



# સૌરાષ્ટ્ર યુનિવર્સિટી

## એકેડેમિક વિભાગ

યુનિવર્સિટી કેમ્પસ, યુનિવર્સિટી રોડ, રાજકોટ-૩૬૦૦૦૫

ફોન નં.(૦૨૮૧)૨૫૭૮૫૦૧ એક્સટે. નં.૨૦૨, ૩૦૪ ફેક્સ નં.(૦૨૮૧)૨૫૭૬૩૪૭ ઈ-મેઈલ : academic@sauuni.ac.in

નં.એકે/વિજ્ઞાન/૧૬૭૩૫/૨૦૨૪

તા.૦૨/૦૧/૨૦૨૪

માઈક્રોબાયોલોજી

પરિપત્ર:-

સૌરાષ્ટ્ર યુનિવર્સિટીની વિજ્ઞાન વિદ્યાશાખા હેઠળની સ્નાતક કક્ષાના B.Sc.(માઈક્રોબાયોલોજી)ના અભ્યાસક્રમ ચલાવતી સર્વે સંલગ્ન કોલેજોના આચાર્યશ્રીઓને આથી જાણ કરવામાં આવે છે કે, NEP-2020 અંતર્ગતના રાજ્ય સરકારશ્રીના તા.૧૧/૦૭/૨૦૨૩ના ઠરાવ ત્યારબાદ તા.૨૭/૦૭/૨૦૨૩ના રોજ પ્રકાશિત થયેલ સ્ટાન્ડર્ડ ઓપરેટિંગ પ્રોસિજર(SOP) તેમજ ત્યારબાદ તેને આનુસંગિક તા.૨૮/૦૭/૨૦૨૩ના રોજ આવેલ સુધારા મુજબના અભ્યાસક્રમો ચેરમેનશ્રી, માઈક્રોબાયોલોજી વિષયની અભ્યાસ સમિતિ દ્વારા રજુ કરાયેલ B.Sc.(માઈક્રોબાયોલોજી) સેમેસ્ટર-૦૨ના અભ્યાસક્રમો આગામી શૈક્ષણિક સત્ર જુન-૨૦૨૩થી અમલમાં આવે તે રીતે માઈક્રોબાયોલોજી વિષયની અભ્યાસ સમિતિ, વિજ્ઞાન વિદ્યાશાખા, એકેડેમિક કાઉન્સિલ તથા સિન્ડિકેટની બહાલીની અપેક્ષાએ મંજૂર કરવા માન.કુલપતિશ્રીને ભલામણ કરેલ, જે માન.કુલપતિશ્રીએ મંજૂર કરેલ છે. જેથી સંબંધિત તમામે તે મુજબ તેની યુસ્તપણે અમલવારી કરવી.

(મુસદ્દો કુલસચિવશ્રીએ મંજૂર કરેલ છે.)

સહી/-

(ડૉ.આર.જી.પરમાર)

કુલસચિવ

બિડાણ:- ઉક્ત અભ્યાસક્રમ (સોફ્ટ કોપી)

રવાના કર્યું

પ્રતિ,

(૧) વિજ્ઞાન વિદ્યાશાખા હેઠળની માઈક્રોબાયોલોજી વિષય ચલાવતી સ્નાતક કક્ષાની સર્વે સંલગ્ન કોલેજોના આચાર્યશ્રીઓ તરફ

(૨) વિજ્ઞાન વિદ્યાશાખા હેઠળની માઈક્રોબાયોલોજી વિષયની અભ્યાસ સમિતિના સર્વે સભ્યશ્રીઓ

નકલ જાણ અર્થે રવાના:-

૧. માન.કુલપતિશ્રી/કુલસચિવશ્રીના અંગત સચિવ

નકલ રવાના (યોગ્ય કાર્યવાહી અર્થે):-

૧. ડીનશ્રી, વિજ્ઞાન વિદ્યાશાખા

૨. પરીક્ષા વિભાગ

૩. પી.જી.ટી.આર.વિભાગ

૪. જોડાણ વિભાગ



# SAURASHTRA UNIVERSITY



## FACULTY OF SCIENCE

### Course Structure and Syllabus for Science FYUGP

## B.Sc. Honours/ Honours with Research in Microbiology

#### Based on

UGC's guidelines NEP-2020 "Curriculum and Credit Framework for Undergraduate Programmes- CCFUP" and

Education Department, Government of Gujarat's  
Uniform Credit Structure for all HEIs of Gujarat State and  
Implementation of the Common Curriculum and Credit Framework under the National  
Education Policy-2020

(No: KCG/admin/2023-24/0607/kh.1 Sachivalaya, Gandhinagar dated 11/07/2023) and

Standard Operating Procedure for Implementation of NEP-2020 for the State of  
Gujarat- HEIs of Gujarat

(No: KCG/admin/2023-24/865/ dated 26/07/2023) and

Additional content to be added to SOP published by KCG

(No: KCG/NEP-2020/2023-24/893/ dated 28/07/2023)

General Guidelines for Implementation of **Four Year Under Graduate Programmes**  
for Saurashtra University (16 pages) published in August 2023

(E-mail from Academic Section Saurashtra University dated Oct 11, 2023)

**Effective from November –2023 & onwards**

(Submitted on 23/11/2023)



## PREFACE

Timely revision of the curriculum to encompass new knowledge and information is a prime criterion of IQAC and a prime need for the college educational systems affiliated with Universities. Under the NEP -2020 and UGC guidelines, a student must be offered the latest courses of varied nature with societal, environmental, and economic implications. The curriculum should offer multiple entry-exit and a choice of vast subjects to choose from to a student to facilitate his learning abilities, aptitude, and inclination.

Microbiology is a foundation subject for Agriculture, Biochemistry, Bioinformatics, Biotechnology, Environmental Science, Genetic engineering, Molecular biology, and Medical Microbiology and hence holds the central position in the curriculum of these subjects. Looking at the rapid inventions and technological developments in the field of Microbiology and keeping in view the recommendations of UGC and NEP-2020, this syllabus has been formulated by the combined and coordinated efforts of all the faculty members of all the Microbiology Departments of Colleges affiliated to Saurashtra University.

The composition of a curriculum for a particular subject requires the following criteria to be considered:

1. Guidelines and Model curriculum were given by the UGC, State Government, and the University
2. Regional needs and Present National and International trends in the subject
3. Geographical parameters of the University and its demographic property
4. Relationship with other related subjects and resources of educational needs.
5. Financial and statutory provisions of the State government

The content of a syllabus should be such that it maintains continuity with the course content of higher secondary classes and post-graduate courses. The current curriculum is made keeping this in mind and is an effort to impart fundamental knowledge of the subject needed at this level. The curriculum is designed per the guidelines of UGC and NEP-2020 and reflects the courses' total credit, teaching hours, and question paper style. The syllabus units are well-defined, and the scope of each is given in detail. A list of reference books is provided at the end of each course. Microbiology being an experimental science, sufficient emphasis is given to training and instrumentation. The following objectives have been considered while formulation the curriculum:

1. To provide an updated, feasible, and modern syllabus to the students, emphasizing knowledge and skill to build up their valuable college education and job-oriented carrier.
2. To frame the syllabus in accordance with the semester system and UGC – NEP 2020 guidelines and in consultation with all stakeholders.
3. To offer the students an array of Core, Interdisciplinary, Multidisciplinary, Skill enhancement, Ability enhancement and Value-added courses to select from and to facilitate his academic, intellectual and social grooming.

The Board of Studies for Microbiology expresses heartfelt gratitude to the Dean, Faculty of Science, Saurashtra University, for valuable guidelines and the Academic Section for much-needed cooperation. The Board wishes all the students pursuing Microbiology a very bright future.

(Dr. Neepa Dilipkumar Pandhi)  
Chairman, Board of Studies, Microbiology  
Saurashtra University, Rajkot (Gujarat)  
Date: 23<sup>rd</sup> November 2023



## Saurashtra University, Rajkot

### MICROBIOLOGY PROGRAMME - B.Sc. (Honours) / B.Sc. (Honours with Research) Curriculum Framework & Syllabus for A.Y. 2023-2024 & Onwards

#### GRADUATE ATTRIBUTES

Graduates should be able to demonstrate the acquisition of the following:

- **Academic excellence:** Comprehensive knowledge and coherent understanding of Microbiology and other interdisciplinary areas of study
- **Practical, professional, and procedural knowledge** required for carrying out professional or highly skilled work/tasks related to Microbiology, including knowledge required for undertaking self-employment initiatives and knowledge and mindset required for entrepreneurship, improved product development, or a new mode of organization
- **Critical and Analytical reasoning/thinking and Effective communications:** Analysis and evaluation of information to form a judgment about a subject or idea and ability to communicate the same in a structured form.
- **Research-related skills:** the ability to understand basic research ethics and skills in practicing/doing ethics in the field/ in personal research work, regardless of the funding authority or field of study.
- **Leadership qualities and Teamwork abilities:** The graduates should be able to demonstrate the capability for mapping out the tasks of a team and setting direction and inspiring vision, and building a team that can help achieve the goals
- **Global Citizenship:** Mutual understanding with others from diverse cultures, perspectives, and backgrounds by embracing and practicing constitutional, humanistic, ethical, and moral values in life, including universal human values of truth, righteous conduct, peace, love, nonviolence, and scientific temper.
- **Life Long Learning:** Ready to imbibe new knowledge, values, and skills with an open mind and willing to adopt change for constructive development.

#### PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

This program will produce Graduates who will attain the following PEOs after a few years.

PEO 1	:	<b>Core subject competency:</b> will acquire the competency to pursue higher education, develop a professional career, or be self-employed with the knowledge and skills of Microbiology and allied sciences.
PEO 2	:	<b>Application of knowledge:</b> will show the ability to apply the knowledge of Microbiology to independently design and execute minor research problems for societal and human welfare.
PEO 3	:	<b>Overall Preparedness:</b> I will have the ability to undertake any assignment as a leader or team member and will be able to contribute to academics, entrepreneurship, and research, with good communication skills.
PEO 4	:	<b>Professionalism:</b> will possess strong professional ethics to fulfill moral duties towards his profession, community, society, and the nation.
PEO 5	:	<b>Learning environment:</b> will show readiness for lifelong learning to meet personal, professional, social, and global demands through knowledge and skills.



<b>PROGRAM OUTCOMES: (POs)</b>	
After completion of the B.Sc. Microbiology program, the Student will be able to:	
<b>PO 1</b>	: <b>Specific Disciplinary knowledge:</b> Demonstrate an understanding of fundamental principles, scope, and applications of Microbiology and can appreciate the beneficial and harmful role of microorganisms
<b>PO 2</b>	: <b>Problem analysis:</b> Accurately identify and critically analyze problems in various domains of Biological sciences.
<b>PO 3</b>	: <b>Designing viable solutions:</b> Search for and successfully arrive at viable conclusions/solutions about various aspects of life sciences using the right approach and appropriate tools and techniques
<b>PO 4</b>	: <b>Scientific aptitude:</b> Ability to solve local, regional, national, or global problems scientifically using logical thinking and advanced techniques.
<b>PO 5</b>	: <b>Modern tool usage:</b> Understand standard operating procedures and safety measures and acquire in-depth technical competence to handle the basic laboratory instruments and retrieve scientific information with modern data search tools.
<b>PO 6</b>	: <b>Global citizen:</b> Demonstrate the ability to understand the needs of changing world from a Microbiology perspective and with an insight into his constructive role for the societal benefits honestly and consistently with a strong sense of ethics and values.
<b>PO 7</b>	: <b>Environment and sustainability:</b> Can be an ambassador for Environmental protection and advocate for the need to advocate for sustainable development.
<b>PO 8</b>	: <b>Ethics:</b> Commitment to professional and social ethics and work accordingly
<b>PO 9</b>	: <b>Individual and team work:</b> Exhibit the potential to effectively accomplish tasks as a leader or a member of a team as well as independently in multidisciplinary settings.
<b>PO 10</b>	: <b>Communication:</b> Possess practical Communicate skills in spoken and written forms for practical idea sharing with the scientific community, society, and colleagues.
<b>PO 11</b>	: <b>Scientific Innovations and fund management:</b> Ability to design a research project and manage its execution to generate new scientific insights, innovations, and revenues with proper time and fund management.
<b>PO 12</b>	: <b>Life-long learning:</b> Ready to undertake life-long learning to periodically update scientific knowledge and its application.

### **PROGRAM SPECIFIC OUTCOMES (PSOs) for B. Sc. Microbiology program**

After completion of the program, the Graduate will:	
<b>PSO1</b>	: Acquire sound knowledge about the fundamentals of Microbiology to develop a solid base to enable the understanding of emerging and advanced concepts in life sciences.
<b>PSO2</b>	: Be equipped with knowledge, skill, and inspiration to pursue higher education and research in Microbiology and allied fields to answer urgent global problems.
<b>PSO3</b>	: Use Microbiology principles and applications to find innovative solutions for environment, agriculture, and health-related issues at local and global levels.
<b>PSO4</b>	: Acquire the skill and the required knowledge to be an entrepreneur/self-employed and serve the scientific community and society by generating problem solutions and employment.
<b>PSO5</b>	: Become competent and eligible to appear in various competitive exams, placement in government and private sectors of academia, research, and industries, and become a successful Microbiologist serving the Nation.



**B.Sc. Honours/ Honours with Research in Microbiology**  
(NCrF Level- 4.5 First Year – UG Certificate in Microbiology)  
**Semester II**

SN	Course Category As per GoG- NEP-SOP - July 2023& additional content 28/7/23	Course Title	Credit			Hrs./ Week		Evaluation - Weightage CCE: SEE = 50:50				
			T	P	Total	T	P	CCE Marks		SEE Marks		Total Marks
								T	P	T	P	
1	<b>Major (Core) 3</b> (Microbiology)	<b>Microbiology-3:</b> Microbial Growth and Control (4- Credit Course including Theory & Practical components)	3	1	4	3	2	25	25	50	-	100
2	<b>Major (Core) 4</b> (Microbiology)	<b>Microbiology-4:</b> Microbial Taxonomy and Diversity (4- Credit Course including Theory & Practical components)	3	1	4	3	2	25	25	50	-	100
3	<b>Minor (Elective)*-2</b>	(As per GoG- NEP-SOP July 2023& additional content 28/7/23 – Clause 3.3.2) <b>Any One from Basket</b> (As per the expertise and resources available in the college) (4- Credit Course including Theory & Practical components)	3	1	4	3	2	25	25	50	-	100
4	<b>Multi/Inter- Disciplinary Course -2 (MDC/IDC-2) (Elective)**</b> Categories: Natural & Physical Science/ Maths, Stat.and Comp. Appl./Lib., Info. & Media Sci./Comm. & Mgt./Huma., and Social Sci./ Sanskrit etc...	(As per GoG- NEP-SOP July 2023& additional content 28/7/23 – Clause 3.3.3) <b>Any One from Basket</b> (As per the expertise and resources available in the college) (4- Credit Course including Theory & Practical components)	3	1	4	3	2	25	25	50	-	100
5	<b>Ability Enhancement Course -2 (AEC-2)</b>	(As per GoG- NEP-SOP July 2023& additional content 28/7/23 – Clause 3.3.4) <b>English Language:</b>	2	-	2	2	-	25	-	25	-	50
6	<b>Skill Enhancement Course-2 (SEC-2)</b>	(As per GoG- NEP-SOP July 2023& additional content 28/7/23 – Clause 3.3.5) <b>Skill based Practical Course-2: Mushroom Cultivation</b>	-	2	2	-	4	-	25	-	25	50
7	<b>Common Value-Added Course-2-(C-VAC-2)***</b> NSS/NCC/ Sports & Fitness/ Ethics and Culture/ Culture and Communication / Ethics and Values in Ancient Indian Traditions/ Human Values and Ethics/IPDC	(As per GoG- NEP-SOP July 2023& additional content 28/7/23 – Clause 3.3.6) VAC based on <b>IKS:</b> NSS/NCC/Sports & Fitness/Human Values and Ethics	-	2	2	-	4	-	25	-	25	50
<b>Total Credits and Marks (Semester-II)</b>			14	08	22	14	16	125	150	225	50	550



\* Any one course from the basket, selected as a Minor elective course as per the expertise and resources available in the college for Semester - I will continue as a Minor in the semester-II as well.

\*\* Any one course from the basket, selected as Multi/Inter disciplinary elective courses (MDC/IDC) as per the expertise and resources available in the college for Semester – I will continue in the semester-II as well.

\*\*\* Common **Value-Added Elective Courses (C-VAC-2)** common to all is to be selected from University Basket for semester II, as per the expertise and resources available in the college.

<b>Courses Offered by BoS in Microbiology to other FYUGP- B.Sc. Program in Semester-II</b>												
SN	Course Category As per GoG- NEP-SOP - July 2023& additional content 28/7/23	Course Title	Credit			Hrs./ Week		Evaluation - Weightage CCE: SEE = 50:50				
			T	P	Total	T	P	CCE Marks		SEE Marks		Total Marks
								T	P	T	P	
1	<b>Minor (Elective)-2</b> (Microbiology) (In addition to courses mentioned in SOP basket)	Microbiology-2: Basic Principles of Microbial Growth and Control <b>(4- Credit Course</b> including Theory & Practical components)	3	1	4	3	2	25	25	50	-	100
2	<b>Multi/Inter – Disciplinary Course -2</b> (MDC/IDC-2) <b>(Elective)</b> (Microbiology) (In addition to courses mentioned in SOP basket)	Microbiology – 2 Introduction to Microbial Systematics and Diversity	3	1	4	3	2	25	25	50	-	100



**Evaluation Scheme:** (As per GoG- NEP-SOP July 2023& additional content 28/7/23 – Chapter-7: Evaluation Reforms)

The evaluation process should be formulated to make a systematic evaluation of students’ progress based on UGC guidelines. The evaluation must be designed with learner attributes in mind. These attributes have clear linkages to Programme Education Objectives and Outcomes. The evaluation consists of the following two components:

1. Continuous and Comprehensive Evaluation (CCE)- Formative
2. Semester End Evaluation (SEE)- Summative

CCE carries 50% of the total marks allotted to a subject and the other 50% being assigned to the SEE.

