St Aloysius College (Autonomous)

Mangaluru

Re-accredited by NAAC "A^{++}" Grade

Course structure and syllabus of

B.Sc.

MICROBIOLOGY

Under NEP Regulations, 2021

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Re-accredited by NAAC with 'A' Grade with CGPA 3.62/4
Recognized by UGC as a "College with Potential for Excellence"
Conferred "College with "STAR STATUS" by DBT, Government of India.
Centre for Research Capacity Building under UGC-STRIDE

Date:

NOTIFICATION

Sub: Syllabus of **B.Sc. MCROBIOLOGY** under NEP Regulations, 2021.
(As per Mangalore University guidelines)

Ref: 1. Decision of the Academic Council meeting held on 18-12-2021 vide Agenda No: 6.16 (2021-22)
2. Office Notification dated 21-02-2022

Pursuant to the above, the Syllabus of **B.Sc. MCROBIOLOGY** under NEP Regulations, 2021 which was approved by the Academic Council at its meeting held on 18-12-2021 is hereby notified for implementation with effect from the academic year **2021-22**.

PRINCIPAL **REGISTRAR**

To:

1. The Chairman/Dean/HOD.
2. The Registrar's Office
3. Library

Total Credits for the Program: B.Sc. Basic – 136 and B.Sc. Hons. –176

Starting year of Implementation: 2021-22

Learning Outcomes based Curriculum Framework (LOCF) for MICROBIOLOGY

Undergraduate Programme

Preamble

Microbiology is the study of microorganisms or microbes such as 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 the recycling of dead and decaying organic matter in nature. Thus, the science of microbiology has an important role to play in health, agriculture, the 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.

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

8 core courses encompass all important aspects of the discipline of Microbiology and are all compulsory courses.

1. Introduction:

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

2. Learning Outcomes-based approach to Curriculum Planning:

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

Microbiology, the outcomes are defined in terms of the understanding and knowledge of the students in microbiology and the practical skills the students are required to have to be competitive microbiologists so that they are able to play their role as microbiologists wherever required in the society such as the diseases caused by the microbes, their diagnosis, and remedies; the role of microbiologists in the biotechnology industry and how they may be able to fit the bill in the industry.

The students are also trained in such a way that they develop critical thinking and problem-solving as related to microbiology. The curriculum developed and the teaching and the evaluation tasks are such that the students are able to apply their knowledge and training of microbiology to solve the problems of microbiology as these exist or appear from time to time in the society. The curriculum envisions that the students once graduate as specialists in a discipline, have an important role to play in the newer developments and innovations in the future in the subject for the advancement of the discipline.

2.1 Nature and Extent of the Programme:

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

2.2 Aims of Bachelor's degree programme in MICROBIOLOGY:

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

3. Graduate Attributes in Microbiology:

As mentioned earlier, a degree in Microbiology is the first college/university level degree in the country as in several parts of the world. The students graduating with this degree must have a thorough understanding of basic knowledge or understanding of the fundamentals of Microbiology as applicable to wide-ranging contexts. They should have the appropriate skills in Microbiology so as to perform their duties as microbiologists. They must be able to analyze the problems related to microbiology and come up with the most suitable solutions. As microbiology is an interdisciplinary subject the students might have to take inputs from other areas of expertise. So the students must develop the spirit of teamwork. Microbiology is a very dynamic subject and practitioners might have to face several newer problems. To this end, microbiologists must be trained to be innovative to solve such newer problems.

Several newer developments are taking place in microbiology. The students are trained to pick up leads and see the possibility of converting these into products through entrepreneurship. To this end, the students are made to interact with industry experts so that they may be able to see the possibility of their transition into entrepreneurs. They are also made aware of the requirements of developing a Microbiology enterprise by having knowledge of patents, copyrights, and various regulatory processes to make their efforts a success.

Besides attaining the attributes related to the profession of Microbiology, the graduates in this discipline should also develop ethical awareness which is mandatory for practicing a scientific discipline including ethics of working in a laboratory and ethics followed for scientific publishing of their research work in the future. The students graduating in

microbiology should also develop excellent communication skills both in the written as well as spoken language which are a must for them to pursue higher studies from some of the best and internationally acclaimed universities and research institutions spread across the globe.

4. Qualification Descriptors:

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

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

Program Outcomes:

Competencies need to be acquired by the candidate securing a B.Sc. (Basic) or B.Sc. (Hons)

By the end of the program the students will be able to:

1. **PO**. Have a knowledge and understanding of concepts of microbiology and its application in pharma, food, agriculture, beverages, and nutraceutical industries.
2. **PO.** Understand the distribution, morphology, and physiology of microorganisms and demonstrate skills in aseptic handling of microbes including isolation, identification, and maintenance.
3. **PO**. Competent to apply the knowledge gained for conserving the environment and resolving the environmental-related issues.
4. **PO.** Learning and practicing professional skills in handling microbes and contaminants in laboratories and production sectors.
5. **PO.** Exploring the microbial world and analyzing the specific benefits and challenges.
6. **PO.** Applying the knowledge acquired to undertake studies and identify specific remedial measures for the challenges in the health, agriculture, and food sectors.
7. **PO**. Thorough knowledge and application of good laboratory and good manufacturing practices in microbial quality control.
8. **PO.** Understanding biochemical and physiological aspects of microbes and developing broader perspectives to identify innovative solutions for present and future challenges posed by microbes.
9. **PO.** Understanding and application of microbial principles in forensic and working knowledge about clinical microbiology.
10. **PO.** Demonstrate the ability to identify ethical issues related to recombinant DNA technology, GMOs, intellectual property rights, biosafety, and biohazards.
11. **PO.** Demonstrate the ability to identify key questions in microbiological research, optimize research methods, and analyze outcomes by adopting scientific methods, thereby improving employability.
12. **PO**. Enhance and demonstrate analytical skills and apply basic computational and statistical techniques in the field of microbiology.

PROGRAMME SPECIFIC OUTCOMES

PSO.1. Acquired knowledge and understanding of the microbiology concepts as applicable to diverse areas such as medicine, industry, environment, genetics, agriculture, food, and others.
PSO.2. Demonstrate key practical skills/competencies in working with microbes for study and use in the laboratory as well as outside, including the use of good microbiological practices.
PSO.3. Competent enough to use microbiology knowledge and skills to analyze problems involving microbes, articulate these with peers/ team members/ other stakeholders-, and undertake remedial measures/studies, etc.
PSO.4. Developed a broader perspective of the discipline of Microbiology to enable him to identify challenging societal problems and plan his professional career to develop innovative solutions for such problems.

(B3-I) Model Programme Structure for Bachelor of Science (Basic/Hons.) Programme with (Subjects with practical)

[Biochemistry, Biotechnology, Botany, Chemistry, Electronics, Geography, Mathematics, Philosophy, Physics, Statistics, Zoology, Psychology, Microbiology, Physical Education, Yogic Science]

Sem.	Discipline Core (DSC) (Credits)	Discipline Elective(DSE) / Open Elective (OE) (Credits)	Ability Enhancement Compulsory Courses (AECC), Languages (Credits) (L+T+P)		Skill Enhancement Courses (SEC)		Total Credits
					Skill based (Credits) (L+T+P)	Value based (Credits) (L+T+P)	
I	DSC A1(4) A2(2) DSC B1(4) B2(2)	OE-1 (3)	L1-1(3), L2-1(3) (4 hrs. each)	Env. Studies (3) (3+0+0)	SEC-1: Digital Fluency (2) (2+0+0)	Yoga/ Health & Wellness/ Sports NCC/NSS/R&R(S&G)/ Cultural & Others (2) (0+0+4)	25/26
II	DSC A3(4) A4(2) DSC B3(4) B4(2)	OE-2 (3)	L1-2(3), L2-2(3) (4 hrs. each)	SEC-1: Digital Fluency (2) (2+0+0)	Env. Studies (3) (3+0+0)		26/25
Students exiting the programme after securing 46 credits will be awarded UG Certificate in the relevant Discipline provided they secure 4 credits in work based vocational courses during summer term or internship/Apprenticeship in addition to 6 credits from skill-based courses earned during first year.							
III	DSC A5(4) A6(2) DSC B5(4) B6(2)	OE-3 (3)	L1-3(3), L2-3(3) (4 hrs. each)	Indian Constitution (3) (3+0+0)	SEC-2:AI/Financial Edu. & Inv. Aw.(2)(2+0+0)	Yoga/ Health & Wellness/ Sports NCC/NSS/R&R(S&G)/ Cultural & Others (2) (0+0+4)	25
IV	DSC A7(4), A8(2) DSC B7(4), B8(2)	Indian Constitution (3)(3+0+0)	L1-4(3), L2-4(3) (4 hrs. each)	OE-3 (3)	SEC-3: Financial Edu. &Inv.Aw /AI(2)(2+0+0)		25
Students exiting the programme after securing 92 credits will be awarded UG Diploma in Discipline A and B provided they secure 4 credits in skill based Vocational courses offer during first –or –second –year summer term.							
V	DSC A9(4) A10(2) A11(4) A12(2);		DSC B9(4), B10(2),B11(4), B12(2)		SEC-4: SEC-4: Cyber Security(2) (2+0+0)/General Aptitude (3) (2+0+2)		26/27
VI	DSC A13(4) A14(2), A15(4), A16(2);		DSC B13(4), B14(2), B15(4),B16(2)		Internship (2)		26
Students exiting the programme after 3 years will be awarded UG Degree in Disciplines A and B as double majors upon securing 136 credits and satisfying the minimum credit requirements under each category of courses prescribed							
B.Sc. (Honours with Research) in Discipline A			**B.Sc. (Honours) in Discipline A**				
VII	DSC A17(4), A18(2), A19(4), A20(2); Res. Methodology-1 (4)	DSE-E1 (3), Vocational-1(3) Res. Proposal formulation (2)*	DSC A17(4), A18(2), A19(4), A20(2); Res. Methodology-1 (4)		DSE-E1(3), Vocational-1(3)		22
VIII	DSC A21(4)	DSE-E2(3), Vocational -2 (3) Research Project (10+2*)	DSC A21(4),A22(2) Internship/Apprenticeship (4)		DSE –E2(3), E3(3) Vocational -2(3), 3(3);		22
Bachelor of Science Degree Honours with or without research, B.Sc.(Honours with Research) or B.Sc. (Honours) in Discipline A upon securing 176 credits and satisfying the minimum credit requirements under each category of courses prescribed.							

