nd Edition, Sinauer Associates publications, 1999.

6-S.R. Maloy, J.E. Cronan, D. Friefelder, Microbial Genetics, 2nd Edition, Jones and Bartlett Publishers, 1994.

Pharmaceutical Microbiology		**Subject code:** MIB152M602
Course Level: 300	**Credit units: 4**	**L-T-P-C-3-1-0-4**

Course Objective:

This course is designed to provide knowledge about the microorganisms commonly used in pharmaceutical industries, sources of contamination, and spoilage of pharmaceutical products. Further, this course will also provide different Government regulatory practices and policies for the pharmaceutical industry.

Course Outcome: On completion of the course the students will be expected to

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	Remember the concept in Pharmaceutical microbiology, important microbes, and microbial products	**BT 1**
CO 2	Understanding the basics of pharmaceutical microbiology and ir microorganisms playing a role pharmaceutically	**BT 2**
CO 3	Apply the knowledge to develop a valuable microbial product	**BT 3**
CO 4	Analysis of the issue in the pharmaceutical industry related to microbes	**BT 4**

Detailed Syllabus:

Modules	**Topics / Course content**	**Periods**
I	An introduction and application of pharmaceutical microbiology; Basic aspects of pharmaceutical microbiology; Biology of pharmaceutically important microorganisms: Bacteria and fungi (yeast and molds); Study of microbial growth cycle, Microbiological growth media; Assessment of	**15**

	microbial growth; Isolation, identification, and characterization methods of microorganisms; Handling, cultivation, and preservation methods of microorganisms; Physical and chemical factors influencing microbial growth.	
II	Microbial products in pharmaceutical industry: impacts and opportunities; antibiotics, production of antibiotics antifungal agents, antiviral, antiprotozoal drugs, small molecules, growth factors, hormones, vitamins, therapeutic enzymes, recombinant proteins, immunological products and vaccines etc.;	**15**
III	Microbial sources, contamination and spoilage of pharmaceuticals; Factors affecting microbial spoilage of pharmaceutical products; Microbial control in pharmaceutical industries; Antimicrobial resistance, Methodologies for testing of antimicrobial activity (broth-dilution methods and agar diffusion methods); Antimicrobial/preservative efficacy testing	**15**
IV	Microbial production of pharmaceuticals; Primary metabolic products, Secondary metabolic products; History and discovery of microbial natural products; Screening and development approaches for new microbial natural products; Good laboratory/manufacturing practices for pharmaceuticals production, validation and regulation; Government regulatory practices and policies for pharmaceutical industry: Food and Drug Administration (FDA), The Central Drugs Standard Control Organisation (CDSCO), the Drug Controller General of India (DCGI); patenting of pharmaceutical products.	**15**
Total		**60**

Textbooks:

1. Geoff Hanlon & Norman A (2013). HodgesEssential Microbiology for Pharmacy and Pharmaceutical Science, Wiley-Blackwell
2. Madhu Raju Saghee , Tim Sandle , Edward C. Tidswell (2011). Microbiology and Sterility Assurance in Pharmaceuticals and Medical Devices,Business Horizons.
3. Geoff Hanlon, Norman A. Hodges (2013). Essential Microbiology for Pharmacy and Pharmaceutical Science,Wiley-Blackwell. 41

References:

1. Stephen P. Denyer , Norman A. Hodges, Sean P. Gorman , Brendan F. Gilmore (2011). Hugo and Russell's Pharmaceutical Microbiology,Wiley-Blackwell.
2. Prahlad Singh Mehra (2011). A Textbook of Pharmaceutical Microbiology,I K International Publishing House

Paper: Inheritance Biology	**Subject code: MIB152M603**
Course Level-300	**Credit units: 4 L-T-P-C-4-0-0-4**

Course Objective:

The course is developed with an objective to understand the fundamental principles of Mendelian inheritance, including multiple allelism, lethal alleles, gene interactions, and sex-linked transmission. The course is also designed to enable the students to apply the principles of inheritance as formulated by Mendel and understand basic aspects of the flow of genetic information from DNA to proteins. Further, this course will enable students to understand the structure and its functional role in encoding genetic material.

Course Outcome: On completion of the course the students will be expected to

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	Remember the basic concept of genetics.	**BT 1**
CO 2	Understanding the transmission of character from one generation to generation	**BT 2**
CO 3	Apply the Mendelian law and another concept to recognize the genetic disorder	**BT 3**
CO 4	Analysis Patterns of inheritance of character generation to generation	**BT 4**

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Rules of Inheritance: Milestones in genetics, Mendelian genetics- Examples In pea plants, Drosophila and human, Patterns of inheritance, concept of gene.	**12**
II	Chromosomes as genetic material: Inheritance, Types, structure, Mitosis, Meiosis, polytene chromosome. DNA as the genetic material: - Structure, replication, gene expression- transcription, translation, and recombination.	**12**
III	Genome – Prokaryotic and Eukaryotic genome organization, Organelle genomes and Jumping genes, Genetic basis of heritable change – Mutation and its effects, chromosomal variations, Chromosomal syndromes	**12**
IV	Animal development – Embryogenesis, Genes involved in early development in Drosophila, Basic body axis formation, Evolution of body plan	**12**
Total		**48**

Textbooks:

1. Brooker, R. J. 1999. Genetics: Analysis and Principles. Benjamin Cummings, Longman, INC.

2. Gardner E. J. M. J. Simmons and D.P. Snustad 1991 Principles of Genetics. John Wiley & Sons. INC. New York.

Reference Books:

1. Griffiths,AJF, Wessler SR, Lewontin RC, Gelbart WM and JH Miller 2005, Introduction to genetic analysis W.H. Freeman and Company, New York.