In each course, every credit carries 25 marks, of which 50% marks is assigned for CCE and rest 50% marks for SEE. The 50% marks assigned to the CCE is distributed between the continuous classroom evaluation and mid-term evaluation. The pattern may be as follow:

SN	Evaluation	*T-3 + P-1 = Total 4 credit subjects (Marks)	2 credit subjects (Marks)
1	<b>CCE (50%)</b>		
	Classroom & Mid-Term Evaluation	<b>T-25 + P- 25</b>	<b>25</b>
2	<b>SEE (50%)</b>	<b>50</b>	<b>25</b>
	<b>Total</b>	<b>100</b>	<b>50</b>

\*T = Theory; P= Practical

### Continuous and Comprehensive Evaluation (CCE)

Subject–wise CCE will be undertaken by the concerned faculty member. The mode of evaluation will be decided by the faculty member concerned with the subject. Normally CCE consists of class participation, case analysis and presentation, assignment, tutorials, slip tests (announced/ surprised), quizzes, attendance etc. or any combination of these. The students are expected to submit their answer scripts/ reports of internal evaluation within the stipulated time. Failure to do so may result in the script not being valued. Another part of CCE consists of mid-term written evaluation, which is compulsory for all students. It can be done in a scheduled manner. The duration of the mid-term evaluation shall be one hour.

### Semester End Evaluation (SEE)

The SEE carries 50% of the marks assigned to a course. SEE shall be of 2 ½ hours for 3/4 credit course and 2 hours in case of 1/2 credit courses. The controller of the examination will conduct these examinations. Paper setting and evaluation will be done by the external examiners to an extent of 50% of the evaluation process. This examination shall be conducted as per a schedule which shall be notified in advance.

The backlog exam will be conducted twice a year just after the result declared of the semester evaluation. Students shall have a second chance to clear their backlog and avoid the burden to carry forward the backlog with the next semester exam.

Appearance in all the evaluations is mandatory and no exemption can be granted except in the following case:





1. In case of inability to attend the exam due to reasons considered genuine by the controller of examination in consultation with the Director/Board.
2. In case of medical emergency, a certificate from the registered medical practitioner must be produced before the commencement of exams. The evaluation board will then take final decision on the recommendation for exemption.

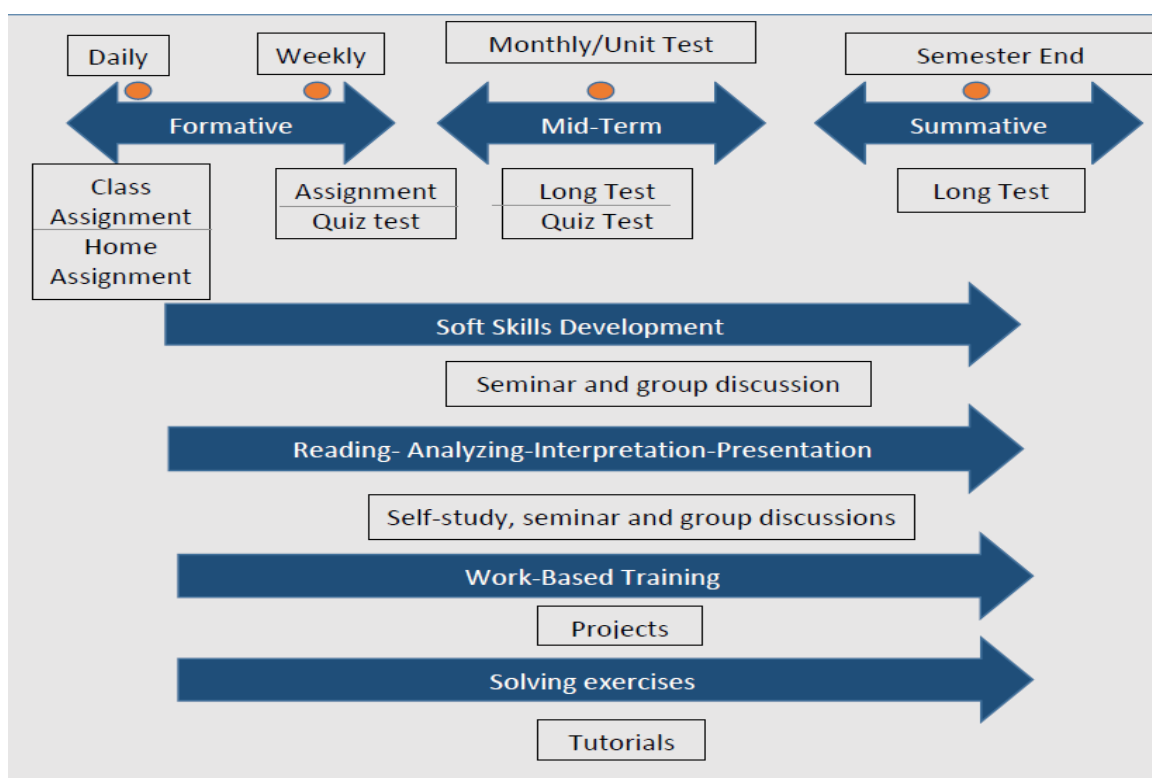
### Eligibility Criteria to appear in SEE

To be able to appear for the SEE, a student must comply with the following conditions:

1. Should have at least 75% of attendance in all the courses put together.
2. Should have at least 70% of attendance in each course/subject.
3. Should not have any disciplinary proceedings pending against him/her.
4. Should have no pending due.

### Continuum of Evaluation

Evaluation must be continuous which may include both formative and summative components in a timely manner for continuous feedback as follow:



### Mode of Evaluation

A wide range of modes of evaluation for evaluating students is available for the teachers/ institutions to use. A suitable compendium of such a mode needs to be carefully chosen for a particular program depending on its nature, objectives, and available resources. The mode of evaluation can be as below:



Written Mode	Oral Mode	Practical Mode	Integrated Mode
Semester Exam Class Test Open book exam/test Open note exam/test Self-test/Online test Essay/Article writing Quizzes/Objective test Class assignment Home assignment Reports writing Research/Dissertation Class Studies	Viva/Oral exam Group Discussion Role Play Authentic Problem Solving Quiz Interview	Lab work Computer simulation/virtual labs Craft work Co-curricular work	Paper presentation/Seminar Field Assignment Poster Presentation

Written Mode		
Evaluation Type	Nature	Objective
Semester Exam	Traditionally essay type, with objective / short answer questions to evaluate Lower Order Thinking (LOT) OBE skills	For depth and planned preparation
Class test	Traditionally essay type	Fixed date forces students to learn
Open book test	Allowed choice of reference book	Measures what students can do with resources, less stress on memory
Open note test	To get used to the system	Encourage good note taking
Self-test	For subjective and objective items	Mastery learning occurs with proper feedback
Article/essay writing	Individual long written assignment	Individual expression and creativity
Quizzes/Objective test	Short duration structured test	Excellent validity as greater syllabus coverage
Class assignment	With defined time	Student's performance to make decision
Home assignment	With undefined time	Reinforce learning and facilitate mastery of specific skills
Reports Writing	On activities performed or event observed	Develop a key transferable skill
Research/Dissertation	Detailed research-based report	To judge creativity and research skills
Case Studies	Analyse a given case (real or fictional)	To assess thinking, value, and attitude
Oral Mode		
Evaluation Type	Nature	Objective
Viva/Oral exam	Individually or in small group	Practical experience towards job interview situation
Group discussion	Small group of 2-5 members work on a joint task	Encourage teamwork
Role Play	Small group of 2-5 members work	Develop personality



	on a joint task	
Authenticate problem solving	Small group of 2-5 members work on a joint task	Communication of ideas
Quiz	Small group of 2-5 members work on a joint task	Assess memory power
Interview	Individually	Judge the personal confidence level

<b>Practical Mode</b>		
<b>Evaluation Type</b>	<b>Nature</b>	<b>Objective</b>
Lab work	Component of working with one's hand	Keep the students on the task
Computer simulation/virtual labs	Component of working with one's hand	To understand the practical exposure
Craft work	Component of working with one's hand	Encourage application of concepts learnt
Co-curricular work	Component of working with one's hand	For immediate feedback

<b>Integrated Mode</b>		
<b>Evaluation Type</b>	<b>Nature</b>	<b>Objective</b>
Paper presentation/Seminar	Group or individual work	Learn from others presentation
Field Assignment	Field visit with report	Develop observation and recording skills
Poster presentation	Group or individual work	Develop research, creativity, and discussion skills
Paper presentation/Seminar	Group or individual work	Learn from others presentation

## Models of Evaluation

Based on the types of evaluation, various models of evaluation implementation are suggested for theory, practical, self-study and work-based learning. The focus of these models is to encourage the students to improve on skills and performance.