Note: Only those students who secure 75% marks or CGPA if 7.5 and above in the first six semesters may choose to undertake research in the fourth year. Honours students not undertaking research have to do 3to 4 Additional courses/Entrepreneurship courses and Internship/Apprenticeship for 12 credits.

Curriculum Structure for the Undergraduate Degree Program BSc (Basic /Hons.)
Total Credits for the Program: 176
Starting year of implementation: 2021-22
Name of the Degree Program: B.Sc. (Basic/Hons.) Microbiology

Microbiology Program Articulation Matrix:

Semester	Title / Name of the course	Program outcomes that the course addresses (Not more than 3 per course)	Pre-requisite course (s)	Pedagogy	Assessment
I	**G 509 DC1.1** **General Microbiology** **4 Credits** **100 Marks**	1. Knowledge and Understanding of Concepts of microbiology. 2. Learning and practicing Professional skills in handling microbes. 3. Thorough Knowledge an Application of Good laboratory and good manufacturing Practices in Microbial quality control.	PUC or +2 (Life Sciences As one of the Core disciplines)	The general pedagogy to be followed for theory and practical are as under. Lecturing, Tutorials, Group / Individual Discussions, Seminar, Assignments, Counseling, Remedial Coaching. Field/Institution/Industrial visits, Hands-on training, Case observations, Models/charts, preparations, Problem Solving mechanism, Demonstrations, Project presentations, Experiential Documentation and Innovative methods.	LSSSDC (NSDC) assessment and certification For lab Technician or Lab Assistant Job role
	G 509 DC2.1P **General Microbiology** **2 Credits** **50 Marks**				

II	**G 509 DC1.2** **Microbial Biochemistry and Physiology 4 Credits** **100 Marks**	Thorough knowledge and understanding of concepts of microbiology and its application in different microbiological industries.		The general pedagogy to be followed for theory and practical areas under. Lecturing, Tutorials, Group/Individual Discussions, Seminars, Assignments, Counseling, Remedial Coaching. Field/Institution/Industry visits, Hands on training, Case observations, Models/charts preparations, Problem solving mechanism, Demonstrations, Project presentations, Experiential documentation and Innovative methods.	LSSSDC(NSDC) Assessment and certification for lab technician or Lab assistant job role
	G 509 DC2.2 P Microbial Biochemistry and Physiology **2 Credits** **50 Marks**				

Theory: 60:40

Practicum: 50:50 converted as 25+25=50

1. **Ratio of weightage (marks) between Internal & End Semester Examinations for THEORY: 60:40**

   THEORY INTERNAL COMPONENT: 40

   - Two internal tests: **10×2=20**
   - Assignment: **05**
   - Attendance: **05**
   - Continuous Unit wise tests (objective/MCQ): **05**
   - Group projects:**05**

2. Practicum component marks: 50

Internal component of practicum:50 (converted to 25)

Internal:

- Continuous Assessment of all practical experiments: **15**
- Attendance: **05**
- Model practical Test: **20**
- Maintenance of Records: **05**
- Viva: 05

End semester Practicum: 50 (converted to 25)

B. Sc., Microbiology (Basic / Hons.)Semester 1

Course Title: G 509 DC1.1 General Microbiology	
Total Contact Hours: **56**	Course Credits: **4+2**
Formative Assessment Marks: **60%**	Duration of ESA/Exam: **3Hrs**

Course Prerequisite(s): *Mention only course titles from the curriculum that are needed to be taken by the students before registering for this course.*

Course Learning Outcomes

Outcome 1. Have developed a good knowledge of the development of the discipline of Microbiology and the contributions made by prominent scientists in this field.

Outcome 2. Have developed a very good understanding of the characteristics of different types of microorganisms, methods to organize/classify these and, basic tools to study these in the laboratory.

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

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

Outcome 5. Are able to perform basic experiments to grow and study microorganisms in the laboratory.

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs1-12)

Course Outcomes (COs) /Program Outcomes (POs)	1	2	3	4	5	6	7	8	9	10	11	12
1. Thorough knowledge and understanding of concepts of microbiology												
2. Learning and practicing professional skills in handling microbes												
3. 3. Thorough knowledge and application of good laboratory and good manufacturing practices in microbial quality control.												

Course Articulation Matrix relates course outcomes of course with the corresponding program outcomes whose attainment is attempted in this course. Mark 'X' in the intersection cell if a course outcome addresses a particular program outcome.

B.Sc., Microbiology (Basic/ Hons.) Semester 1

Title of the Courses:

Course1: G 509 DC1.1 General Microbiology

Course2: G 509 OE1.1 Microorganisms for Human Welfare

Course1: **G 509 DC1.1, General Microbiology**		Course 2: **G 509 OE1.1 Microorganisms for Human Welfare**	
Number of Theory Credits	Number of lecture hours/semester	Number of Theory Credits	Number of lecture hours/ semester
4	**56**	**3**	**42**

Content of Course 1: Theory: G 509 DC1.1 General Microbiology----56Hrs

UNIT – 1: HISTORICAL DEVELOPMENT OF MICROBIOLOGY----------14Hrs

1. **HISTORICAL DEVELOPMENT OF MICROBIOLOGY- Theory** of spontaneous generation, Biogenesis, and Abiogenesis. Contributions of Anton Van Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister and Edward Jenner, Alexander Fleming, Martinus Beijerinck, Sergei Winogradsky, Elie Metchnikoff. Contributions of Indian scientists in the field of Microbiology. Scope of Microbiology.

   Fossil evidence of microorganisms. Origin of life, primitive cells, and evolution of microorganisms.

2. **MICROSCOPY-** working principle, construction and operation of simple and compound microscopes. Dark -Field Microscope, Fluorescence Microscope, Electron Microscope-Scanning Electron and Transmission Electron Microscopes.

UNIT –2: STAINING, STERILIZATION AND PRESERVATION OF MICROORGANISMS-14Hrs

1. **STAINING**: Nature of strains, principles, mechanism, methods and types of staining- Simple, Differential-Gram staining, Acid fast staining, staining of capsule, cell wall, endospore.

   Sterilization: Principles, types and techniques, Physical, chemical, radiation and mechanical.

2. **MICROBIAL CULTURE METHODS:** Types and uses of Different culture media: Commonly Used Media-Peptone, Meat extract, Yeast agar, Nutrient agar & Nutrient broth. Selective media, Differential Media, Assay media, Maintenance media, Enrichment media. Anaerobic Media, Media for culture of Fungi.

   Culture of Bacteria and Fungi: Methods- The streak plate, pour plate, spread plate. Cultivation of anaerobic bacteria. Maintenance and Preservation of Pure cultures: Methods of Maintenance and Preservation. Culture Collections. Colony Characteristics.

UNIT–3: BACTERIAL GROWTH AND GROWTH CURVE----------14HRS

1. **BACTERIAL GROWTH CURVE**: The lag Phase, The logarithmic Phase, The Stationary Phase and The Decline Phase. Synchronous Growth and Continuous Culture- Chemostat and Turbidostat. Mathematics of Growth: Generation time and growth rate. Factors influencing growth curve.

2. **MEASUREMENT OF MICROBIAL GROWTH**-Methods for Measuring Bacterial Growth: Microscopic Count, Electronic Counter, Plate count, Membrane filter, Turbidimetric measurement, Nitrogen determination, Dry Weight determination, Measurement of biochemical activity.

UNIT–4 PROKARYOTIC MICROORGANISMS: ----------14HRS

1. **OVERVIEW OF PROKARYOTIC CELL STRUCTURE:** Size, shape, arrangement. Ultrastructure of prokaryotic cell: Bacterial and Archaeal-cell wall and cell membrane. Components external to cell wall- capsule, slime, s-layer, pili, fimbriae, flagella; structure, motility, chemotaxis.
2. **CYTOPLAMS COMPOSITION AND ENDOSPORE**. Cytoplasmic matrix- Cytoskeleton, ribosome, inclusion granules: Nuclear Materials – Bacterial structure (its differences with the Eukaryotic chromosome); Extra Chromosomal material. Bacterial Endospore - Examples of spore-forming organisms, habitats, function, formation, and germination. Reproduction in bacteria

PRACTICAL: G 509 DC 2.1P: GENERAL MICROBIOLOGY

1. Microbiological laboratory standards and safety protocols.
2. Operation and working principles of Light/Compound microscope.
3. Working principles and operations of the basic equipment of microbiological laboratory-Laminar Air Flow Chamber, Autoclave, Hot air Oven, Incubator, pH meter, Anaerobic jar, Magnetic stirrer, Common Glassware used in Microbiology Laboratory
4. Study of bacterial motility by hanging drop method.
5. Staining –simple and
6. differential staining- Gram staining.
7. Negative staining – capsule staining by India Ink Method
8. Bacterial endospore staining.
9. Preparation of Culture media: Nutrient Broth and Nutrient Agar.