2. Simmons S 2006, Principles of genetics, 4th Edition, John Wiley & Sons (Asia) Pte Ltd. New Jersey.

3. Klug, W. S. and M. R. Cummings 1994 Concepts of Genetics MacMillan Colley Publishing and Company NY.

4. Strickberger M. W. 1996. Genetics. Mac Millan Publishing Co. NewYork

5. Tamarin,. R H. 1999. Principles of Genetics. McGraw-Hill.

Paper : Practical on Genetic Engineering **Subject code:** MIB152M604

Course Level-300 **Credit units: 4** **L-T-P-C-0-0-8-4**

Course Objective:

This course is design with an objective to provide the practical knowledge and procedure of genomic and plasmid DNA isolation, primer designing, role of different enzymes used in DNA digestion and different techniques involve in the identification and amplification of specific DNA sequences. Further, this course also provides information regarding gene cloning and mutation.

Course Outcome: On completion of the course the students will be expected to

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	Remember the basic concept of genome organization and omics approaches	**BT 1**
CO 2	Understanding of the replication, Transcription, and mechanism in the cell.	**BT 2**
CO 3	apply the knowledge of genome organization in mutation and virulence gene study	**BT 3**
CO 4	Analysis of genetic material to correlate gene mutation and its impact on function.	**BT 4**

Detailed Syllabus:

Modules	**Topics (if applicable) & Course Contents**	**Periods**
I.	1.Isolation of Bacterial Genomic DNA. 2.Isolation of Plasmid from bacterial cell. 3. Study different conformations of plasmid DNA through agarose gel electrophoresis.	**24**
II.	5. Study the effect of chemical (HNO2) and physical (UV) mutagens on bacterial cells. 6. Study survival curve of bacteria after exposure to ultraviolet (UV) light.	**24**

	7.Demonstration of bacterial conjugation.	
III.	8.Competent cell preparation in *E.coli* 9.Transformation through heat shock method in *E.coli*. 10.Digestion of DNA using restriction enzymes and analysis by agarose gel electrophoresis	**24**
IV	12.Designing of primers for DNA amplification 13.Amplification of DNA by PCR	**24**
TOTAL		**96**

Reference Books:

1. Klug WS, Cummings MR, Spencer, C, Palladino, M (2011). Concepts of Genetics, 10th Ed., Benjamin Cummings

2. Krebs J, Goldstein E, Kilpatrick S (2013). Lewin's Essential Genes, 3rd Ed., Jones and Bartlett Learning

3. Pierce BA (2011) Genetics: A Conceptual Approach, 4th Ed., Macmillan Higher Education Learning

4. Watson JD, Baker TA, Bell SP et al. (2008) Molecular Biology of the Gene, 6th Ed., Benjamin Cummings

5. Gardner EJ, Simmons MJ, Snustad DP (2008). Principles of Genetics. 8th Ed. Wiley-India

Suggested reading

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

2. Sambrook J and Russell DW. (2001). Molecular Cloning: A Laboratory Manual. 4th Edition, Cold Spring Harbour Laboratory press.

3. Maloy SR, Cronan JE and Friefelder D (2004) Microbial Genetics 2nd EDITION., Jones and Barlett Publisher.

Paper II: Food Microbiology	**Subject code:** MIB152N601	
Course Level-300	**Credit units: 4**	**L-T-P-C-4-0-0-4**

Course Outcome: On completion of the course the students will be expected to

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	Remember the Micro-organisms and their importance in food microbiology – molds, yeast, bacteria	**BT 1**
CO 2	Understanding of the organisms, and different factors those influence microbial growth in food	**BT 2**
CO 3	apply the knowledge of microbes in Food fermentation **–** Bread, vinegar, fermented vegetables, fermented dairy products	**BT 3**
CO 4	Analysis of the microbial potential for fermentation and product development	**BT 4**

Detailed Syllabus:

Modules	**Topics / Course content**	**Periods**
I	Micro-organisms and their importance in food microbiology – molds, yeast, bacteria, general features, classification; principles of food preservation; asepsis – control of micro-organisms (anaerobic conditions, high temperature, low temperature, drying); factors influencing microbial growth in food – extrinsic and intrinsic factors; chemical preservation and food additives; canning process for heat treatment. Contamination and Spoilage **–** Cereals, Sugar products, vegetables, fruits, meat and meat products; milk and milk products, fish and sea food, poultry, spoilage of canned food; detection of spoilage and characterization.	**12**

II	Food-borne infections and intoxications – bacterial: *Brucella, Bacillus, Clostridium, Escherichia, Shigella, Staphylococcus, Vibrio, Yersinia* and non-bacterial intoxication (with examples of infective and toxic types) – Protozoa, algae, fungi and viruses; food borne outbreaks– laboratory testing procedures, preventive measures, GMP and Hazard Analysis and Critical Control Point (HACCP). Food control agencies and its regulations; Employee's health standards, waste treatment, disposal and quality control.	**12**
III	Food fermentation – Bread, vinegar, fermented vegetables, fermented dairy products; experimental and industrial production methods; spoilage and defects of fermented dairy products; oriental fermented foods – its quality standard and control. Preservation of food: High temperature (Boiling, Pasteurization. Appertization) Low temperature (Freezing): Dehydration. Osmotic Pressure. Chemical Preservations. Radiation	**12**
IV	Microbial cells as food (Single cell protein), mushroom cultivation; fermented beverages –beer and wine; steroid conversion – industrial enzymes, production of amylases, proteinases, cellulases, amino acid production – glutamic acid and lysine; pickles, olives and soy sauce.	**12**
Total		**48**

Textbooks:

1. Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*. 8th edition. McGraw Hill Higher Education.
2. Food Microbiology by William C Frazier. Tata Mgraw Hill
3. Food Microbiology by dams and Moss. Springer Verlag