**Evaluation Norms & Question Paper Pattern for Theory & Practical Courses:** Please refer General Guidelines for Implementation of **Four Year Under Graduate Programmes** for Saurashtra University (16 pages) published in August 2023.

<b>Model for Theory Courses- Theory-3+Practical-1 = 4 Credit Course</b>	
<b>CCE-50% (50 Marks)SEE-50% (50 Marks)</b>	
<b>Exam Pattern</b>	<b>Marks</b>
Class Test (Average of <b>TWO</b> tests)	<b>T-25 + P-25</b>
Quiz (Average of <b>TWO</b> quiz)	
Home Assignment	
Active Learning- PBL/CSBL/Seminar/Flipped Class Room etc. OBE evaluation tools.	
Class Assignment	
Attendance	
<b>Continuous and Comprehensive Evaluation</b>	
<b>Semester-End Evaluation</b>	<b>T-50</b>



<b>Model for Practical Courses-1 Credit Course</b>	
<b>CCE-100% (25 Marks)</b>	
<b>Exam Pattern</b>	<b>Marks</b>
Lab work assessment	10
Viva voce/Lab quiz	10
Attendance	05
<b>Continuous and Comprehensive Evaluation</b>	<b>25</b>

<b>Model for Skill Enhancement Course - Skill based Practical Course -2 Credit Course</b>	
<b>CCE-50% (25 Marks)SEE-50% (25 Marks)</b>	
<b>Exam Pattern</b>	<b>Marks</b>
Lab work assessment or Project based Assessment	10
Viva voce/Lab quiz	10
Attendance& Performance	05
<b>Continuous and Comprehensive Evaluation</b>	<b>25</b>
<b>Semester-End Evaluation</b>	<b>25</b>



### Suggested Question Paper Format for 4 Credit Course (Theory)

**Time: 2 Hours**

**Marks: 50**

Q. 1. Unit I	(A)		(10/7/6/5)
	(B)		(0/3/4/5)
		<b>OR</b>	
	(A)		(10/7/6/5)
	(B)		(0/3/4/5)
Q. 2. Unit II	(A)		(10/7/6/5)
	(B)		(0/3/4/5)
		<b>OR</b>	
	(A)		(10/7/6/5)
	(B)		(0/3/4/5)
Q. 3. Unit III	(A)		(10/7/6/5)
	(B)		(0/3/4/5)
		<b>OR</b>	
	(A)		(10/7/6/5)
	(B)		(0/3/4/5)
Q. 4. Unit IV	(A)		(10/7/6/5)
	(B)		(0/3/4/5)
		<b>OR</b>	
	(A)		(10/7/6/5)
	(B)		(0/3/4/5)
Q. 5. Unit V	(A)		(10/7/6/5)
	(B)		(0/3/4/5)
		<b>OR</b>	
	(A)		(10/7/6/5)
	(B)		(0/3/4/5)



### Suggested Question Paper Format for 2 Credit Course (Theory)

**Time: 1 Hour**

**Marks: 25**

Q. 1. Unit I	(A)	(10/7/6/5)
	(B)	(0/3/4/5)

**OR**

	(A)	(10/7/6/5)
	(B)	(0/3/4/5)

Q. 2. Unit II	(A)	(10/7/6/5)
	(B)	(0/3/4/5)

**OR**

	(A)	(10/7/6/5)
	(B)	(0/3/4/5)

Q. 3. Unit III	(A)	(5)
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**OR**

	(A)	(5)
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### Practical Question Paper Pattern Semester End Examination (SEE)

**Instructions:**

- Certified journal is compulsory for appearing for semester end practical examination.
- Student should have at least 75% attendance in practical sessions during the semester.
- Time duration: **2 Hours**.

Ex. No.	Detail of Exercise	Marks
1	Perform any one from the given list of exercises as per the instruction of the examiner.	10
2	Spotting	05
3	Viva-voce	05
4	Certified Journal	05
	<b>TOTAL</b>	<b>25</b>



**B.Sc. Honours/ Honours with Research in Microbiology**  
(NCRF Level- 4.5 First Year – Certificate in Microbiology)

**Semester – II**

Course Category	<b>Major-3</b>
Title of the Course	<b>Microbiology -3: Microbial Growth and Control</b>
Course Credit	<b>03</b>
Teaching Hours per Sem.	<b>45</b>
Total Marks	<b>CCE- 25+ SEE- 50</b>

1	Employability/Entrepreneurship/Skill Development પર કેન્દ્રિત થયેલ છે કે નહિ ?	Yes/No				
2	Value added Courses Imparting Transferable and Life Skills ના ગુણો ધરાવે છે ?	Yes/No				
3	Major	Yes/No	Minor	Yes/No		
	Skill Enhancement Courses	Yes/No	Ability Enhancement Courses	Yes/No		
	Value Added Courses	Yes/No	Exit/ Vocational Courses	Yes/No		
4	Holistic Education	Yes/No	Multidisciplinary	Yes/No	Interdisciplinary	Yes/No
5	દિવ્યાંગ માટે વિષય અંતર્ગત આનુસંગિક જોગવાઈ કરાયેલ છે ?	Yes/No				
6	New India Literacy Programme (NILP) મુજબનો વિષય છે ?	Yes/No				
7	Swayam પ્લેટફોર્મ પરના MOOC વિષય પર આધારિત આ વિષય છે ?	Yes/No				
8	ઇન્ડિયન નોલેજ સીસ્ટમ (IKS) પર આધારિત વિષય છે ?	Yes/No				

**Course Outcomes:**

**On completion of the course, the student shall be able to:**

1. Explain basic requirements for microbial growth and evaluate its characteristics.
2. Summarize specific requirement of nutrition, chemicals and physical condition for growth
3. Apply different methods of microbial control, namely, by antibiotics, chemicals and physical methods.
4. Isolate and purify bacterial culture, measuring microbial growth and interpret cultural characteristics and growth pattern of different microbes.
5. Select appropriate methods for effective control of microbial growth under different conditions.



Course Content	Hours	Marks
<b>Unit-I: Microbial Growth and Nutrition</b>	<b>9 hrs</b>	<b>10</b>
<ul style="list-style-type: none"><li>• Introduction and Definition of Growth, Modes of Cell division in prokaryotes</li><li>• Bacterial Growth Curve</li><li>• Synchronous culture &amp; Continuous Growth of Bacteria</li><li>• Measurement of Bacterial Growth</li></ul>		
<b>Unit-II: Microbial cultivation and Pure Culture Techniques</b>	<b>9 hrs</b>	<b>10</b>
<ul style="list-style-type: none"><li>• Types of bacteria based on nutritional requirements</li><li>• Chemical and Physical requirement of Growth- Bacteriological Media, Air, pH &amp; Temperature</li><li>• Cultivation of Anaerobes</li><li>• Natural Microbial Population (Mixed Cultures), Selective methods to obtain Pure Cultures, Cultural Characteristics, Isolation, purification and Preservation of pure cultures</li></ul>		
<b>Unit-III: Control of Microbes by Physical methods</b>	<b>9 hrs</b>	<b>10</b>
<ul style="list-style-type: none"><li>• Definitions: Sanitization, Antisepsis, Sterilization, Disinfection, Microbiocidal &amp; Microbiostasis, Thermal Death Time, Thermal Death Point, z-Value &amp; F-value, D-Value</li><li>• Control by Temperature:<ul style="list-style-type: none"><li>a) <u>High Temperature</u>: Moist Heat – Autoclave, Boiling, Pasteurization, Fractional Sterilization Dry Heat – Hot Air Oven, Incineration,</li><li>b) <u>Control by Desiccation</u></li><li>c) <u>Control by Low Temperature</u></li></ul></li><li>• Control by Radiation – UV radiation, x-rays, Gamma rays and Cathode rays</li><li>• Control by Filtration</li></ul>		
<b>Unit-IV: Control of Microbes by Chemical methods</b>	<b>9 hrs</b>	<b>10</b>
<ul style="list-style-type: none"><li>• Characteristics of an Ideal Antimicrobial agent</li><li>• Halogens – Iodine &amp; Chlorine, Heavy Metals &amp; Dyes</li><li>• Phenol &amp; Phenolic compounds, Phenol coefficient method, Alcohols</li><li>• Detergents &amp; Quaternary Ammonium Compounds, Aldehydes &amp; Gaseous agents</li></ul>		
<b>Unit- V: Control of Microbes by Antibiotics</b>	<b>9 hrs</b>	<b>10</b>
<ul style="list-style-type: none"><li>• Chemotherapeutic agents and Chemotherapy, Characteristics of ideal chemotherapeutic agent</li><li>• Antibiotics and their mode of action: Inhibition Effect on cell wall synthesis, nucleic acid and protein synthesis, Damage to cytoplasmic membrane, Inhibition of specific enzyme system</li><li>• Antifungal, antiviral and antitumor chemotherapeutic agents</li><li>• Microbiological assay of antibiotics</li></ul>		