Suggested Readings:

1. A Textbook of Microbiology, R. C. Dubey and D. K. Maheshwari, 1st edition, 1999, S. Chand & Company Ltd.
2. Alexopoulos, C.J., Mims, C.W., and Blackwell, M. 2002. Introductory Mycology. John Wiley and Sons (Asia) Pvt. Ltd. Singapore. 869 pp.
3. Atlas, R.M. 1984. Basic and practical microbiology. MacMillan Publishers, USA. 987pp.
4. Black, J.G. 2008. Microbiology principles and explorations. 7edn. John Wiley and Sons Inc., New Jersey 846 pp.
5. Brock Biology of Microorganisms, M.T.Madigan, J.M.Martinko, P. V. Dunlap, D. P. Clark- 12th edition, Pearson International edition 2009, Pearson Benjamin Cummings.
6. Foundations in Microbiology, K. P. Talaro, 7th International edition 2009, McGraw Hill.
7. General Microbiology, Stanier, Ingraham et al, 4th and 5th edition 1987, Macmillan education limited.
8. Microbiology – An Introduction, G. J.Tortora, B. R.Funke, C. L. Case, 10th ed. 2008, Pearson Education.
9. Microbiology- Concepts and Applications, PelczarJr,Chan, Krieg, International ed, McGraw Hill.
10. Pommerville, J.C. Alcamo's Fundamentals of Microbiology. Jones and Bartlett
11. Prescott, Harley, Klein's Microbiology, J.M. Willey, L.M. Sherwood, C.J. Pub.Sudbury, 835 pp.
12. Schlegel, H.G. 1995.General Microbiology. Cambridge University Press, Cambridge, 655 pp.
13. Toratora, G.J., Funke, B.R. and Case, C.L. 2007. Microbiology 9th ed. Pearson Education Pte. Ltd., San Francisco. 958pp.Woolverton, 7th International, edition 2008, McGraw Hill.

OPEN ELECTIVE-1st Semester

SEMESTER-I-OE: Microorganisms for Human Welfare -G509.IOE

COURSE OUTCOMES:

- Acquire the knowledge of importance of microbes in human welfare.
- Acquire the knowledge of importance of microbes in agriculture.
- Acquire the knowledge of importance of microbes in pharmacy.

Course Title & Code: Microorganisms for Human Welfare G509.1OE	
Total Contact Hours: **42**	Course Credits: **3**
Formative Assessment Marks: **60%**	Duration of ESA /Exam: **2.5 Hrs**
Microorganisms for Human Welfare- G509.1OE	**42Hrs**
Unit–1: Food and Fermentation Technology	14Hrs
Fermented Foods–Types, Nutritional Values, Advantages and Health Benefits Prebiotics, Probiotics, Synbiotics and Nutraceuticals Fermented Products: Alcoholic-Beer and whisky; nonalcoholic beverages-coffee and tea; fermented dairy products-yogurt and cheese; fermented fruit drinks-wine	
Unit–2: Agriculture	14Hrs
Bio-fertilizers and bio-pesticides - types and applications, beneficial microorganisms in agriculture, AM fungi, Mushroom cultivation, Biogas production.	
Unit –3: Biopharmaceuticals	14Hrs
Microbial Drugs–Introduction, Discovery, Antibiotic –Definition, Characteristics, Types, Functions. Antibiotic Therapy and Development of Drug Resistance Vaccines–Types, Properties, Functions and Schedules	

Suggested Readings:

1. A Textbook of Microbiology, R. C. Dubey and D. K. Maheshwari, 1st edition, 1999, S. Chand & Company Ltd.
2. Atlas, R.M. 1984. Basic and practical microbiology. MacMillan Publishers, USA. 987pp.
3. Black, J.G. 2008. Microbiology principles and explorations. 7edn. John Wiley and Sons Inc., New Jersey 846 pp.
4. Brock Biology of Microorganisms, M.T.Madigan, J.M.Martinko, P. V. Dunlap, D. P. Clark- 12th edition, Pearson International edition 2009, Pearson Benjamin Cummings.

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B.SC., MICROBIOLOGY (BASIC / HONS.) SEMESTER 2

Title of the Courses:

Course 1: G 509 DC1.2 Microbial Biochemistry and Physiology

Course 2: G 509 OE1.2, BACTERIOLOGY

Course1: G 509 DC1.2 , Microbial Biochemistry and Physiology		**Course 2: G 509 OE1.2 BACTERIOLOGY**	
Number of Theory Credits	Number of lecture hours/semester	Number of Theory Credits	Number of lecture hours/semester
4	**56**	**3**	**42**

Content of Course: G 509 DC1.2. MICROBIAL BIOCHEMISTRY AND PHYSIOLOGY. –

56Hrs

Course Learning Outcomes

Outcome 1. Have developed a good knowledge of biochemical concepts with regard to the chemical bonds in biological compounds.

Outcome 2. Have developed a very good understanding of the characteristics of Structure and properties of Water as a universal solvent, polarity, hydrophilic and hydrophobic interactions, properties of water, Acids, bases, electrolytes, hydrogen ion concentration, pH, buffers.

Outcome 3. Describe the definition, classification, structure and properties of carbohydrates and amino acids and proteins, lipids; fatty acids: types and classification, Vitamins

Outcome 4. Have an understanding the principles of bioenergetics and role of respiration in synthesis of energy molecules.

Outcome 5. Perform biochemical tests with application of biochemical principles.

UNIT-1. BIOCHEMICAL CONCEPTS1 **14Hrs**

1.BASIC BIOCHEMICAL CONCEPTS: Major elements of life and their primary characteristics, atomic bonds and molecules – bonding properties of carbon, chemical bonds- covalent and non-covalent, Hydrogen bonds and Vander Waal Forces.

2.BIOLOGICAL SOLVENTS: Structure and properties of water molecule, Water as an universal solvent, polarity, hydrophilic and hydrophobic interactions, properties of water, Acids, bases, electrolytes, hydrogen ion concentration, pH, buffers and physiological buffer system, Handerson–Hasselbalch equation.

UNIT- 2. MACROMOLECULES **14HRS**

1. **CARBOHYDRATES & PROTEINS:** Definition, classification, structure and properties. Amino acids and proteins: Definition, structure, classification and properties
2. **LIPIDS AND FATS:** Definition, classification, structure, properties and importance of lipids; fatty acids: types and classification, Vitamins, Definition, structure, properties and importance of chlorophyll, cytochromes and hemoglobin.

UNIT- 3. MICROBIAL NUTRITION AND THE INFLUENCE OF ENVIRONMENTAL FACTORS ON GROWTH **14hrs**

1. UPTAKE OF NUTRIENTS BY THE CELL: Passive Diffusion Facilitated Diffusion, Active Transport Group Translocation and Iron uptake.

Common Nutritional Requirements, Requirements for Carbon, Hydrogen, Oxygen, Nitrogen, Phosphorus Sulphur and Electrons. Nutritional types of Microorganisms. Growth Factors. Nutritional Classifications. Phototrophs and Chemotrophs, Autotrophs and Heterotrophs.

2. ENVIRONMENTAL FACTORS FOR GROWTH: Temperature-Cardinal Temperatures, Temperature classes of organisms. pH: Microbial growth at low and high pH , Osmotic effects on Microbial Growth , Compatible solutes, Oxygen and Microbial Growth-Oxygen

classes of Microorganisms., Toxic forms of Oxygen-Superoxide and Other Oxygen Species, Hydrostatic Pressure and Radiation.

UNIT–4 : BIOENERGETICS & RESPIRATION 14hrs

1. BIOENERGETICS: Free energy, Enthalpy, Entropy, Classification of high energy compounds, Oxidation-reduction reactions, equilibrium constant, Redox potential, Laws of thermodynamics, Energy coupling reactions, Exothermic and Endothermic reactions.

2. RESPIRATION: Glycolysis, TCA cycle, and electron transport chain, oxidative and substrate level phosphorylation. Anaerobic respiration, Fermentation (homo and heterolactic fermentation).

COURSE 1: PRACTICALS: G 509 DC2.2P MICROBIAL BIOCHEMISTRY AND PHYSIOLOGY

1. Preparation of Normal, Molar, and percent solutions
2. Calibration of pH meter and determination of pH of natural samples
3. Preparation of Buffer Solutions
4. Qualitative determination and identification of Carbohydrates
5. Qualitative determination and identification of Proteins
6. Colorimetric estimation of Protein by Lowry's method.
7. Colorimetric estimation of sugar by DNS method.
8. Determination of bacterial growth by spectrophotometric method & and calculation of generation time
9. Biochemical tests used for the identification of bacteria: Catalase test, Oxidase test, and Gelatin hydrolysis
10. Fermentation of Glucose, Sucrose, Lactose

Text Books/References

1. Boyer R. (2002),Concepts in Biochemistry2nd Edition,Brooks/Cole, Australia.
2. Caldwell, D.R. (1995) –Microbial Physiology and Metabolism. Brown Publishers.
3. Felix Franks, 1993; Protein Biotechnology, Humana Press, New Jersey.
4. Harper,1999;Biochemistry,McGrawHill,NewYork.
5. LodasH,T.Baltimore,A.BerckB.L.Zipursky,P.MatsudairaandJ.Darnell.(2004)–
6. Moat A. G., Foster J.W. Spector. (2004), Microbial Physiology 4th Edition Panima Book Distributors. Molecular Cell Biology, Scientific American Books, Inc. New

York.

7. NelsonandCox,2000;LehningerPrinciplesofBiochemistry, Elsevier Publ.
8. Palmer T. (2001), Biochemistry, Biotechnology and Clinical Chemistry, Harwood Publication, Chichester.
9. StryerL, 1995; Biochemistry, Freemanand Company, NewYork.
10. Voet & Voet, 1995;Biochemistry,John Wiley and Sons, New York.