References:

1. Adams MR & MO Moss (2005). Food Microbiology, New Age International (P) Limited. Publishers; 1st Edition, New Delhi.
2. James M Jay (2004). Modern Food Microbiology, CBS Publishers & Distributors; 4th Edition, New Delhi.
3. William Frazier and Dennis Westhoff (2008) - Food Microbiology McGraw Hill Education; 4 edition.
4. Basic food microbiology by Banwart. Cbs Publishers & Distributors Pvt Ltd.
5. Principles of Microbiology by Ronald M. Atlas (1995), Amy Mc Cullen
6. Fundamental Principles of Bacteriology A J Salle

SYLLABUS (7th SEMESTER)

Paper I: Industrial & Food Microbiology		**Subject code:** MIB152M701
Course Level-400	**Credit-4**	**L-T-P-C-4-4-0-4**

Course Objective:

This course is designed with the objective to provide basic information about the history of microbiological development, Classification of the living system, and basic instruments used for the observation of microbes. Further, this course also designs to provide information about different culture media used for growing microbes, sterilization techniques and distribution of microbes in different environments along with their application in industries.

Course Outcomes

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the contribution made by prominent scientists in this field along with identifying different systems of microorganism in different kind of Industry and food Microbiology.	**BT 1**
CO 2	**Understand** the basic tool and techniques use for the microorganism growth and survival in food.	**BT 2**
CO 3	**Apply** the knowledge gained in solving of problems associated with the topic such Industry and Food spoilage.	**BT 3**
CO 4	**Analyze** the components of the cellular structure in prokaryotes, eukaryotes and its analysis through sophisticated techniques.	**BT 4**

Detailed Syllabus:

Modules	Topics (if applicable) & Course Contents	Periods
I.	**Brief history and development of environmental microbiology:** History and development of Food Microbiology, germ theory of fermentation, contribution of various researchers to the field of Food Microbiology, Scope of Food Microbiology,	**16**
II.	**Food Fermentations:** Fermentation –definition and types Microorganisms used in food fermentations, Dairy Fermentations-starter cultures and their types, Microbial Processes & Products, concept of probiotics.	**16**
III.	**Bioprocessing:** Overview of bioprocessing, Growth cultivation-batch and continuous type, Types of fermentation-submerged, solid and surface type, Upstream Processing and Downstream Processing, industrial production of organic food-citric, lactic acid vinegar, enzymes and vitamin B-12.	**16**
IV	**Application of Microorganism in Food Industry:** Application of microorganism in food industry such as meat, vegetables, dairy products and beverages. Probiotics products, Food Safety and HACCP. Case study of Food and Industrial microbiology.	**16**
TOTAL		**64**

Textbooks:

1. Adams MR and Moss MO. (1995). *Food Microbiology*, The Royal Society of Chemistry, Cambridge.
2. Banwart GJ. (1989), *Basic food microbiology*, Chapman & Hall, New York.
3. Jay JM, Loessner MJ and Golden DA. (2005). *Modern Food Microbiology*. 7th edition, CBS Publishers and Distributors, Delhi, India.

Reference Books:

1. Frazier WC and West off DC. (1988) *Food microbiology*, TATA McGraw Hill Publishing Company Ltd. New Delhi.

2. Adams MR and Moss MO. (1995). *Food Microbiology*, The Royal Society of Chemistry, Cambridge.
3. Jay JM, Loessner MJ and Golden DA. (2005). Modern Food Microbiology. 7th edition, CBS Publishers and Distributors, Delhi, India.
4. Prescott, Harley and Klein Wim. Microbiology, C. Brown Publishers

Paper : Environmental and Agricultural Microbiology	**Subject code:** MIB152M702	
Course level-400	**Credit units: 4**	**L-T-P-C-3-1-0-4**

Course Objective:

To provide students a basic understanding of environmental and agricultural microbiology including; microbial diversity in the environment in relation to environment and agricultural welfare, ecosystem wellness, microbial interactions with pollutants in the soil and environment and the fate of microbial pathogens in the environment and agricultural fields.

Course Outcome: On completion of the course the students will be expected to

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the basic concept of microbial diversity biofertilizers and pesticides, microbial waste recycling and bioremediation	**BT 1**
CO 2	Understanding of the microbial interactions with pollutants in the soil and environment and the fate of microbial pathogens in the environment	**BT 2**
CO 3	apply the knowledge to recognize the ecological problems and critical evaluation of the human impacts on pollution, climate changes and as well as environmental protection	**BT 3**
CO 4	**Analyze** the Emerging problems in current environmental and agricultural issues.	**BT 4**

Detailed Syllabus:

Modules	Topics (if applicable) & Course Contents	Periods
I.	Soil Microbiology:, soil as a habitat for micro-organisms, microflora of various soil types, rhizosphere and rhizoplane. Nitrogen fixation: asymbiotic and symbiotic nitrogen fixation systems, root nodulation, symbiotic bacteria (process of root nodule formation), leghemoglobin, nitrification and ammonification. Microbial interactions: Symbiosis, mutualism, commensalism, amensalism, competition, antibiosis, actinorrhiza, mycorrhizal fungi and its effect on plants.	**12**
II.	Aquatic Microbiology: Water ecosystems (fresh water, pond, lakes), marine habitats (estuaries, deep sea, hydrothermal vents), eutrophication, cyanobacterial and microlagal blooms: ecological implications and human health, toxins produced by cyanobacteria and other microalgae.; Extreme environments and extremophilic microbes: Habitats, diversity, adaptations and potential applications. Aero-microbiology - droplet nuclei, aerosol, assessment of air quality.	**12**
III.	Bio-fertilizers and Biopesticides in agriculture: Principles of crop inoculation with microbial agents, microbial inoculants and production, carriers for inoculants: types and characteristics, strain selection of bacteria, cyanobacteria and microalgae for biofertilizer production, phosphate solubilizing microorganisms, plant growth promoting rhizobacteria, (PGPR), biocontrol agents.	**12**
IV	Bioremediation of Xenobiotics, petroleum, oil spill, Microbial remediation of heavy metal pollution, tolerance to heavy metal by microbes, resistance developed in microbes to heavy metals, Microbial deterioration and degradation of plant food materials, leather, store and buildings materials, paper and other cellulosic materials, fuel and lubricants, metals, plastics, cosmetics, pharmaceutical products.	**12**
	TOTAL	**48**