### **Text books:**

1. Pelczar, M.J., Chan, E.C.S. and Kreig, N.R. (2002) Microbiology. 5th Edition, Tata McGraw-Hill, New Delhi. (UNIT: 1 & 2)
2. Powar, C.B., Daginawala, J.F. (2010). General Microbiology Vol-I. Mumbai: Himalaya Publishing House. (UNIT: 3,4 &5)

### **Reference books:**

1. Stanier, R.Y. (1987). General Microbiology, 5<sup>th</sup> Edition: Macmillan publication.

### **Pedagogic tools:**

- Chalk and Board
- Power point presentation
- Video
- Seminars

### **Suggested reading / E-resources**

<https://www.youtube.com/watch?v=Uf8a7cCVjM4>

<https://www.youtube.com/watch?v=BkbLI2mAMP8>

### **Suggested MOOCs**

- <https://alison.com/course/introduction-to-microbiology>
- <https://extendedstudies.ucsd.edu/courses-and-programs/microbiology-with-lab>



**B.Sc. Honours/ Honours with Research in Microbiology**  
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**Semester – II**

Course Category	<b>Major Practical - 3</b>
Title of the Course	<b>Microbiology -3P: Microbial Growth and Control</b>
Course Credit	<b>01</b>
Teaching Hours per Sem.	<b>30</b>
Total Marks	<b>CCE- 25</b>

**Course Outcomes:**

**At the end of the course, the student shall be able to:**

1. Use various microbial techniques and instrument to measure microbial growth.
2. Use basic instrumentS needed for the conduction of experiments in a Microbiology laboratory
3. Perform simple techniques of observation and study of microbial morphology and cellular structure, methods of microbial control, etc.
4. Acquire skill of isolating and purifying a bacterial culture, measuring microbial growth and interpret cultural characteristics and growth pattern of different microbes.
5. Select appropriate method to choose for effective control of microbial growth.

1	Employability/Entrepreneurship/Skill Development પરકેન્દ્રિતથયેલછેકેનહિ ?	Yes/No				
2	Value added Courses Imparting Transferable and Life Skills નાગુણોધરાવેછે?	Yes/No				
3	Major	Yes/No	Minor	Yes/No		
	Skill Enhancement Courses	Yes/No	Ability Enhancement Courses	Yes/No		
	Value Added Courses	Yes/No	Exit/ Vocational Courses	Yes/No		
4	Holistic Education	Yes/No	Multidisciplinary	Yes/No	Interdisciplinary	Yes/No
5	દિવ્યાંગમાટેવિષયઅંતર્ગતઆનુસાંગિકજોગવાઈકરાયેલછે ?	Yes/No				
6	New India Literacy Programme (NILP) મુજબનોવિષયછે ?	Yes/No				
7	Swayam પ્લેટફોર્મપરના MOOC વિષયપરઆધારિતઆવિષયછે ?	Yes/No				
8	ઇન્ડિયનનોલેજસીસ્ટમ (IKS) પરઆધારિતવિષયછે ?	Yes/No				



### Major Practical-3

Sr. No.	Experiment
1	Measurement of size of microorganisms by Micrometry (Demonstration)
2	Calibrations of microscopic measurements (Ocular & stage micrometers)
3	Isolation of microorganisms by various methods
4	Turbidimetric study of growth curve of <i>E.coli</i> and derivation of Growth rate & Generation time.
5	Enumeration of bacteria by viable count technique.
6	Enumeration of bacteria by Total Count Technique.
7	Effect of various chemicals on microbial growth
8	Effect of antibiotics on microbial growth

#### Reference Books:

1. Patel. R.J., Patel. K.R. (2009). Experimental Microbiology, Vol-I, Ahmedabad: Aditya Publications.
2. Patel. R.J., Patel. K.R. (2009). Experimental Microbiology, Vol-II, Ahmedabad: Aditya Publications.
3. Dubey, R.C., Maheshwari, D.K. (2005). Practical Microbiology. New Delhi: S. Chand & Company Limited.
4. Sharma, K. (2005). Manual of Microbiology – Tools and Techniques. New Delhi: Ane books.
5. Benson, H.J. (2002). Microbiological Applications – Laboratory Manual in General Microbiology – 8<sup>th</sup> edition: MacGrow Hill Company.

#### Pedagogic tools:

- Chalk and Board
- Power point presentation
- Video

#### Suggested reading / E-resources

- [https://www.youtube.com/watch?v=R6Uv\\_WJlmM](https://www.youtube.com/watch?v=R6Uv_WJlmM)
- [https://www.youtube.com/watch?v=KHg\\_PyjQPwk](https://www.youtube.com/watch?v=KHg_PyjQPwk)

#### Suggested MOOCs

- <https://alison.com/course/introduction-to-microbiology>
- <https://extendedstudies.ucsd.edu/courses-and-programs/microbiology-with-lab>



**B.Sc. Honours/ Honours with Research in Microbiology**  
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**Semester – II**

Course Category	<b>Major-4</b>
Title of the Course	<b>Microbiology -4: Microbial Taxonomy and Diversity</b>
Course Credit	<b>03</b>
Teaching Hours per Sem.	<b>45</b>
Total Marks	<b>CCE- 25+ SEE- 50</b>

1	Employability/Entrepreneurship/Skill Development પરકેન્દ્રિતથયેલછેકેનહિ ?	Yes/No				
2	Value added Courses Imparting Transferable and Life Skillsનાગુણોધરાવેછે?	Yes/No				
3	Major	Yes/No	Minor	Yes/No		
	Skill Enhancement Courses	Yes/No	Ability Enhancement Courses	Yes/No		
	Value Added Courses	Yes/No	Exit/ Vocational Courses	Yes/No		
4	Holistic Education	Yes/No	Multidisciplinary	Yes/No	Interdisciplinary	Yes/No
5	દિવ્યાંગમાટેવિષયઅંતર્ગતઆનુસાંગિકજોગવાઈકરાયેલછે ?	Yes/No				
6	New India Literacy Programme (NILP) મુજબનોવિષયછે?	Yes/No				
7	Swayam પ્લેટફોર્મપરના MOOC વિષયપરઆધારિતઆવિષયછે ?	Yes/No				
8	ઇન્ડીયનનોલેજસીસ્ટમ (IKS) પરઆધારિતવિષયછે ?	Yes/No				

**Course Outcomes:**

**At the end of the course, the student shall be able to:**

1. Identify major groups of microorganisms with respect to its diversity that laid the groundwork for modern Microbiology.
2. Explain major features of bacterial classification, characteristics of prokaryotic cells and eukaryotic cells and major groups of microorganisms.
3. Outline the structural and functional differences among all the microbes such as morphological features of bacterial cell and its organelles.
4. Analyze the role of microbes in their natural environments with respect to the maintenance of functioning of eco-system.
5. Explain the underlying facts of identification and classification of microorganisms.