SEMESTER-II-OE: -G509.2OE

Course Title & Code: BACTERIOLOGY - G509.2OE	
Total Contact Hours: **42**	Course Credits: **3**
Formative Assessment Marks: **60%**	Duration of ESA /Exam: **2.5Hrs**

COURSE OUTCOMES:

- Acquire the knowledge of bacteria.
- Acquire the knowledge of control of microorganisms.
- Acquire the knowledge of nutrition of microbes.

	42Hrs
Unit–1: Bacteria:	**14Hrs**
Bacteria: Cell size, shape and arrangement, glycocalyx, capsule, flagella, fimbriae and pili. Cell-wall: Composition and detailed structure of Gram-positive and Gram-negative cell walls, Archaebacterial cell wall, lipopolysaccharide (LPS), spheroplasts, protoplasts, and L-forms. Cell Membrane: Structure, function and chemical composition of bacterial and archaeal cell membranes. Cytoplasm- Ribosomes, mesosomes, inclusion bodies, nucleoid, genome and plasmids Endospore: Structure, formation, stages of sporulation.	
Unit–2: Control of Microorganisms	**14Hrs**
Physical methods of microbial control: heat, low temperature, high pressure, filtration, desiccation, osmotic pressure, radiation.	
Unit –3: Nutritional requirements of Bacteria	**14Hrs**
Nutritional requirements in bacteria and nutritional categories; Culture media: natural and synthetic media, chemically defined media, complex media, selective, differential, indicator, enriched and enrichment media. Asexual methods of reproduction, logarithmic representation of bacterial populations, phases of growth, calculation of generation time and specific growth rate.	

Suggested Readings:

5. A Textbook of Microbiology, R. C. Dubey and D. K. Maheshwari, 1st edition, 1999, S. Chand & Company Ltd.
6. Atlas, R.M. 1984. Basic and practical microbiology. MacMillan Publishers, USA. 987pp.
7. Black, J.G. 2008. Microbiology principles and explorations. 7edn. John Wiley and Sons Inc., New Jersey 846 pp.
8. Brock Biology of Microorganisms, M.T.Madigan, J.M.Martinko, P. V. Dunlap, D. P. Clark- 12th edition, Pearson International edition 2009, Pearson Benjamin Cummings.

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SECOND YEAR B.SC -III & IV SEMESTERS- MICROBIOLOGY CURRICULUM

Microbiology Program Articulation Matrix:

Semester	Title /Name of the course	Program outcomes that the course addresses.	Pre- requisite course (s)	Pedagogy	Assessment
III	**G509 DC1.3 Microbial Diversity** **4 Credits** **100 Marks**	1.Knowledge and understating the concepts of Microbial ecology. 2.Knowledge and understanding the presence of microbes in natural habitats. 3.Knowledge and understanding of the water treatment and their utilities.	Eligibility from 2nd semester	The general pedagogy to be followed for theory and practical are as under. Lecturing, Tutorials, Group/Individual Discussions, Seminar, Assignments, Counseling, Remedial Coaching. Field/Institution/Industrial visits, Hands on training, Case observations, Models/charts , preparations, Problem Solving mechanism, Demonstrations, Project presentations, Experiential Documentation and Innovative methods.	LSSSDC (NSDC) assessment and certification For lab Technician or Lab assistant Job role
	G509 DC2.3P Microbial Diversity **2 Credits** **50 Marks**	Applying the skills in designing and estimation by performing experiments.			
	G509.3OE Virology **3 Credits ,50 Marks**	1.Knowlegde of viruses. 2.Understading the replication mechanisms of viruses.			
IV	**DSC-4T** **G509 DC1.4 Microbial Enzymology and Metabolism** **4 Credits** **100 Marks**	1 Knowledge and Understanding of metabolism. 2. Learning and practicing Professional skills in performing experiments. 3. Knowledge and understanding of the role of microbes in geochemical cycles and cycling of elements.	Eligibility from 3rd semester	The general pedagogy tobe followed for theory and practical areas under. Lecturing, Tutorials, Group/Individual Discussions, Seminars, Assignments, Counseling, Remedial Coaching. Field/Institution/Industry visits, Hands on training, Case observations, Models/charts preparations, Problem solving mechanism, Demonstrations, Project presentations, Experiential documentation and Innovative methods.	LSSSDC(NS DC) Assessment and certification for lab technician or Lab assistant job role
	G509 DC2.4P Microbial Enzymology and Metabolism **2 Credits** **50 Marks**	Applying the skills in designing and estimation by performing experiments.			
	G509.4OE Environmental and Sanitary Microbiology				

Second Year B.Sc.
Third Semester- Paper-3- Subject: Microbiology
MICROBIAL DIVERSITY–G509 DC1.3

Microbial Diversity	
Total Contact Hours: **56**	Course Credits: **4+2**
Formative Assessment Marks: **60%**	Duration of ESA /Exam: **2.5hrs**

TOTAL 56 hours

Course Learning Outcomes

Course Outcomes (COs): At the end of the course the student should be able to:

1. Knowledge about microbes and their diversity
2. Study, characters, classification and economic importance of Pro-eukaryotic and Eukaryotic microbes.
3. Knowledge about viruses and their diversity

UNIT-1

1. **BIODIVERSITY AND MICROBIAL DIVERSITY:** Concept, definition, and levels of biodiversity; Biosystematics – Major classification systems- Numerical and Chemotaxonomy.
2. **STUDY AND MEASURES OF MICROBIAL DIVERSITY:** Conservation and Economic values of microbial diversity. An overview of Bergey's Manual of Systematic Bacteriology.

14 hours

UNIT-2

1. **DIVERSITY OF PROKARYOTIC ORGANISMS:** Archaea: General characters and types, Actinomycetes: General Characters, Rickettsia- General Characters. Cyanobacteria: General Characters and Classifications. Similarities and Dissimilarities between Cyanobacteria and Bacteria. Morphology and Reproduction of Nostoc, Stigonema and Scytonema.

2. **EUKARYOTIC ORGANISM:** Fungi: General characters and Reproduction: Asexual and Sexual Reproduction. Spores and Spore dispersal. Classifications. Morphology:

Microscopic and Macroscopic, Asexual and Sexual Reproduction of: Rhizopus, Penicillium, Fusarium and Yeast

14 hours

UNIT-3

1. STUDY OF PROTOZOA: Study of *Entamoeba histolytica*: Morphology; Trophozoite and Cyst and Life cycle: Encystations and Excystation-Quadrinucleate cyst.

Plasmodium: Organism Characteristics and Life cycle in man and Mosquito. Morphological forms seen in humans: Trophozoites, Schizonts, Merozoites, Gametocytes, Forms in Liver: Sporozoites and, Merozoites. Morphological forms in Mosquitoes: Macrogametes and Microgametes, Ookinete, Oocyst Sporozoites.

2. MORPHOLOGY AND LIFE CYCLE: Balantidium and *Trichomonas vaginalis*.

14 hours

UNIT -4

1. DIVERSITY OF VIRUSES: General properties of Viruses, Helical Capsid, Icosahedral Capsids, Viral envelopes and Enzymes.

Viruses of Bacteria**:** Classification**,** Multiplication of Bacteriophages –Lysogenic and Lytic cycle. One step growth curve of viruses. A brief account of Plants, Insects, Algal and Fungal Viruses.

Classification of viruses based on the basis of differences in their transcription processes. General account on Prions, Viroids, and Virusoides.

2. VIRUSES CULTIVATION AND QUANTIFICATION: Egg and cell cultures-monolayer and continuous cell cultures and Plaque assay.

14 hours

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Second Year B.Sc

Third Semester -Paper-3 -Subject: Microbiology

MICROBIAL DIVERSITY –G509 DC 2.4P

(Each Practical session is 4 hours duration)

1. Measurement of Bacteria by Micrometry.
2. Total count of Bacteria by Haemocytometer.
3. Isolation of bacteria from air and water: Gravity Settle method
4. Isolation of Fungi from air and water: Gravity Settle method
5. Isolation of Bacteria from soil
6. Isolation of Fungi from soil
7. Slide culture technique for Fungi.
8. Tease Mount and staining Techniques for Fungi
9. Study of Yeast Wet mount and Stained specimen observation.
10. Isolation of Coliphages from Raw Sewage.
11. Study of permanent slides: Protozoa*: Amoeba, Entamoeba, Balantidium, Plasmodium.*
12. Study of Cyanobacteria: Nostoc, Scytonema, Oscillatoria.
13. Demonstration of fungi from plant root.
14. KOH solubility test

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NEP-Fourth Semester-Paper-4-Subject: Microbiology
(MICROBIAL ENZYMOLOGY AND METABOLISM) G509 DC 1.4

Course Title & Code: **Microbial Enzymology and Metabolism- G509 DC1.4**	
Total Contact Hours: **56**	Course Credits: **4+2**
Formative Assessment Marks: **60%**	Duration of ESA /Exam: **2.5Hrs**

Total 56 hours

Course Learning Outcomes

Outcome 1. Understand the enzymes and their role in metabolism.

Outcome 2. Understand the fermentation pathways and their importance.

Outcome 3. Describing the growth characteristics of the microorganisms which require different nutrient for growth and the associated mechanisms of energy generation for their survival like autotrophs, heterotrophs, chemolithotrophs.

Outcome 4. Describe the metabolic pathway of photosynthesis as an energy yielding metabolic pathway in bacteria.

Outcome 5. Describe the biogeochemical cycles and mineral transformation by microbes.