Text Books

1. Subba Rao NS (1995). Soil Microbiology, Oxford & IBH Publishing Co. Pvt. Ltd, 4th edition.
2. Rangaswami G, Bhagyaraj DJ (2001). Agricultural Microbiology, Prentice Hall of India, New Delhi, 2nd edition.

Reference Books:

1. Ljungdahl LG, Adams MW, Barton LL, Ferry JG, Johnson MK (2003). Biochemistry and Physiology of Anaerobic Bacteria, Springer. 8. Madigan MT, Martinko JM, Dunlap PV, Clark DP (2012).
2. Brock Biology of Microorganisms, Prentice Hall, USA.

3. Environmental Biotechnology: Principles and Applications by Bruce E Rittman and Perry L McCarty, McGraw-Hill International editions
4. Dubey RC, Maheswari DK (1999). Textbook of Microbiology, S. Chand & Co. 4. Evans GM, Furlong JC (2011).
5. Environmental Biotechnology- Theroy and application. Wiley-Blackwell.
6. Maier RM, Pepper IL, Gerba CP (2009). Environmental microbiology, Elsevier.
7. Osborn AM, Smith CCJ (2005). Molecular microbial ecology, Taylor & Francis US.

Paper : Microbial Physiology and Metabolism	**Subject code:** MIB152M703
Course level-400	**Credit units: 4** **L-T-P-C-4-0-0-4**

Course Objective:

This course is design with an objective to provide the basic idea about the microbial growth and the impact of different environmental factors on their growth and adaptation. Further, this course also provides information regarding assimilation of different nutrients and detail idea about microbial metabolism.

Course Outcome: On completion of the course the students will be expected to

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the growth characteristics of the microorganisms capable of growing under unusual environmental condition of temperature, oxygen, and solute and water activity	**BT 1**
CO 2	**Understand** various physical parameters which affect production of industrial products by the microorganisms and the safety aspects of the production and use of these products	**BT 2**
CO 3	**Apply** the knowledge to Identify different food born microorganism and develope food preservation techniques.	**BT 3**
CO 4	**Analyze** the practical knowledge to Develope laboratory skills in the production of alcohol and enzymes by fermentative process using bacteria/yeast; skills for laboratory testing and quality control of food.	**BT 4**

Detailed Syllabus:

Modules	Topics (if applicable) & Course Contents	Periods
I.	**Microbial Growth and Environmental Effect on Microbial Growth** Definitions of growth, measurement of microbial growth, Batch culture, Continuous culture, generation time and specific growth rate, synchronous growth, diauxic growth curve. Microbial growth in response to environment -Temperature (psychrophiles, mesophiles, thermophiles, extremophiles, thermodurics, psychrotrophs), pH (acidophiles, alkaliphiles), solute and water activity (halophiles, xerophiles, osmophilic), Oxygen (aerobic, anaerobic, microaerophilic, facultative aerobe, facultative anaerobe), barophilic. Microbial growth in response to nutrition and energy–Autotroph/Phototroph, heterotrophy, Chemolithoautotroph, Chemolithoheterotroph, Chemoheterotroph, Chemolithotroph, photolithoautotroph, Photoorganoheterotroph.	**12**
II.	**Nutrient uptake and Transport** Passive and facilitated diffusion; Primary and secondary active transport, concept of uniport, symport and antiport; Group translocation; Iron uptake.Aerobic Respiration:Concept of aerobic respiration, anaerobic respiration and fermentation; Sugar degradation pathways i.e. EMP, ED, Pentose phosphate pathway: TCA cycle. Electron transport chain: components of respiratory chain, comparison of mitochondrial and bacterial ETC, electron transport phosphorylation, uncouplers and inhibitors.	**12**
III.	**Chemoheterotrophic Metabolism- Anaerobic respiration and fermentation** Anaerobic respiration with special reference to dissimilatory nitrate reduction (Denitrification; nitrate /nitrite and nitrate/ammonia respiration; fermentative nitrate reduction) Fermentation - Alcohol fermentation and Pasteur effect; Lactate fermentation (homofermentative and heterofermentative pathways), concept of linear and branched fermentation pathways.	**12**
IV	**Chemolithotrophic and Phototrophic Metabolism** Introduction to aerobic and anaerobic chemolithotrophy with an example each. Hydrogen oxidation (definition and reaction) and methanogenesis (definition and reaction). Introduction to phototrophic metabolism - groups of phototrophic microorganisms, anoxygenic vs. oxygenic photosynthesis with reference to photosynthesis in green bacteria, purple bacteria and cyanobacteria.	**12**
	TOTAL	**48**

Textbooks:

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

Reference Books:

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

Minor: Practical on Food and Environmental Microbiology Subject code: MIB152M704

Course level -400 **Credit units: 4** **L-T-P-C-4-0-0-4**

Course Objective:

This course is design with an objective to provide information on different biochemical test used for identification of bacterial organisms from different food samples. Further, this course also designs to include different test employed for checking the food quality and to familiarize the student with basic practical knowledge in environmental, Soil and food Microbiology.