Course Content	Hours
<b>Unit. 1: Introduction to Microbial Diversity</b>	<b>9 hrs</b>
<ul style="list-style-type: none"><li>• Introduction to Biodiversity- Microbial evolution and diversity, Types of diversity</li><li>• Microbial Taxonomy: Introduction and overview, Taxonomic ranks of microorganisms, Classification systems</li><li>• Major characteristics used in taxonomy</li><li>• Assessing Microbial Phylogeny</li></ul>	
<b>Unit. 2: Prokaryotic Diversity</b>	<b>9 hrs</b>
<ul style="list-style-type: none"><li>• <u>Gram negative bacteria</u> – General features of:<ul style="list-style-type: none"><li>○ Aerobic/Microaerophilic motile, helical vibroid</li><li>○ Non-motile curved bacteria</li><li>○ Aerobic/Microaerophilic rods and cocci</li></ul></li><li>• <u>Gram negative bacteria</u> – General features of:<ul style="list-style-type: none"><li>○ Facultative anaerobes – rods, curved and helical bacteria</li><li>○ Dissimilatory Sulphate reducers</li></ul></li><li>• <u>Gram negative bacteria</u> – General features of:<ul style="list-style-type: none"><li>○ Anaerobic cocci</li><li>○ Phototrophic bacteria</li></ul></li><li>• <u>Gram positive bacteria</u> – General features of:<ul style="list-style-type: none"><li>○ Endospore forming rods and cocci</li><li>○ Asporogenous rods</li><li>○ Mycobacteria and Actinomycetes</li></ul></li></ul>	
<b>Unit 3: Diversity of some unusual Prokaryotes</b>	<b>9 hrs</b>
<ul style="list-style-type: none"><li>• <u>General Features of Bacteria with unusual morphology:</u><ul style="list-style-type: none"><li>○ Budding and appendaged bacteria</li><li>○ Sheathed Bacteria</li><li>○ Mycoplasma</li></ul></li><li>• Bacteria with gliding motility,</li><li>• Rickettsia and Chlamydia</li><li>• Introduction to Archaea<ul style="list-style-type: none"><li>○ Thermophiles</li><li>○ Halophiles</li><li>○ Acidophiles</li><li>○ Barophiles</li><li>○ Methanogens</li><li>○ Psychrophiles</li></ul></li></ul>	
<b>Unit. 4: Eukaryotic Diversity</b>	<b>9 hrs</b>
<ul style="list-style-type: none"><li>• Fungi: General characteristics – Definition, occurrence, structure and Economic importance of fungi</li><li>• Algae: General Characteristics – Definition, Occurrence, Ultra- Structure, Reproduction</li><li>• General Characteristics – Definition, Occurrence, Ultra- Structure, Reproduction and Economic importance of Protozoa</li><li>• Economic importance of Fungi, Algae and Protozoa</li></ul>	



<b>Unit. 5: Akaryotic Diversity - Viruses</b>	<b>9 hrs</b>
<ul style="list-style-type: none"><li>• Introduction to Viruses: Definition, General features of viruses: Size, Capsids symmetry, Chemical Nature, Life cycle</li><li>• Overview of Bacterial Virus: T4 and Lambda</li><li>• Overview of plant Virus: TMV</li><li>• Overview of Animal viruses; HIV</li></ul>	

#### **Text Books:**

- Pelczar, M.J., Chan, E.C.S., Kreig, N.R. (1993). Microbiology, 5<sup>th</sup> Edition. New Delhi: Tata McGraw Hill Publishing Company Ltd.
- Prescott, M.J., Harley, J.P., Klein, D.A. (2002). Microbiology, 5<sup>th</sup> Edition, New York: WCB McGrawHill publication.

#### **Reference Books:**

1. Modi, H.A. Elementary Microbiology - Vol -I, AktaPrakashan, Nadiyad.
2. Modi, H.A. Elementary Microbiology – Vol-II, AktaPrakashan, Nadiyad.
3. Dubey, R.C.and Maheshwari, D.K., A Text Book of Microbiology, S. Chand Publications, New Delhi.
4. Tortora, Funke & Case. Microbiology-An Introduction, 8 Edition, Pearson Education, Delhi.
5. Powar and Dagainawala, General Microbiology Vol-II. Himalaya Publishing House, Mumbai.
6. Atlas. R.M., Principles of Microbiology- 2<sup>nd</sup> Edition ,

#### **Pedagogic tools:**

- Chalk and Board
- PPT and Videos.
- Assignment
- Class Activity: Think-Pair-Share / Class Test

#### **Suggested reading / E-resources**

- Bacterial Growth Curve Protocol | Protocols | Microbe Notes
- NPTEL :: Biotechnology - Microbiology
- 9: Microbial Growth - Biology LibreTexts
- Lecture notes, lecture 1 - Micro Chapter The microbial world The microbes - StuDocu

#### **Suggested MOOCs**

- General Microbiology - Course (swyam2.ac.in)



**B.Sc. Honours/ Honours with Research in Microbiology**  
(NCRF Level- 4.5 First Year – Certificate in Microbiology)

**Semester – II**

Course Category	<b>Major Practical - 4</b>
Title of the Course	<b>Microbiology -4P: Microbial Taxonomy and Diversity</b>
Course Credit	<b>01</b>
Teaching Hours per Sem.	<b>30</b>
Total Marks	<b>CCE- 25</b>

1	Employability/Entrepreneurship/Skill Development પરકેન્દ્રિતથયેલછેકેનહિ ?	Yes/No				
2	Value added Courses Imparting Transferable and Life Skills નાગુણોધરાવેછે?	Yes/No				
3	Major	Yes/No	Minor	Yes/No		
	Skill Enhancement Courses	Yes/No	Ability Enhancement Courses	Yes/No		
	Value Added Courses	Yes/No	Exit/ Vocational Courses	Yes/No		
4	Holistic Education	Yes/No	Multidisciplinary	Yes/No	Interdisciplinary	Yes/No
5	દિવ્યાંગમાટેવિષયઅંતર્ગતઆનુસાંગિકજોગવાઈકરાયેલછે ?	Yes/No				
6	New India Literacy Programme (NILP) મુજબનોવિષયછે ?	Yes/No				
7	Swayam પ્લેટફોર્મપરના MOOC વિષયપરઆધારિતઆવિષયછે ?	Yes/No				
8	ઇન્ડિયનનોલેજસીસ્ટમ (IKS) પરઆધારિતવિષયછે ?	Yes/No				

**Course Objectives:**

**At the end of the course, the student shall be able to:**

1. Acquire basic skill of isolation and cultivation of different microorganisms.
2. Use various methods of microbial identification, especially by biochemical and morphological characteristics
3. Perform Microscopic observation and study of microbial morphology and cellular structure to identify and distinguish microbes.
4. Perform qualitative and quantitative estimation of various biomolecules.
5. Identify sub-cellular organelles by microscopic observation of cells. .



## Major Practical-4

Sr. No.	Experiment
1	Isolation of Gram negative bacteria from the given sample.
2	Identification of Gram negative bacteria from the given pure culture using biochemical media ( <i>E.coli</i> , <i>Enterobacter aerogens</i> , <i>Proteus</i> , <i>Salmonella</i> )
3	Isolation of Gram positive bacteria from the given sample.
4	Identification of Gram positive bacteria from the given pure culture using biochemical media ( <i>Bacillus megaterium</i> , <i>Bacillus subtilis</i> , <i>Staphylococcus aureus</i> )
5	Identification of Fungi on the basis of Morphological Characteristics.
6	Cultivation of yeast from different natural samples and its morphological characterization using microscopic observation.
7	Microscopic observation of different algae from the given samples.
8	Microscopic observation of different protozoa from the given sample.
9	Isolation and cultivation of bacteriophage of <i>E.coli</i> from the given sewage sample.

### Reference Books:

1. Jayaraman, J. (2011). Laboratory Manual in Biochemistry: New Age International Private Limited. India
2. Sawhney S.K., Singh, R. (2005). Introductory Practical Biochemistry: Alpha Science International.
3. Cappuccino, J.G., Sherman, N. (2004). International student edition: Microbiology- A laboratory Manual 4<sup>th</sup> edition: Benjamin Cummings publications

### Pedagogic tools:

- Chalk and Board
- Power point presentation
- Video

### Suggested reading / E-resources

- <https://www.youtube.com/watch?v=5YBdvAiKV24>
- <https://www.youtube.com/watch?v=-IEOxfIPWsk>
- <https://www.youtube.com/watch?v=omOjA-mIZVY>

### Suggested MOOCs

- <https://www.my-mooc.com/en/mooc/extremes-life-microbes-diversity-kyotoux-003x-0/>
- <https://www.mbl.edu/education/advanced-research-training-courses/course-offerings/microbial-diversity>
- <https://www.lunduniversity.lu.se/lubas/i-uoh-lu-BIOR18>





**B.Sc. Honours/ Honours with Research in Microbiology**  
(NCrF Level- 4.5 First Year – Certificate in Microbiology)

**Semester – II**

Course Category	<b>Skill Enhancement Course (SEC)-2</b> Skill based Practical Course-2; In addition to courses mentioned in SOP basket
Title of the Course	<b>Mushroom Cultivation</b>
Course Credit	<b>02</b>
Teaching Hours per Sem.	<b>60</b>
Total Marks	<b>CCE-25 + SEE-25</b>

1	Employability/Entrepreneurship/Skill Development પરકેન્દ્રિતથયેલછેકેનહિ ?	Yes/No				
2	Value added Courses Imparting Transferable and Life Skillsનાગુણોધરાવેછે?	Yes/No				
3	Major	Yes/No	Minor	Yes/No		
	Skill Enhancement Courses	Yes/No	Ability Enhancement Courses	Yes/No		
	Value Added Courses	Yes/No	Exit/ Vocational Courses	Yes/No		
4	Holistic Education	Yes/No	Multidisciplinary	Yes/No	Interdisciplinary	Yes/No
5	દિવ્યાંગમાટેવિષયઅંતર્ગતઆનુસાંગિકજોગવાઈકરાયેલછે ?	Yes/No				
6	New India Literacy Programme (NILP) મુજબનોવિષયછે ?	Yes/No				
7	Swayam પ્લેટફોર્મપરના MOOC વિષયપરઆધારિતઆવિષયછે ?	Yes/No				
8	ઇન્ડીયનનોલેજસીસ્ટમ (IKS) પરઆધારિતવિષયછે ?	Yes/No				

**Course Outcomes:**

At the end of the course, the student shall be able to:

1. Identify the edible and poisonous mushrooms.
2. Perform the preparation of bed for mushroom cultivation and it's harvesting
3. Identify and apply pests and diseases control and post harvesting management of Mushrooms
4. Comprehend marketing trends of Mushrooms.
5. Be self-employed and generate income.