UNIT-1

1. ENZYMES. Structure and classification of Enzymes, Mechanism of Enzyme Reactions, Effect of environment on Enzyme Activity. Coenzymes & Cofactors.

2. THE NATURE AND SIGNIFICANCE OF METABOLIC REGULATION: Metabolic Channeling, Control of Enzyme Activity- Allosteric Regulation, Covalent Modification of Enzymes, Feedback Inhibition. Enzyme catalysis: Catalytic mechanisms with type examples, catalytic mechanisms and testing -Serine proteases and Lysozyme

14 hours.

UNIT-2

1. CATABOLISM: Catabolism of Lipid, Amino acid and Protein Catabolism. Protein and Amino Acid Catabolism, Reserve Polymers: Methylotrophs: i. Oxidation of methane, methanol,methylamines

2. FERMENTATIONS: Common Microbial Fermentations: Alcohol Fermentation, Lactic acid Fermentation-Homo Hetero Lactic acid, Mixed Acid Fermentation, Butanediol Fermentation, Propionic acid fermentation.

Molecular basis of Signal transduction in bacteria- Two-component regulatory systems, Examples of Two –Component Regulatory Systems: Protein kinases and Response regulators.

14 hours.

UNIT-3

1.BACTERIAL PHOTOSYNTHESIS: Photosynthetic Bacteria: Characteristic of Photosynthetic Bacteria- Chromatiaceae (Purple Sulphur Bacteria), Rhodospirillaceae (Purple Non Sulphur Bacteria), Chlorobiaceae (Non Motile Green and Brown Sulphur Bacteria) , Chloroflexaceae Filamentous Gliding Green Bacteria , Cyanobacteria (Blue Green Bacteria) and Prochlorophyta .

Bacteriochlorophylls, Carotenois and Phycobilins. Photosynthetic apparatus in prokaryotes.Reaction Centres, Antenna Pigments and Chlorosomes.

Types of Bacterial Photosynthesis: Photosynthesis in Purple and Green bacteria, Anoxygenic photosynthesis and Oxygenic Photosynthesis. Light reactions: Photophosphorylation-Cyclic and Non Cyclic Photophosphorylations.

Dark reactions: Reductive Pentose Pathway and Pyruvate Synthetase Pathway (Reductive Carboxylic Acid Cycle).

2. CHEMOLITHOTROPHY: Oxidation of Ammonium and Nitrites, Iron, Hydrogen and Sulphur Compounds.Microbiologically Influenced Corrosion: Microorganisms involved and their detection.Biofilms: Formation and development and Biofilm development factors.

Significance: Biofilms and infectious diseases and biofilm uses.

14 hours

UNIT-4

1. NITRIFICATION: Bioenergetics and Enzymology of Nitrification. Anammox. Nitrogen Fixation: Nitrogen Fixing Bacteria: Free Living Nitrogen Fixing Bacteria, Symbiotic Nitrogen Fixing Bacteria and Associative Nitrogen Fixing. Nitrogenasae. Electron flow in Nitrogen fixation. Nitrogen fixation by Rhizobium: Process of root nodule formation, Leghaemoglobin**.**

2. GEOMICROBIOLOGY AND MINERAL TRANSFORMATION: Biogeochemical cycle- Reservoir Cycling of Sulphur-Microorganisms involved in sulphur cycle., Acid rain.

Cycling of Phosphorus-Eutrophication and Carbon cycling –Greenhouse effect and Global warming.

14 hours

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Third Semester-Paper-4-Subject: Microbiology

MICROBIAL ENZYMOLOGY AND METABOLISM - G509 DC2.4P

(Each Practical session is 4 hours in duration)

1. Handling of micropipettes and checking their accuracy
2. Demonstration of Rhizobium from root nodules
3. Nitrate Reduction Test
4. Starch Hydrolysis Test
5. Ammonification Test
6. Amylase Assay
7. Effect of pH, salt, Temp on growth.
8. Determination of Thermal Death Point
9. Growth of Bacteria in high salt concentration-Growth on Mannitol salt agar.
10. Measurement of Enzyme Activity of Alfa Amylase.
11. Effect of Temperature on Enzyme Activity.
12. Identification of amino acids by TLC and paper chromatography.

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OPEN ELECTIVE

Course Title & Code: VIRIOLOGY - G509.3OE	
Total Contact Hours: **42**	Course Credits: **3**
Formative Assessment Marks: **60%**	Duration of ESA /Exam: **2.5hrs**

III SEMESTER -VIRIOLOGY Course 2 : G509.3OE

COURSE OUTCOMES:

- Understand the concepts of viruses.
- Acquire the knowledge of virus replication.
- Understand the mode of infections by viruses.

III SEMESTER OE-VIRIOLOGY Course 2 : Theory: OE- 2T, MBL 302	**42 Hrs**
Unit – 1: Introduction to Viruses	**14 Hrs**
Properties of viruses; general nature and important features Subviral particles; viroids, prions and their importance Isolation and cultivation of viruses	
Unit – 2 Structure, and multiplication of viruses	**14 Hrs**
Morphological characters: Capsid symmetry and different shapes of viruses with examples Viral multiplication in the Cell: Lytic and lysogenic cycle Description of important viruses: salient features of the viruses infecting different hosts - Bacteriophages (T4 & Lambda); Plant (TMV & Cauliflower Mosaic Virus), Human (HIV & Hepatitis viruses)	
Unit – 3: Role of Viruses in Disease and its prevention	**14 Hrs**
Viruses as pathogens: Role of viruses in causing diseases Prevention and control of viruses: Viral vaccines, interferons and antiviral compounds	

References

1.Prescott, L.M.; J.P. Harley and D.A.Klein. 2010. Microbiology. 8th edition. McGrow Hill.

2.Michael T.Madigan and John M. Martinko.2010.13th Edition..Brock Biology of Microorganisms, Pearson Prentice Hall.

3. Michael Pelczar.1998. Microbilogy-5th Ed ,McGraw Hill Book Company.

4. Jacquelyn G. Black .2012 .Microbiology: Principles and Explorations, 8th Edition. Wiley.

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OPEN ELECTIVE

IV SEMESTER-OE- Environmental and Sanitary Microbiology Course 2: G509.4OE

Course Title & Code: Environmental and Sanitary Microbiology G509.4OE	
Total Contact Hours: **42**	Course Credits: **3**
Formative Assessment Marks: **60%**	Duration of ESA /Exam: **2.5hrs**

COURSE OUTCOMES:

- **Acquire the knowledge of microbes in environment.**
- **Acquire the knowledge of water borne infections.**
- **Understand the importance of the role of microbes in public health.**

IV SEM-OE-Environmental and Sanitary Microbiology Course 2 : Theory: OE- 2T, G509.4OE	**42 Hrs**
Unit – 1: Soil and Air Microbiology	**14 Hrs**
Soil and Air as a major component of environment. Types, properties and uses of soil and air. Distribution of microorganisms in soil and air. Major types of beneficial microorganisms in soil. Major types of harmful microorganisms in soil	
Unit – 2: Water Microbiology	**14 Hrs**
Water as a major component of environment. Types, properties and uses of water. Microorganisms of different water bodies. Standard qualities of drinking water	
Unit – 3: Sanitary Microbiology	**14 Hrs**
Public health hygiene and communicable diseases. Survey and surveillance of microbial infections. Airborne microbial infections, waterborne microbial infections, Food borne microbial infections. Epidemiology of microbial infections, their detection and control.	

References

1. Atlas, R.M. and Bartha R. 1998. Microbial Ecology: Fundamentals and Applications. 4th Ed. Redwood city. CA. Benjamin / Cummings.

2. Mitchell, R. 2010. Introduction to Environmental Microbiology. 2nd Ed. Prentice - Hall. Inc. Englewood Cliffs - New Jersey.

3. Michael T.Madigan and John M. Martinko.2009.12th Edition, Brock Biology of Microorganisms. Pearson Prentice Hall.

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Third Year B.Sc.- SEMESTER-5

G509 DC 1.5a - Molecular Biology

Program Name	**B.Sc. in MICROBIOLOGY**	Semester	**V**
Course Title	**MOLECULAR BIOLOGY (Theory)**		
Course Code:	**G509 DC 1.5**	No. of Credits	**04**
Contact hours	**60 Hours (4 Hours per week)**		
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Outcomes (COs)

After the successful completion of the course, the student will be able to:

CO1. Understand concepts involved in replication, transcription, translation, and regulation of gene expression in bacteria and Eukaryotes.

CO2. Differentiate the process of replication, transcription, translation, and regulation of gene expression in bacteria and Eukaryotes.

CO3. Understand the genetic switch in bacteriophages.

CO4. Compare and contrast housekeeping, constitutive, inducible, and repressible genes

CO5. Outline regulatory mechanisms in bacteria to control cellular processes

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Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-12)

Course Outcomes (COs) / Program Outcomes (POs)	1	2	3	4	5	6	7	8	9	10	11	12
Understand concepts involved in replication, transcription, translation, and regulation of gene expression in bacteria and eukaryotes		√	√		√							√
Differentiate the process of replication, transcription, translation, regulation of gene expression in bacteria and eukaryotes		√	√		√							√
Understand the genetic switch in bacteriophages		√	√		√							√
Compare and contrast housekeeping, constitutive, inducible and repressible genes		√	√		√							√
Outline regulatory mechanisms in bacteria to control cellular processes		√	√		√							√

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Two Internal tests	10 x 2 = 20
Assignment	05

MCQs	05
Group Project	05
Attendance	05
Total	**40 Marks**

G509 DC 1.5a- Molecular Biology

Total Hours- 60

UNIT-1

DNA Replication and Repair Mechanisms.