Course Outcome: On completion of the course the students will be expected to

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** different microbial species involved in the spoilage of different food types and the importanance of removing microbes from	**BT 1**
CO 2	**Understand** about many important microbes that are important in food industries as well as in the environment.	**BT 2**

CO 3	**Apply** the importanance of removing microbes from such food items	**BT 3**
CO 4	**Analyze** bacterial diseases that is associated with the consumption of contaminated foods, the estimation of DO of organisms in environment.	**BT 4**

Detailed Syllabus:

Modules	**Topics (if applicable) & Course Contents**	**Periods**
I.	**Food micro-organisms:** Determination of microorganism in Food / water Samples: Standard plate count, Most probable numbers, Direct microscopic counts, Biochemical test. Collection of milk samples from infected milking cow shed areas and application of COB (Clot on boiling) Test and MR (Milk Ring) Test to study the level of adulteration of milk	**16**
II.	**Food and Dairy Microbiology:** MBRT of milk samples and their standard plate count, Alkaline phosphatase test to check the efficiency of pasteurization of milk, Isolation of any food borne bacteria from food products, Isolation of spoilage microorganisms from spoiled vegetables/fruits, Isolation of spoilage microorganisms from bread, Preparation of Yogurt/Dahi.	**16**
III.	**Microbes in environment and its isolation:** Analysis of soil - pH, moisture content, Isolation of microbes (bacteria & fungi) from soil (28ºC & 45ºC), Isolation of microbes (bacteria & fungi) from rhizosphere and rhizoplane, Assessment of microbiological quality of water, Determination of BOD of waste water sample.	**16**
IV.	**Microbes in Environment:** Estimation of DO, in water sample; Estimation H_2S and residual chlorine content in water; Assessment of microbiological quality of water; Study the presence of microbial activity by detecting (qualitatively) enzymes (dehydrogenase, amylase, urease) in soil. Isolation of *Rhizobia* from root nodule using Yeast Extract Agar Medium (YEMA). Study of anatogonism of micro-organism by dual culture inoculation method (Bacterium Vs Bacterium; Bacterium Vs fungus; Fungus Vs Fungus).	**16**
	TOTAL	**64**

Text Books:

1. Quality Control in the Food Industry V1, S Herschdoerfer,ISBN: 9780323152068,: Academic Press, 1967

2. Principles of Sensory Evaluation of Food- 1965 MA Amerine, RM ,Pangborn and EB Roessler, Elsevier.
3. Harrigan WF (1998) Laboratory Methods in Food Microbiology, 3rd ed. Academic Press.
4. Garg N, Garg KL and Mukerji KG (2010) Laboratory Manual of Food Microbiology I K International Publishing House Pvt. Ltd.
5. Jay JM, Loessner MJ, Golden DA (2005) Modern Food Microbiology, 7th edition. Springer.
6.Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing, USA

Reference Books:

1. Madigan MT, Martinko JM and Parker J. (2014). Brock Biology of Microorganisms. 14th edition. Pearson/ Benjamin Cummings
2. Maier RM, Pepper IL and Gerba CP. (2009). Environmental Microbiology. 2nd edition, Academic Press
3. Okafor, N (2011). Environmental Microbiology of Aquatic & Waste systems. 1st edition, Springer,New York
4. Singh A, Kuhad, RC & Ward OP (2009). Advances in Applied Bioremediation. Volume 17, Springer-Verlag, Berlin Hedeilberg

Subject Name: Environmental Microbiology	**Subject code: MIB152N701**
Course Level-400	**Scheme of evaluation: (T)**

Course Objective:

This course is designed with the objective to provide basic information about the history of microbiological development, Classification of the living system, and basic instruments used for the observation of microbes. Further, this course also designs to provide information about

different culture media used for growing microbes, sterilization techniques and distribution of microbes in different environments along with their application in industries.

Course Outcomes

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the contribution made by prominent scientists in this field along with identifying different systems of microorganism in different kind of environment.	**BT 1**
CO 2	**Understand** the basic tool and techniques use for the microorganism growth and survival in extreme environment.	**BT 2**
CO 3	**Apply** the knowledge gained in solving of problems associated with the topic such environmental clean-up, bioremediation, bioaugmentation.	**BT 3**
CO 4	**Analyze** the components of the cellular structure in prokaryotes, eukaryotes and its analysis through sophisticated techniues.	**BT 4**

Detailed Syllabus:

Modules	Topics (if applicable) & Course Contents	Periods
I.	**Brief history and development of environmental microbiology:** History and development of microbial ecology highlighting significant contributions of microbiologists.	**16**
II.	**Microbial diversity in normal environments:** Diversity of microbes in terrestrial , aquatic, atmosphere animal and their potential applications.	**16**
III.	**Bioremediation of environmental Contaminants:** Pollutant, Petroleum hydrocarbons and pesticides. Bio-recovery of metals, Bio composting **Waste management**: Treatment of sewage (Primary, Secondary and Tertiary treatments), Solid waste management.	**16**

IV	**Application of Environmental Microbiology and Case Study:** Application of Microorganism in various field of environmental microbiology and pollutant removal.	**16**
	TOTAL	**64**

Textbooks:

1.Ian L. Pepper, Charles P. Gerba and Terry J. Gentry (2015). *Environmental Microbiology*. 1st edition. Academic Press.

2. Mohapatra P. (2008). *Textbook of environmental microbiology*. 1st edition (reprint), I. K. Internation publishing house, .

Reference Books:

1.Sarma PD (2005). *Environmental Microbiology*. 1st edition. Alpha Science International, 2005.

2.Cindy H. Nakatsu, Robert V. Miller, Suresh D. Pillai (2020). *Manual of Environmental Microbiology, A Laboratory Manual*. 1st edition. John Wiley & Sons.