Course Content	Hours
<b>UNITS – 1: Introduction</b>	<b>12hrs</b>
<ul style="list-style-type: none"> <li>• General History, edible mushrooms, mushrooms with medicinal importance and poisonous mushrooms.</li> <li>• Common Indian mushrooms and morphology, distribution, structure and life cycle of <i>Agaricus</i>, Microscopic observations of mushrooms</li> <li>• Nutritional value, medicinal value and advantages.</li> <li>• Identification of Edible and poisonous mushrooms</li> </ul>	
<b>UNIT – 2: Basics of Mushroom Cultivation</b>	<b>12hrs</b>
<ul style="list-style-type: none"> <li>• Fundamentals of cultivation system- small village unit &amp; larger commercial unit.</li> <li>• Principles of mushroom farm layout- location of building plot, design of farm, bulk chamber, composting platform, equipments &amp; facilities , pasteurization room &amp; growing rooms.</li> <li>• Cultivation: Paddy straw mushroom – substrate, spawn making.</li> </ul>	
<b>UNITS –3: Methods of Mushroom Cultivation</b>	<b>16hrs</b>
<ul style="list-style-type: none"> <li>• Cultivation of mushrooms at laboratory level - Bed method, polythene bag method, field cultivation.</li> <li>• Oyster mushroom cultivation –Substrate, spawning, pre-treatment of substrate.</li> <li>• Maintenance and Storage of mushroom – short term and long term storage.</li> <li>• Diseases- Common pests, disease prevention and control measures.</li> <li>• Processing - Blanching, steeping, sun drying, canning, pickling, freeze drying.</li> </ul>	

### Text Books

1. Harander Singh. 1991. Mushrooms- The Art of Cultivation- Sterling Publishers.
2. Kaul, T.N. (1997). Introduction to Mushroom Science (Systematics). Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi & Calcutta, India.
3. Vijaya Khader (1998). Mushrooms for Livelihood. Kalyani Publishers, Ludhiana, India.

### Reference books

1. Mushroom Production and Processing Technology, Pathak Yadav Gour (2010) Published by Agrobios (India).
2. Singh, Reeti and Singh, V.C. (2005). Modern Mushroom Cultivation. Agrobios, India.
3. Suman, B.C. and Sharma, V.P. (2005). Mushroom Cultivation and Uses. Agrobios, India.

### Pedagogic tools:

- Chalk and Board
- PPT and Videos.
- Assignment
- Class Activity: Think-Pair-Share / Class Test

### Suggested reading / E-resources

- <https://www.youtube.com/watch?v=W2mIa0bPjL0>
- <https://www.classcentral.com/course/swayam-vocational-mushroom-production-23137>
- [https://onlinecourses.swyam2.ac.in/nos20\\_ge07/preview](https://onlinecourses.swyam2.ac.in/nos20_ge07/preview)



### Suggested MOOCs

- <http://ecoursesonline.iasri.res.in/course/view.php?id=150>

### Evaluation of Skill Enhancement Course - Skill based Practical Course:

<b>Model for Practical Courses-2 Credit Course</b>	
<b>CCE-50% (25 Marks)SEE-50% (25 Marks)</b>	
<b>Exam Pattern</b>	<b>Marks</b>
Lab work assessment	10
Viva voce/Lab quiz	10
Attendance	05
<b>Continuous and Comprehensive Evaluation</b>	<b>25</b>
<b>Semester-End Evaluation- TWO/THREE Exercise from Each Head – 1.5 hrs.</b>	<b>25</b>



### Courses Offered by BoS in Microbiology to other FYUGP- B.Sc. Program in Semester-II

SN	Course Category As per GoG- NEP-SOP - July 2023& additional content 28/7/23	Course Title	Credit			Hrs./ Week		Evaluation - Weightage CCE: SEE = 50:50					
			T	P	Total	T	P	CCE Marks		SEE Marks		Total Marks	
								T	P	T	P		
1	<b>Minor (Elective)-2</b> (Microbiology) (In addition to courses mentioned in SOP basket)	Microbiology-2: Basic Principles of Microbial Growth and Control <b>(4- Credit Course</b> including Theory & Practical components)	3	1	4	3	2	25	25	50	-	100	
2	<b>Multi/Inter – Disciplinary Course -2</b> (MDC/IDC-2) <b>(Elective)</b> (Microbiology) (In addition to courses mentioned in SOP basket)	Microbiology – 2 Introduction to Microbial Systematics and Diversity	3	1	4	3	2	25	25	50	-	100	



**B.Sc. Honours/ Honours with Research in Microbiology**  
(NCrF Level- 4.5 First Year – Certificate in Microbiology)

**Semester-II**

Course Category	<b>Minor-2</b> In addition to courses mentioned in SOP basket; Recommended for Physical Science, Mathematical Science, Life science Programs
Title of the Course	<b>Microbiology -2: Basic Principles of Microbial Growth and Control</b>
Course Credit	<b>03</b>
Teaching Hours per Sem.	<b>45</b>
Total Marks	<b>CCE- 25 + SEE- 50</b>

1	Employability/Entrepreneurship/Skill Development પર કેન્દ્રિત થયેલ છે કે નહિ ?	Yes/No				
2	Value added Courses Imparting Transferable and Life Skills ના ગુણો ધરાવે છે ?	Yes/No				
3	Major	Yes/No	Minor	Yes/No		
	Skill Enhancement Courses	Yes/No	Ability Enhancement Courses	Yes/No		
	Value Added Courses	Yes/No	Exit/ Vocational Courses	Yes/No		
4	Holistic Education	Yes/No	Multidisciplinary	Yes/No	Interdisciplinary	Yes/No
5	દિવ્યાંગ માટે વિષય અંતર્ગત આનુસંગિક જોગવાઈ કરાયેલ છે ?	Yes/No				
6	New India Literacy Programme (NILP) મુજબનો વિષય છે ?	Yes/No				
7	Swayam પ્લેટફોર્મ પરના MOOC વિષય પર આધારિત આ વિષય છે ?	Yes/No				
8	ઇન્ડિયન નોલેજ સીસ્ટમ (IKS) પર આધારિત વિષય છે ?	Yes/No				

**Course Outcomes:**

**On completion of the course, the student shall be able to:**

1. Explain basic requirements for microbial growth and evaluate its characteristics.
2. Summarize specific requirement of nutrition, chemicals and physical condition for growth
3. Apply different methods of microbial control, namely, by antibiotics, chemicals and physical methods.
4. Isolate and purify bacterial culture, measuring microbial growth and interpret cultural characteristics and growth pattern of different microbes.
5. Select appropriate methods for effective control of microbial growth under different conditions.



Course Content	Hours	Marks
<b>Unit-I: Overview of Microbial Growth and Nutrition</b>	<b>9 hrs</b>	<b>10</b>
<ul style="list-style-type: none"><li>• Definition of Growth, Modes of Cell division in prokaryotes</li><li>• Understanding of Bacterial Growth Curve</li><li>• Synchronous culture &amp; Continuous Growth of Bacteria</li><li>• Quantitative Measurement of Bacterial Growth</li></ul>		
<b>Unit-II: Cultivation of Microbes and Pure Culture Techniques</b>	<b>9 hrs</b>	<b>10</b>
<ul style="list-style-type: none"><li>• Classification of bacteria based on nutritional requirements</li><li>• Chemical and Physical requirement of Growth- Bacteriological Media, Air, pH &amp; Temperature</li><li>• Techniques for Cultivation of Anaerobes</li><li>• Pure Culture: Natural Microbial Population (Mixed Cultures), Selective methods to obtain Pure Cultures, Cultural Characteristics, Isolation, purification and Preservation of pure cultures</li></ul>		
<b>Unit-III: microbial Control: Physical methods</b>	<b>9 hrs</b>	<b>10</b>
<ul style="list-style-type: none"><li>• Definitions: Sanitization, Antisepsis, Sterilization, Disinfection, Microbiocidal &amp; Microbiostasis, Thermal Death Time, Thermal Death Point, z-Value &amp; F-value, D-Value</li><li>• Control by Temperature:<ul style="list-style-type: none"><li>b) <u>High Temperature</u>: Moist Heat – Autoclave, Boiling, Pasteurization, Fractional Sterilization</li><li>  Dry Heat – Hot Air Oven, Incineration,</li><li>b) <u>Control by Desiccation</u></li><li>c) <u>Control by Low Temperature</u></li></ul></li><li>• Control by Radiation – UV radiation, x-rays, Gamma rays and Cathode rays</li><li>• Control by Filtration</li></ul>		
<b>Unit-IV: Microbial Control: Chemical methods</b>	<b>9 hrs</b>	<b>10</b>
<ul style="list-style-type: none"><li>• Characteristics of an Ideal Antimicrobial agent</li><li>• Halogens – Iodine &amp; Chlorine, Heavy Metals &amp; Dyes</li><li>• Phenol &amp; Phenolic compounds, Phenol coefficient method, Alcohols</li><li>• Detergents &amp; Quaternary Ammonium Compounds, Aldehydes &amp; Gaseous agents</li></ul>		
<b>Unit- V: Microbial Control: Antibiotics</b>	<b>9 hrs</b>	<b>10</b>
<ul style="list-style-type: none"><li>• Chemotherapeutic agents and Chemotherapy, Characteristics of ideal chemotherapeutic agent</li><li>• Antibiotics and their mode of action: Inhibition Effect on cell wall synthesis, nucleic acid and protein synthesis, Damage to cytoplasmic membrane, Inhibition of specific enzyme system</li><li>• Antifungal, antiviral and antitumor chemotherapeutic agents</li><li>• Microbiological assay of antibiotics</li></ul>		