1. **DNA Replication:** Central dogma of molecular biology, Gene, Structure of DNA, Bacterial Cell cycle. Replicon. *OriC*. Bidirectional replication. Steps in Initiation of Replication. DNA polymerases, Replication fork, replisome. Mechanism of DNA polymerase III in detail. Ligase. Eukaryotic DNA polymerases. Termination of replication. Types of DNA replication – Rolling circle and theta model. Modes of DNA replication – Conservative, Semi-Conservative and dispersive.
2. **DNA Repair Mechanisms:** Enzymes involved in DNA repair. Methods of DNA Mismatch repair, Direct repair, Base –Excision Repair, Nucleotide –excision repair, Post replication repair.

15 hours

UNIT-2

Transcription

1. **Prokaryotic transcription:** Transcription bubble, Stages of transcription, Bacterial RNA polymerase - structure and mechanism, recognition of promoters and DNA melting, abortive initiation. Elongation, Termination, antitermination.
2. **Eukaryotic Transcription**: Eukaryotic RNA polymerases - RNA polymerase I, II, III. Mechanism of RNA polymerase in detail. Promoters, Transcription factors, basal apparatus, promoter clearance, elongation. Enhancers, silencers, termination. RNA splicing and Processing, polyadenylation, Catalytic RNAs - auto splicing, ribozymes, RNA editing.

15 hours

UNIT-3

Translation

1. **Genetic Code:** Genetic code, tRNA structure, charging of tRNA, differences between initiator tRNA and elongator tRNA, ribosome structure. Stages of translation. Role of IFs in the initiation of bacterial translation, Formation of the initiation complex. Elongation of polypeptide - EF-Tu, EF-G, peptide bond formation, peptidyl transferase activity, translocation, eEFs. Termination. Differences between prokaryotic and Eukaryotic translation.
2. **Stages in Translation & PTM**: Regulation of translation. Post-translational modifications of proteins.

15 hours

UNIT-4

Regulation of gene expression & Genetic exchange in prokaryotes

1. **Control of gene expression in prokaryotes**
   Regulatory mechanisms in bacteria. Positive and negative transcriptional control in bacteria. Operon concept, polycistronic mRNA. *lac* operon - negative inducible. Catabolite repression of *lac* operon.

Regulation by lac repressor and CAP. *trp* operon regulation – repressor control & attenuator control. Regulation of lytic to lysogenic life cycle in bacteriophage lambda. Control of lytic cycle by regulatory proteins – *cro* gene, *N* gene.

2. Genetic exchange in prokaryotes

Transformation-Griffith experiment, Competence in transformation, uptake and integration of DNA in transformation. Conjugation –Mechanisms of DNA transfer during conjugation. Formation of Hfr strains, Formation of F-Prime (F´), and Transduction -Generalized and Specialized, Low frequency and high-frequency transductions. **15 hours**

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Course Title	**MOLECULAR BIOLOGY (Practical)**	Practical Credits	**02**
Course Code	**G509 DC2.5P**	Contact Hours	**4 Hours/ week**
Formative Assessment	**25 Marks**	Summative Assessment	**25 Marks**

Practical Content

1. Micropipeting: Moving Very Small Volumes Very Accurately
2. Study of semi-conservative replication of DNA through micrographs / schematic representations
3. Extraction of crude DNA from bacteria and yeast by phenol/chloroform method.
4. Determination of purity and quantity of DNA
5. Extraction and visualization of plasmids from bacterial cultures
6. Extraction and visualization of genomic DNA from bacterial cultures
7. β-galactosidase Activity Assay in Yeast
8. DNA extraction from agarose gel.
9. Determination of the quantity of RNA.
10. Restriction enzyme digestion of DNA molecule - DNA fingerprinting
11. Resolution and visualization of proteins by Polyacrylamide Gel Electrophoresis (SDS-PAGE)

Formative Assessment for Practical	
Assessment	**Marks**
Continuous Assessment	15
Class Records	05
Model Practical Test	20
Attendance	05
Viva	05
Total	**50 (Converted to 25) Marks**

References	
1	*Karp's Cell and Molecular Biology* by Gerald Karp, Janet Iwasa, Wallace Marshall. Ninth Edition. 2020

2	Lewin's Genes XII. Jocelyn E Krebs, Elliott S Goldstein, Stephen T Kilpatrick. Jones and Bartlett Learning.2017
3	James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick. Molecular Biology of the Gene, 7th edition. 2017
4	Freifelder's Essentials of MOLECULAR BIOLOGY. George M Malacinski, 4th ed. 2015
5	Freifelder D (2012). Molecular Biology, 5th edition. Narosa Publishing House, India
6	Berg JM, Tymoczko JL, Gatto GJ and Stryer L (2015) Biochemistry, 8th Edition, WH Freeman & Co., New York
7	Alberts Bruce, Johnson A Lewis J Raff M Roberts K, Walter P (2014) Molecular Biology of the Cell. 5th Edition, Taylor and Francis. New York, USA.
8	Tropp BE (2012) Molecular Biology: Genes to Proteins. 4rd Edition, Jones & Bartlett, Learning, Burlington, MA
9	Allison A. Elizabeth (2012) Fundamental Molecular Biology, 2nd Edition. J Willey and Sons, Hoboken, New Jersey
10	Aranda PS, LaJoie DM, Jorcyk C L (2012). Bleach Gel: A Simple Agarose Gel for Analyzing RNA Quality. Electrophoresis. 33(2): 366–369. Doi: 10.1002/elps .201100335.
11	Bloch KD; Grossmann B (1995). Digestion of DNA with Restriction Endonucleases. https://doi.org/10.1002/0471142727.mb0301s31
12	Chomczynski P, Sacchi N (2006). "The single-step method of RNA isolation by acid guanidinium thiocyanate-phenol-chloroform extraction: twenty-something years on". Nat Protoc. 1 (2): 581–5. doi:10.1038/nprot.2006.83.
13	Elkins K M (2013). DNA Extraction Forensic DNA Biology.
14	Frederick M. Ausubel, Roger Brent, Robert E. Kingston, David D. Moore, J.G. Seidman, John A. Smith, Kevin Struhl (2003). Current Protocols in Molecular Biology. John Wiley & Sons, New York, United States.
15	Johnson M (2019). RNA extraction, Synatom Research, Princeton, New Jersey, United States. DOI//dx.doi.org/10.13070/mm.en.2.201.
16	Lewis M. Agarose gel electrophoresis (basic method). Department of Pathology, University of Liverpool. http://diyhpl.us/~bryan/irc/protocol-online/protocolcache/agarogel.html
17	Randall DR. (2009). Molecular Biology Laboratory manual.
18	Sambrook JF, Russell DW (2001). Molecular Cloning: a Laboratory Manual. 3rd edition. Cold Spring Harbor, N.Y. Cold Spring Harbor Laboratory Press
19	Struhl K, Seidman J G, Moore D D, Kingston RE, Brent R, Ausubel FM, Smith JA. (2002). short Protocols in Molecular Biology: A Compendium of Methods from Current Protocols in Molecular Biology. John Wiley & Sons Inc., New York, United States
20	Surzycki S (2000). Basic techniques in molecular biology. Springer.
21	Yılmaz M, Ozic C, Gok İ (2012). Principles of Nucleic Acid Separation by Agarose Gel Electrophoresis. Gel Electrophoresis - Principles and Basics, Dr. Magdeldin S (Ed.), ISBN: 978-953-51-0458-2, InTech. http://www.intechopen. com/books/gel-electrophoresis-principles-And basics

G509-DC 3.5b - Food Microbiology

Program Name	**B.Sc. in Microbiology**	Semester	**V**
Course Title	**FOOD MICROBIOLOGY (Theory)**		
Course Code:	**G509 DC 3.5b**	No. of Credits	**04**
Contact hours	**60 Hours (4 Hours per week)**		
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Outcomes (COs): After the successful completion of the course, the student will be able to:

CO1. To understand the association of microbes in food and the quality testing of food

CO2. To understand the preservation and food safety protocols

CO3. To understand the methods of spoilage of food and the diseases associated with it

CO4. To learn the properties of milk and the types of preservation of milk.

CO5. To learn the types of fermented food and dairy products and their significance

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-15)

Course Outcomes (COs) / Program Outcomes(POs)	Program Outcomes (POs)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
To understand the association of microbes infood and the quality testing of food		√						√			√	√			
To understand the preservation and food safety protocols		√					√			√					
To understand the methods of spoilage of food and the diseases associated with it		√		√											
To learn the properties of milk and the types ofpreservation of milk.	√	√													
To learn the types of fermented food and dairyproducts and their significance				√	√			√							

G509-DC 3.5b – Food Microbiology

Total Hours-60

UNIT-1

Microbes and Food

1. **Microbes and food:** Food as a substrate for microorganisms- Intrinsic and extrinsic parameters affecting the growth of microbes. Microorganisms in food and their sources (molds,yeast, and bacteria)
   Foodborne infections and intoxications- Causative organism, mode of entry, symptoms, Treatment and control of *Staphylococcal* food poisoning, Botulism. Salmonellosis, Brucellosis, Listeriosis. General account of Mycotoxins & Phycotoxins.
2. **Fermented Foods:** Fermented vegetable-sauerkraut, pickles. Meat-sausage. Beverages-kombucha. Sourdough. Microbes as food- SCP, SCO.

15 hours

UNIT-2

Spoilage of Food and Preservation

1. **Spoilage:** Principles of food spoilage. Sources of food contamination, Types of spoilage.Spoilage of meat and poultry, Fish and sea foods. Spoilage of cereals, fruits, and vegetables.Spoilage of canned food.
2. **Preservation:** Principles of Food Preservation. Methods of preservation-Physical (temperature,drying, irradiation), chemical (Class I and Class II). Bio preservation. Canning. Food additives. Food Packaging-Types of packaging materials, properties, and benefits.