3.Bhatia SC. (2007). *Handbook Of Environmental Microbiology*. 1st edition. Atlantic Publishers & Distributors (P) Limited, New Delhi, India.

4.Karnawal A. (2022). *Environmental Microbiology: Advanced Research and Multidisciplinary Applications* 2nd edition. Bentham Science Pub.

SYLLABUS (8th SEMESTER)

Minor: Research Methodology and Scientific Writing		**Subject code:** MIB152M801
Course level -400	**Credit units: 4**	**L-T-P-C-4-0-0-4**

Course Objective:

This course is designed with an objective to provide students about the fundamentals of research methods and to enable students to understand, also to gain familiarity with a phenomenon or to achieve new insights into research process. The course will also provide a foundation for the course on IPR and biosafety.

Course Outcome: On completion of the course the students will be expected to

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the necessary preventive measures, handling of live bacteria.	**BT 1**
CO 2	**Demonstrate** how to develop survey questionnaires, development of theoretical framework and conceptual framework.	**BT 2**
CO 3	**Apply** the theoretical knowledge for patent and copyright	**BT 3**
CO 4	**Analyze** the issue in patent filing and other related issue	**BT 4**

Detailed Syllabus:

Modules	**Topics (if applicable) & Course Contents**	**Periods**
I.	**Introduction to Research:** Definition, Scope, Limitations. Essential Steps in Research: Need for Review of Literature, Review process, Bibliography, Data Collection.	**16**
II.	**Types of Research:** Descriptive, Analytical, Qualitative, Quantitative, Applied, Fundamental, Survey, Case Studies. Research Design, Types of Research design.	**16**
III.	**Research Report:** Components of a Research Report, Title, Authors and Addresses, Abstract, Summary, Synopsis, Key words, Materials and Methods, Discussion, Acknowledgements, Appendices, References.	**16**
IV.	**IPR and biosafety:** Introduction, Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge. Biosafety: Introduction: Introduction to Biological Safety Cabinets, Biosafety Levels.	**16**
TOTAL		**64**

Text books

1. Indian Patent Act 1970 Acts & Rules, BAREACT, Universal Law Publishing Co. Pvt. Ltd., 2007

2. Genetic Patent Law & Strategy, 1st Edition, Kankanala C., Manupatra Information Solution Pvt. Ltd., 2007

Reference Books:

1. Cr, K. (2020). Research methodology methods and techniques.
2. Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Age International.

Minor: Agriculture Microbiology		**Subject code: MIB152N801**
Course level -400	**Credit units: 4**	**L-T-P-C-4-0-0-4**

Course Objective:

This course is design with an objective to provide the basic information about the microbes present in the soil and their role in mineralization of different organic and inorganic compounds present in the soil. This course is also design to provide information different microbial pathogens that infect plants and the use of microbes in the field of agriculture as biopesticides or biofertilizer etc.

Course Outcome: On completion of the course the students will be expected to

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the soil property and its profile and the types of microbes present in the soil	**BT 1**
CO 2	**Understand** the role of microbes in degrading or recycling different compounds present in the soil and the production of different gases.	**BT 2**
CO 3	**Apply** the knowledge to Identify different soil pathogens associated with plant diseases.	**BT 3**

CO 4	**Analyze** the knowledge in eradicating plant diseases using microbial agents and the application of both wild type and genetically modified microbes in the field of agriculture	**BT 4**

Detailed Syllabus:

Modules	Topics (if applicable) & Course Contents	Periods
I.	**Soil Microbiology** Soil as Microbial Habitat, Soil profile and properties, Soil formation, Diversity and distribution of microorganisms in soil. Microbial Activity in Soil: Mineralization of cellulose, hemicelluloses, lignocelluloses, lignin and humus, phosphate, nitrate, silica, potassium. Carbon dioxide, methane, nitrous oxide, nitric oxide – production and control.	**16**
II.	**Microbes as Plant Pathogens** Concept of plant disease- definitions of disease, disease cycle & pathogenicity, symptoms associated with microbial plant diseases, types of plant pathogens, economic losses, and social impact of plant diseases. Biocontrol mechanisms and ways, Microorganisms used as biocontrol agents against Microbial plant pathogens, Insects, Weeds	**16**
III.	**Biofertilization, Phytostimulation, Bioinsecticides** Plant growth promoting bateria, biofertilizers – symbiotic (*Bradyrhizobium, Rhizobium, Frankia*), Non-Symbiotic (*Azospirillum, Azotobacter, Mycorrhizae*, MHBs, Phosphate solubilizers, algae), Novel combination of microbes as biofertilizers, PGPRs, General account of microbes used as bioinsecticides and their advantages over synthetic pesticides, *Bacillus thuringiensis*, production, Field applications, Viruses – cultivation and field applications.	**16**
IV.	**Agriculture Biotechnology** Biotech feed, Silage, Biomanure, biogas, biofuels – advantages and processing parameters. Genetically Modified crops**:** Advantages, social and environmental aspects, Bt crops, golden rice, transgenic animals.	**16**
	TOTAL	**64**

Text books

1. Agrios GN. (2006). Plant Pathology.5th edition. Academic press, San Diego,
2. Singh RS. (1998). Plant Diseases Management.7th edition.Oxford & IBH, New Delhi.
3. Glick BR, Pasternak JJ, and Patten CL (2010) Molecular Biotechnology 4th edition, ASM Press,

4. Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing, USA
5. Maier RM, Pepper IL and Gerba CP. (2009).Env.Microbiology. 2nd edition, Academic Press
6. Barton LL & Northup DE (2011). Microbial Ecology. 1st edition, Wiley Blackwell, USA
7. Campbell RE. (1983). Microbial Ecology.Blackwell Scientific Publication, Oxford, England.

Reference Books:

1.Coyne MS. (2001). Soil Microbiology: An Exploratory Approach. Delmar Thomson Learning.
2. Altman A (1998). Agriculture Biotechnology, Ist edition, Marcel decker Inc.
3.Mahendra K. Rai (2005). Hand Book of Microbial Biofertilizers, The Haworth Press, Inc. NewYork.
4.Reddy, S.M. et. al. (2002). Bioinoculants for Sustainable Agriculture and Forestry, Sci.Pubs.
5.Saleem F and Shakoori AR (2012) Development of Bioinsecticide, Lap Lambert Academic Publishing GmbH KG

Paper: Microbial enzyme: Current trend in industry and Healthcare Subject code: MIB152 M4 802

Course Level: 400 Credit units: 4 L-T-P-C-4-0-0-4

Course Objective:

This course will provide detail knowledge about microbial enzymes, its large scale production, recovery of enzymes and different enzyme purification methods. This course is also design with an objective to build a strong foundation in the application of enzymes in industries, medicine, diagnosis etc.

Course Outcome: On completion of the course the students will be expected to

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	Remember on how microbes serve as a source for a large number of enzymes	**BT 1**
CO 2	Understanding how these enzymes are produced in the laboratory, how their production is increased by	**BT 2**

CO 3	Apply practical skill for production and purification of enzymes; factors affecting microbial enzyme production; immobilization of enzymes	**BT 3**
CO 4	Analysis the impact of enzymes on the synthesis of chemicals, food technology, medicine and in healthcare	**BT 4**

Detailed Syllabus:

Modules	**Topics / Course content**	**Periods**
I	Basic concepts of enzymes**:** Nomenclature, classification, methods for determination of enzyme activity. Isolation and purification of enzymes. Enzyme kinetics: Michaelis- Menten equation, effect of pH, substrate concentration, temperature and inhibitors. Isoenzymes and allosteric enzymes. Enzyme inhibition- competitive and non-competitive inhibition	**15**
II	Enzymes from microbial sources, large scale production of enzymes, recovery of enzymes, enzyme purification methods - enzyme precipitation, separation by chromatography, enzyme reactors.	**15**
III	Immobilized enzymes: Physical and chemical methods of immobilization, immobilization supports, kinetics of immobilized enzymes. Enzyme catalysis in apolar medium, reverse micellar entrapment of enzymes and its applications.	**15**
IV	Application of enzymes:synthesis of chemicals using enzymes, food technology and medicine. Enzymes in diagnostic assays. Enzyme electrodes, immunoenzyme techniques.	**15**
Total		**60**

Textbooks:

1. Berg JM,Tymoczko JL,StryerL., Biochemistry. 6th Edition.Freeman (2006).
2. Prakash Singh Bisen, Anjana Sharma, Introduction to Instrumentation in Life Sciences, Taylor and Francis, (2012).
3. James Bailey and David Ollis, Fundamentals of Biochemical Engineering, 2nd edition, McGraw-Hill, (1986).
4. Casida LE, Industrial Microbiology, J. Wiley, (1968).
5. Chisti. Y.Encyclopedia of Bioprocess Technology, Vol-5, John Wiley and Sons, New York.

6. Michael L. Shuler and Fikret Kargi. Bioproccess Engineering: Basic Concepts, 2nd Edition. Prentice Hall. (2001)

Reference Books

1. Fogarty, W.M., Kelly, C.T. Microbial Enzymes and Biotechnology
2. Goutam Brahmachari .Biotechnology of Microbial Enzymes .Academic Press (2016)

Paper I: Parasitology, Medical and Veterinary Microbiology Subject code: MIB152M803

Course Level: 400 **Credit units: 4** **L-T-P-C-3-1-0-4**

Course Objective:

The course is developed with an aim to enable the students develop a proper understanding of different pathogenic microbes, understand the mode of transmission and life cycle of human and animal pathogen, enable understanding of the mode of action of anti-microbial agents and to impart the basic skills for diagnosis and identification of pathogenic microbes.

Course Outcome: On completion of the course the students will be expected to

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	Remember features of pathogenic microbe, mode of transmission and their life cycle	**BT 1**
CO 2	Understand the different symptoms associated with microbial diseases and their diagnosis	**BT 2**
CO 3	Apply the knowledge in the identification of different pathogenic microbes associated with human diseases.	**BT 3**
CO 4	Analyze and develope strategies to tackle the spread of pathogenic microbes in both community and hospital setting	**BT 4**

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Introduction to medical parasitology-classification. Pathogenesis, transmission, life cycle, lab diagnosis, treatment of Protozoa-*Entamoeba, Toxoplasma, Cryptosporidium, Leishmania,Trypanosoma, Plasmodium, Giardia, Trichomonas*and *Balantidium.* Introduction to *Mycobacteria, Brucella, Listeria, Pasturella*and Erysepelas. Spirochetes, *Rickettsiae, Chlamydia, Mycoplasma* and *Ureoplasma.*	**15**
II	Discovery of pathogenic micro-organisms; normal microflora of human body; role of resident flora. Host-parasite relationships, Infection, type and source. Disease cycle (sources of diseases, reservoirs, transmission of pathogens); Intoxications (exotoxins and endotoxins and their mechanism of action). Antimicrobial agents and antibiotics: Antiseptics, chemotherapeutic agents, effect of antibiotics on protein, nucleic acid, cellwall and cytoplasmic membrane.	**15**
III	Morphology, classification, cultural characteristics, pathogenicity and laboratory diagnosis of Staphylococci, Streptococci, Pneumococci, Neisseriae (Gonococci and Meningococci), *Haemophilus, Bordetella, Corynebacterium, Clostridium.*	**15**
IV	Study of Enterobacteriaceae (*E. coli, Klebsiella, Salmonella, Shigella, Proteus*), Vibrios and Nonfermenting Gram negative bacilli. Emerging communicable diseases (Plague, Anthrax) - symptom, identification, monitoring and surveillance and quarantine administration.	**15**
Total		**60**