15 hours

UNIT-3

Dairy Microbiology

1. **Milk and microorganisms in milk:** History – White revolution. Properties and nutritional value of milk. Types of milk- dried, liquid, condensed. Microorganisms in milk – Normal and abnormal microflora of milk, pathogens found in milk. Starter culture and its types- (single, mixed). Sources of contamination of milk. Microbiological analysis of milk- Rapid platform tests (organoleptic, alcohol, COB, Alcohol test, Phosphatase test, DMC, sedimentation test). Reductase tests. SPC. Preservation of milk- Pasteurization. Dehydration, sterilization. Packing of milk and

dairy products.

2. **Fermentation in milk**: Lactic acid, gassy fermentation, souring, ropiness. Dairy products: Cheese- Types and production (Cheddar), Tofu, Yoghurt, Acidophilus milk. Prebiotics, Probiotics, Synbiotics. **15 hours**

UNIT-4

Food Standards and quality control

1. **Quality testing of food**- Rapid microbiological methods, Examination of fecal contamination, MPN.
2. **Food sanitation and control**- Good Hygiene practices, GLP, GMP (Waste treatment disposal methods), HACCP, Food control agencies, and their regulation**.** Bacterial indicator organisms in food contamination. Food Safety – risk and hazards, food Safety Laws and Regulations- BIS FSSAI, Codex Alimentarius. **15 hours**

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Course Title	**FOOD MICROBIOLOGY (Practical)**	Practical Credits	**02**
Course Code	**G509 DC 4.5P**	Contact Hours	**4HRS/WEEK**
Formative Assessment	**25 Marks**	Summative Assessment	**25 Marks**

Practical Content

1. Isolation of bacteria and fungi from infected fruits and vegetables
2. Isolation of bacteria and fungi from fermented food
3. Reductase tests-MBRT/Resazurin/phosphatase
4. Estimation of Titrable acidity in milk.
5. Fat estimation – Gerber's method
6. Bacterial examination by SPC, DMC
7. Estimation of lactose in milk
8. Production of yogurt
9. Study of food-borne pathogens- *Staphylococcus*, *Salmonella, Aspergillus*, *Clostridium*.
10. Significant microbes in Food and Dairy *Lactobacillus*, *Streptococcus*, *Penicillium*, *Rhizopus*
11. Standard analysis of water
12. Wine preparation
13. Entrepreneurship- To study the necessary measures to be an entrepreneur in food industry.

References	
1	Adams, M.R and Moss, MO. 1995. Food Microbiology. The Royal Society of Chemistry, Cambridge.
2	James. M. Jay, 1992, Modern food microbiology 4ed.
3	Frazier W.C. and Westhoff C.D. 2008 Food Microbiology. Tata McGraw Hill Publishing Company Limited, New Delhi, India.
4	Doyle M. P. and Beuchat L. R. (2007). Food Microbiology- Fundamentals. Frontiers, ASM Press.
5	Garbutt J. (1997). Essentials of Food Microbiology, Armold- International Students edition, London. 8. Marriott N. G. and Gravani R. B. (2006).
6	Principles of Food Sanitation, Food Science text Series, Springer International, New York, USA.
7	Thomas. J, Matthews, Karl; Kniel, Kalmia E (2017), Food Microbiology: An Introduction, AmericanSociety for (ASM).
8	Deak T. and Beuchat L. R. (1996). Hand Book of Food Spoilage Yeasts, CRC Press, New York.

Third Year B.Sc. - SEMESTER-6

G509-DC 1.6a -Immunology & Medical Microbiology

Program Name	**BSc in Microbiology**	Semester	**VI**
Course Title	**IMMUNOLOGY AND MEDICAL MICROBIOLOGY (Theory)**		
Course Code:	**G 509 DC 1.6a**	No. of Credits	**4**
Contact hours	**60 Hours (4 hours per week)**		
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Pre-requisite(s): Common to the Course Programme at Entry Level
Course Outcomes (COs): After the successful completion of the course, the student will be able to: CO1: To gain a preliminary understanding of various immune mechanisms. CO2: To familiarize with Immunological techniques and serodiagnosis of infectious diseases CO3: To understand pathogenic bacterial infections, symptoms, diagnosis, and treatment process. CO4: To understand pathogenic bacterial infections, symptoms, diagnosis and to understand pathogenic bacterialinfections, symptoms, diagnosis, and treatment process.

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-15)

Course Outcomes (COs) / Program Outcomes(POs)	Program Outcomes (POs)														
	1	2	3	4	5	6	7	8	9	10	1	12	13	14	15
To gain a preliminary understanding of various immune mechanisms.	√														
To familiarize myself with Immunological techniquesand serodiagnosis of infectious diseases		√	√							√					
To understand pathogenic bacterial infections, symptoms, diagnosis, and treatment process	√			√						√					
To understand pathogenic bacterial infections, symptoms, diagnosis and to understand pathogenic bacterial infections, symptoms, diagnosis and treatment process treatment process	√				√	√				√					

G509-DC 1.6a -Immunology & Medical Microbiology

Total Hours-60 hours

UNIT-1

Normal Microflora of the Human Body and Host-pathogen Interaction

1. **Normal microflora of the human body:** Importance of normal microflora, normal microflora of skin, throat, gastrointestinal tract, urogenital tract. Host-pathogen interaction: Definitions-Infection, Invasion, Pathogen, Pathogenicity, Virulence, Toxigenicity, Carriers, and their types, Opportunistic infections, and Nosocomial infections. Transmission of infection, Pathophysiologic effects of LPS. Sample collection, transport, and diagnosis.
2. **Clinical Microbiology** - Medical Bacteriology: The following diseases in detail with Symptoms, mode of transmission, prophylaxis, and control respiratory diseases: *Streptococcus pyogenes*, *Haemophilus influenzae*, *Mycobacterium tuberculosis.* Gastrointestinal Diseases: *Escherichia coli*, *Salmonella typhi*, *Vibrio cholera*, Others: *Staphylococcus aureus, Bacillus anthracis, Clostridium tetani.* **15 hours**

UNIT-2

Medical Virology, parasitology, and Mycology

1. **Medical Virology-** The following diseases in detail with Symptoms, mode of transmission, prophylaxis, and control: Polio, Herpes, Hepatitis, Rabies, Dengue, AIDS, Corona, Influenza, swine flu, Ebola, Chikungunya,Japanese Encephalitis

Protozoan diseases: Malaria, Kala-azar, Entamoeba. Fungal infections- Cutaneous mycoses: Tinea, pedis (Athlete's foot). Systemic mycoses: Histoplasmosis. Opportunistic mycoses: Candidiasis.

2. **Antimicrobial agents**: General characteristics and mode of action Antibacterial agents: Inhibitor of nucleic acid synthesis; Inhibitor of cell wall synthesis; Inhibitor of cell membrane function; Inhibitor of protein synthesis; Inhibitor of metabolism. Antifungal agents: Mechanism of action of Amphotericin B, Griseofulvin Antiviral agents: Mechanism of action of Amantadine, Acyclovir, Azidothymidine. Antibiotic resistance, MDR,XDR, MRSA, NDM-1

15 hours

UNIT-3

Immunity and Cells and Organs of the Immune System

1. **Immunity**: Natural (active and passive) and artificial (active and passive) with examples, Innate and acquired, Humoral and cell-mediated.
2. **Cells and organs of the immune system**: Hematopoiesis, cytokines, properties, and functions of B and T Lymphocytes, Natural killer (NK) cells, Granulocytes (Neutrophils, Eosinophils, and Basophils), Monocytes and macrophages, Dendritic cells, and Mast cells. Primary lymphoid organs; Bone marrow and Thymus. Secondary lymphoid organs; Spleen and lymph nodes. **15 hours**

UNIT-4

Antigen, Antibody, and interactions

1. **Antigen**: Immunogenicity and antigenicity, epitopes, hapten. Properties of antigens contribute to immunogenicity; Chemical nature (proteins, carbohydrates, lipids, and nucleic acids), degree of foreignness, molecular weight, chemical composition and complexity, and degradability. Adjuvants (alum, Freund's incomplete and complete) and their importance. B and T cell epitopes.

   Antibody: Basic structure of antibody, light and heavy chain, variable and constant region, hinge region, Fab and Fc. Structure and functions of different types of antibodies (IgM, IgG, IgA, IgE, and IgD).