Textbooks:

1. Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*. 8th edition. McGraw Hill Higher Education.
2. Text Book Of Medical Mycology by JagdishChander, Mehta Publishers, New Delhi
3. Sherris Medical Microbiology : An Introduction to Infectious Diseases by Kenneth Ryan, McGraw-Hill Medical.
4. Jawetz, Melnick, &Adelberg's Medical Microbiology (Lange basic), McGraw-Hill Medical
5. Medical Microbiology by Patrick R. Murray, Michael A. Pfaller, & Ken S. Rosenthal, Elsevier
6. Text book of microbiology by Ananthanarayan and Paniker. Medical Microbiology by Cedric Mims, John Playfair and Ivan roitt. Mosby-wolfe

Reference Books:

1. Jawetz, Melnick, &Adelberg's. (2013). Medical Microbiology. 26th Edition. McGraw-Hill.
2. Dey, N.C., Dey, T.K. and Sinha, D., 1999. Medical Bacteriology including Medical Mycology and AIDS. 17th edition, New Central Book agency. Kolkatta.
3. Finegold, S.M. (2000) Diagnostic Microbiology, 10th Edn. C.V. Mosby Company, St. Louis
4. Chatterjee, 1986. Medical Parasitology. Tata McGraw Hill, New Delhi.
5. Karyakarte, R.P. and Damle, A.S., 2005. Medical Parasitolog. Revised edition. Published by Books and Allied (P) Ltd., Kolkatta.
6. JeyaramPaniker, 2004. Text book of Medical Parasitology. 5th edition, JAYPEE brothers, Medical Publishers (P) Ltd, New Delhi.
7. Veterinary Microbiology and Microbial Disease" by P J Quinn and B K Markey

Paper: Microbiome's role in human and plants health		**Subject code:** MIB152M804
Course Level-300	**Credit units: 4**	**L-T-P-C-3-0-0-3**

Course Objective:

The course is developed with the following objectives:

- To enable the students to develop a proper understanding the microbial community residing in different habitats.
- To understand the role of microbiomes in the environment, in human, and plants.
- To enable understanding of the modern techniques in better understanding of microbiomes.
- To exploit the benefits of the microbial community in benefitting the hosts and also to impart the basic knowledge of microbes in disease.

Course outcome:

- CO-1: Remember the different microbial community present in different environments and hosts.
- CO-2: Understanding the development of the different modern techniques used in different microbiome related work.
- CO-3: Apply the knowledge in gaining insight into the role of microbiome in the health of the hosts.

- ❖ CO-4: Analysis of the role of microbes in different ecosystems and compare the microbial community in different niche.
- ❖ CO-5: Determine the future prospect of different microbial community in providing benefits to the hosts.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Evolution of microbial life on Earth, Symbiosis host-bacteria, Microbial association with plants and animals, Symbiotic and parasitic, Microbiome – definition, History, microbiomes of oceans, lakhs and terrestrial ecosystems, Microbiome ecology, the bacterial, fungal, and viral microbiomes, Microbiome evolution, Earth Microbiome project.	**12**
II	Approaches in Micobiome analysis, genomics, Metagenomics, advanced culturing techniques to study microbiomes. Metagenomics: – definition – principles – methods - whole genome shotgun cloning – metagenomic library production – high throughput screening	**12**
III	Human microbiome: biodiversity and major genera of human-microbiome, human microbiome system as a "holobiont" or "superorganism, microbiome distributions in healthy individuals; composition of specific body sites 'microbiome (nose, skin, oral, urogenital, etc.) - fecal transplants- designer probiotics, Symbiosis-Dysbiosis -Rebiosis, Dynamics microbiome changes from birth to death; pregnancy and the microbiome; personnel microbiome concepts, plant microbiome: microbiome and plant life cycle, microbiome and plant health, microbiome and plant nutrition.	**12**
IV	Microbiome and disease biology: gut-brain conversation, obesity and gut microbiome, microbiome 's role in diseases such as Inflammatory bowel disease (IBD), colitis. diabetes; effects of diet on microbiome; interactions with the immune system and resistance to pathogens; Microbes as neuromodulators, Microbes as cancer therapeutics.	**12**
Total		**48**

Textbooks:

1. Angela E. Douglas (2018). Fundamentals of Microbiome Science – how microbes shape
   animal biology, Princeton University Press, New Jersey, United States.
2. Rob DeSalle and Susan L. Perkins (2015). Welcome to the microbiome. getting to know the trillions of bacteria and other microbes in, on, and around you. Yale University Press.

Reference Books:

1. Rodney Dietert (2016). The Human Superorganism: how the microbiome is revolutionizing
2. the pursuit of a healthy life. Dutton Books.
3. Justin Sonnenburg and Erica Sonnenburg (2014). The good gut: taking control of your
4. weight, your mood, and your long-term health. Penguin Press.
5. Emeran Mayer (2016). The Mind-Gut Connection: How the Astonishing Dialogue Taking
6. Place in Our Bodies Impacts Health, Weight, and Mood. eBook, Harper Wave Books.
7. Martin J. Blaser (2014). Missing Microbes: How the Overuse of Antibiotics Is Fuelling Our Modern Plagues. Harper Collins Publishers. Toronto.
8. Pilar Francino, M (2012). Horizontal Gene Transfer in Book: 978-1-908230-10-2. ebook: 978-1-908230-72-0, Caister Academic Press.