   Antibody-mediated effector functions; opsonization, complement activation, and antibody-dependent cell-mediated cytotoxicity (ADCC). Antigenic determinants on immunoglobulins: Isotype, allotype, and idiotype. Monoclonal antibody production by hybridoma technology
2. **Principles and applications of antigen-antibody interactions**: Definition of affinity and avidity. Immunoprecipitation; Radial (Mancini) and double (Ouchterlony) immunodiffusion. Agglutination reactions: Hemagglutination, Bacterial agglutination, passive agglutination, and agglutination inhibition. Enzyme-linked immune-sorbent assay (ELISA): Direct, indirect, sandwich, and competitive ELISA. Radioimmunoassay (RIA). Immunofluorescence. Hypersensitive reactions:

Classification, Humoral Immunity mediated hypersensitivity; Type I (IgE), Type II (IgG and IgM-ADCC), Type III (Antigen-antibody complex), and Cell-mediated hypersensitivity Type IV (DTH). **15 hours**

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Course Title	**IMMUNOLOGY AND MEDICAL MICROBIOLOGY (Practical)**	Practical Credits	**2**
Course Code	**G509 DC 2.6P**	Contact Hours	**4Hours/week**
Formative Assessment	**25 Marks**	Summative Assessment	**25 Marks**
Practical Content			

1	Identify pathogenic bacteria (any three of *E. coli, Salmonella, Pseudomonas, Staphylococcus Bacillus*) based on cultural, morphological, and biochemical characteristics: IMViC, TSI, nitrate reduction, urease production, and catalase tests
2	Study of composition and use of important differential media for identification of pathogenic bacteria: EMB Agar, McConkey agar, Mannitol salt agar, Salmonella Shigella Agar, TCBS
3	Study of bacterial flora of skin by swab method
4	Perform antibacterial sensitivity by Kirby-Bauer method
5	Study symptoms of the diseases with the help of photographs: Polio, anthrax, herpes, chicken pox, HPV warts, AIDS (candidiasis), dermatomycoses (ringworms)
6	Study of various stages of Malaria parasite in RBCs using permanent mounts.
7	Identification of human blood groups.
8	Perform Total and Differential Leukocyte Count of the given blood sample.
8	Perform Radial and Ouchterlony Immunodiffusion
9	Perform DOT ELISA.
10	Perform immunoelectrophoresis.

REFERENCES	
1	Ananthanarayan R and Paniker C.K.J (2009) Textbook of Microbiology, 8th Edition, University Press,Publication.
2	Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's Medical Microbiology. 26th edition. McGraw Hill Publication
3	Goering R., Dockrell H., Zuckerman M. and Wakelin D. (2007) Mims' Medical Microbiology. 4th edition. Elsevier
4	Willey JM, Sherwood LM, and Woolverton CJ. (2013) Prescott, Harley and Klein's Microbiology.9th edition. McGraw Hill Higher Education
5	Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014). Brock Biology of Microorganisms.14thedition. Pearson International Edition
6	Abbas AK, Lichtman AH, Pillai S. (2007). Cellular and Molecular Immunology. 6th editionSaunders Publication, Philadelphia.
7	Delves P, Martin S, Burton D, Roitt IM. (2006). Roitt's Essential Immunology.11th edition Wiley-Blackwell Scientific Publication, Oxford.
8	Goldsby RA, Kindt TJ, Osborne BA. (2007). Kuby's Immunology. 6th edition W.H. Freeman and Company, New York.
9	Murphy K, Travers.P,Walport M. (2008).Janeway's Immunobiology.7th edition Garland Science, Publishers, New York.
10	Peakman.M.and Vergani D. (2009).Basic and Clinical Immunology,2nd edition Churchill, Livingstone Publishers, Edinburgh.
11	Richard C and Geiffrey S. (2009). Immunology. 6th edition. Wiley Blackwell Publication.

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G509 DC 3.6 - Industrial Microbiology

Program Name	**B.Sc. in Microbiology**	Semester	**VI**
Course Title	**INDUSTRIAL MICROBIOLOGY**		
Course Code:	**G509 DC 3.6**	No. of Credits	**4**
Contact hours	**60 Hours (4 Hours per week)**		
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Pre-requisite(s): Common to the Course Programme at Entry Level

Course Outcomes (COs):

After the successful completion of the course, the student will be able to:

CO1. Learn the overview of the scope and importance of industrially important microbes

CO2. Acquaint with different types of fermentation processes and equipment

CO3. Evaluate the factors influencing the enhancement of cell and product formation during fermentation

CO4. Acquire knowledge of the production of value-added products

CO5. Acquire the knowledge of purification of value-added products

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-15)

Course Outcomes (COs) / Program Outcomes(POs)	Program Outcomes (POs)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Learn the overview of the scope and importance ofindustrially important microbes	√														
Acquaint with different types of fermentation processes and equipment												√			
Evaluate the factors influencing the enhancementof cell and product formation during fermentation								√							
Acquire knowledge of the production of value-added products											√				
Acquire the knowledge of purification of value-added products											√				

G509-DC 3.6b - Industrial Microbiology

UNIT-1

Introduction to Industrial Microbiology

1. **Introduction to Industrial microbiology**: Scope and concepts; Criteria for selection of industrially important microbes; Strain Improvement and inoculum development. Preservation of industrially important microbes.
2. **Types of fermentation process:** Submerged fermentation, Solid state fermentation (Koji), batch fermentation, continuous fermentation, kinetics of fermentation process. **15 hours**

UNIT-2

Basic Design of a Fermenter and Fermentation Media

1. **Fermenter:** Basic features; design and components of a bioreactor; Specialized bioreactors and their applications: tubular bioreactors, fluidized bed reactors, packed bed reactors, membrane bioreactors, Photo-bioreactors, and anaerobic bioreactors; Sterilization of fermenter, Control of air, temperature, pH, foaming and feed; Aseptic inoculation and sampling methods; Scale-up of fermentation process-Merits and demerits.
2. **Fermentation media:** Strategies for media formulation; Natural and synthetic media; Role of buffers, precursors, inhibitors, inducers, and micronutrients. **15 hours**

UNIT-3

General production strategies of microbial products and Downstream processing

1. **General Production Strategies:** Antibiotics, Enzymes, Immobilization Techniques: Enzyme and cell immobilization techniques in industrial processing, anti-cholesterol compounds, anti-cancerous compounds, and hormones.
2. **Downstream processing:** Objectives and significance of downstream processing: Overview of steps in extraction and purification of the product; Filtration and centrifugation; cell disruption- Physical, chemical, and biological methods; Product extraction; product purification, recovery, and product testing. **15 hours**

UNIT-4

Industrial productions

1. **Industrial productions of Beer and Wine:** Raw material, Culture media and Microbial inoculums, Fermentation process- Malt and Malting, Brewing process, Product recovery, and purification. Fermentation processes of Wine- Processes in wine making, Fermentation, Ageing and storage Clarification, Packaging.
2. **Production of Vinegar & Baker's Yeast**: Types of Vinegar, Organisms Involved Manufacture of Vinegar-The Orleans (or slow) method, and the trickling generators (quick) method, Submerged generators, Processing of Vinegar. Manufacture of Baker's yeast- Production of Baker's Yeast, Yeast strain used. Culture maintenance, Factory production. **15 hours**

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Course Title	**INDUSTRIAL MICROBIOLOGY (Practical)**	Practical Credits	**2**
Course Code	**G509 DC 4.6P**	Contact Hours	**4 Hours/ Week**
Formative Assessment	**25 Marks**	Summative Assessment	**25 Marks**

PRACTICAL CONTENT

1. Demonstration of a basic fermenter
2. Preparation of natural medium used in an industry - PDA
3. Preparation of synthetic medium used in an industry – Richards Synthetic Agar
4. Production of amylase by solid substrate fermentation(with at least 2 substrates) - SSF
5. Production of the enzyme (amylase/protease/cellulase/invertase by submerged fermentation
6. Preservation of microbes with glycerol/soil/silica gel/lyophilization.
7. Production and estimation of any one secondary metabolite – total sugars from exopolysaccharides.
8. Downstream technique- Solid-liquid separation by using a centrifugation
9. Downstream technique- Demonstration of Microfiltration technique
10. Downstream technique- cell disruption by sonicator
11. Estimation of Alcohol by Specific Gravity Method.

References

1	Arindam Kuilaand Vinay Sharma (2018) Principles and Applications of Fermentation Technology,Wiley.
2	Casida L E.J.R. (2016) Industrial Microbiology, 2nd edition, New Age International Publisher.
3	Crueger W&A Crueger (2017). Cruegers Biotechnology: A Text Book of Industrial Microbiology.Edited by K.R. Aneja. Panama Publishing Corporation.
4	Michael, J.W., Neil L. Morgan (2013) Industrial microbiology: an Introduction. Blackwell science
5	Nduka Okafor,Benedict Okeke (2017). Modern Industrial Microbiology and Biotechnology. 2ndEdition: CRC Press Publishers

6	Stanbury P.F., W. Whitaker & S.J. Hall (2016). Principles of Fermentation Technology. 3rd edition. Elsevierpublication
7	Alexander N. Glazer, Hiroshi Nikaido (2014), Microbial Biotechnology: Fundamental of appliedMicrobiology, 2nd Edition, Cambridge University Press

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Theory End Semester Examination Question Paper Pattern. Time 2 hours

End Semester Theory Examinations will be common for all science departments. The duration of the examination is **2.5** hours carrying **60 marks.**

The question paper is divided into **Part–A, Part – B, and Part C.**

Part –A -Objective type carrying from each unit - **20** marks.

Part-B -Analytical questions carrying from each unit - **20** marks

Part –C- Descriptive answer for **20** marks.

Question Paper Pattern Sample

I. Section-A –Any 10 out of 12 2 x 10=20 marks.

Q. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12

II. Section-B -Answer any 4 out of 6 5 x 4=20 marks

Q. 1, 2, 3, 4, 5, 6

III. Section-C -Answer any 2 out of 4 10 X 2 =20 marks

Q. 1, 2, 3, 4

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Practical End Semester Examination Question Paper Pattern. Time 2hours

PATTERN OF QUESTION PAPER SEMESTER END EXAMINATION

End Semester Practical Exam: Experiments-20 marks + Class Record-5 marks = Total 25 Marks.

Practical Examination Question Paper Model for I to IV semester.

Q.1. Major Experiment-Experiment to be conducted and result to be reported **7 Marks.**

Q.2. Minor Experiment- Experiment to be conducted and result to be reported **4 Marks.**

Q.3. Identification and Comment of Spotters “A”, “B” and “C” -- 3 x 3 =0**9 Marks.**

Q.4. Class Record **05 Marks.**

Total -**25 Marks**