### **Text books:**

3. Pelczar, M.J., Chan, E.C.S. and Kreig, N.R. (2002) Microbiology. 5th Edition, Tata McGraw-Hill, New Delhi. (UNIT: 1 & 2)
4. Powar, C.B., Daginawala, J.F. (2010). General Microbiology Vol-I. Mumbai: Himalaya Publishing House. (UNIT: 3,4 &5)

### **Reference books:**

2. Stanier, R.Y. (1987). General Microbiology, 5<sup>th</sup> Edition: Macmillan publication.

### **Pedagogic tools:**

- Chalk and Board
- Power point presentation
- Video
- Seminars

### **Suggested reading / E-resources**

<https://www.youtube.com/watch?v=Uf8a7cCVjM4>

<https://www.youtube.com/watch?v=BkbLI2mAMP8>

### **Suggested MOOCs**

- <https://alison.com/course/introduction-to-microbiology>
- <https://extendedstudies.ucsd.edu/courses-and-programs/microbiology-with-lab>



**B.Sc. Honours/ Honours with Research in Microbiology**  
(NCrF Level- 4.5 First Year – Certificate in Microbiology)

**Semester-II**

Course Category	<b>Minor Practical - 2</b> In addition to courses mentioned in SOP basket; Recommended for Physical Science, Mathematical Science, Life science Programs
Title of the Course	<b>Microbiology -2P: Basic Principles of Microbial Growth and Control Practical - 2</b>
Course Credit	<b>01</b>
Teaching Hours per Sem.	<b>30</b>
Total Marks	<b>CCE- 25</b>

**Course Outcomes:**

**At the end of the course, the student shall be able to:**

1. Use various microbial techniques and instrument to measure microbial growth.
2. Use basic instruments needed for the conduction of experiments in a Microbiology laboratory
3. Perform simple techniques of observation and study of microbial morphology and cellular structure, methods of microbial control, etc.
4. Acquire skill of isolating and purifying a bacterial culture, measuring microbial growth and interpret cultural characteristics and growth pattern of different microbes.
5. Select appropriate method to choose for effective control of microbial growth.

1	Employability/Entrepreneurship/Skill Development પરકેન્દ્રિતથયેલછેકેનહિ ?	Yes/No				
2	Value added Courses Imparting Transferable and Life Skills નાગુણોધરાવેછે?	Yes/No				
3	Major	Yes/No	Minor	Yes/No		
	Skill Enhancement Courses	Yes/No	Ability Enhancement Courses	Yes/No		
	Value Added Courses	Yes/No	Exit/ Vocational Courses	Yes/No		
4	Holistic Education	Yes/No	Multidisciplinary	Yes/No	Interdisciplinary	Yes/No
5	દિવ્યાંગમાટેવિષયઅંતર્ગતઆનુસાંગિકજોગવાઈકરાયેલછે ?	Yes/No				
6	New India Literacy Programme (NILP) મુજબનોવિષયછે ?	Yes/No				
7	Swayam પ્લેટફોર્મપરના MOOC વિષયપરઆધારિતઆવિષયછે ?	Yes/No				
8	ઇન્ડિયનનોલેજસીસ્ટમ (IKS) પરઆધારિતવિષયછે ?	Yes/No				





## Minor Practical-2

Sr. No.	Experiment
1	Measurement of size of microorganisms by Micrometry (Demonstration)
2	Calibrations of microscopic measurements (Ocular & stage micrometers)
3	Isolation of microorganisms by various methods
4	Turbidometric study of growth curve of <i>E.coli</i> and derivation of Growth rate & Generation time.
5	Enumeration of bacteria by viable count technique.
6	Enumeration of bacteria by Total Count Technique.
7	Effect of various chemicals on microbial growth
8	Effect of antibiotics on microbial growth

### Reference Books:

6. Patel. R.J., Patel. K.R. (2009). Experimental Microbiology, Vol-I, Ahmedabad: Aditya Publications.
7. Patel. R.J., Patel. K.R. (2009). Experimental Microbiology, Vol-II, Ahmedabad: Aditya Publications.
8. Dubey, R.C., Maheshwari, D.K. (2005). Practical Microbiology. New Delhi: S. Chand & Company Limited.
9. Sharma, K. (2005). Manual of Microbiology – Tools and Techniques. New Delhi: Ane books.
10. Benson, H.J. (2002). Microbiological Applications – Laboratory Manual in General Microbiology – 8<sup>th</sup> edition: MacGraw Hill Company.

### Pedagogic tools:

- Chalk and Board
- Power point presentation
- Video

### Suggested reading / E-resources

- [https://www.youtube.com/watch?v=R6Uv\\_WJlmM](https://www.youtube.com/watch?v=R6Uv_WJlmM)
- [https://www.youtube.com/watch?v=KHg\\_PyjQPwk](https://www.youtube.com/watch?v=KHg_PyjQPwk)

### Suggested MOOCs

- <https://alison.com/course/introduction-to-microbiology>
- <https://extendedstudies.ucsd.edu/courses-and-programs/microbiology-with-lab>



**B.Sc. Honours/ Honours with Research in Microbiology**  
(NCrF Level- 4.5 First Year – Certificate in Microbiology)

**Semester-II**

Course Category	<b>MDC/IDC-2</b> In addition to courses mentioned in SOP basket; Recommended for Physical Science, Mathematical Science, Life science Programs
Title of the Course	<b>Introduction to Microbial Systematics and Diversity</b>
Course Credit	<b>03</b>
Teaching Hours per Sem.	<b>45</b>
Total Marks	<b>CCE- 25 + SEE-50</b>

1	Employability/Entrepreneurship/Skill Development પરકેન્દ્રિતથયેલછેકેનહિ ?	Yes/No				
2	Value added Courses Imparting Transferable and Life Skillsનાગુણોધરાવેછે?	Yes/No				
3	Major	Yes/No	Minor	Yes/No		
	Skill Enhancement Courses	Yes/No	Ability Enhancement Courses	Yes/No		
	Value Added Courses	Yes/No	Exit/ Vocational Courses	Yes/No		
4	Holistic Education	Yes/No	Multidisciplinary	Yes/No	Interdisciplinary	Yes/No
5	દિવ્યાંગમાટેવિષયઅંતર્ગતઆનુસાંગિકજોગવાઈકરાયેલછે ?	Yes/No				
6	New India Literacy Programme (NILP) મુજબનોવિષયછે?	Yes/No				
7	Swayam પ્લેટફોર્મપરના MOOC વિષયપરઆધારિતઆવિષયછે ?	Yes/No				
8	ઇન્ડિયનનોલેજસીસ્ટમ (IKS) પરઆધારિતવિષયછે ?	Yes/No				

<b>Course Outcomes:</b>
<b>At the end of the course, the student shall be able to:</b>
<ol style="list-style-type: none"> <li>1. Identify major groups of microorganisms with respect to its diversity that laid the groundwork for modern Microbiology.</li> <li>2. Explain major features of bacterial classification, characteristics of prokaryotic cells and eukaryotic cells and major groups of microorganisms.</li> <li>3. Outline the structural and functional differences among all the microbes such as morphological features of bacterial cell and its organelles.</li> <li>4. Analyze the role of microbes in their natural environments with respect to the maintenance of functioning of eco-system.</li> <li>5. Explain the underlying facts of identification and classification of microorganisms.</li> </ol>



Course Content	Hours
<b>Unit. 1: Microbial Diversity – An Overview</b>	<b>9 hrs</b>
<ul style="list-style-type: none"> <li>• Introduction to Biodiversity- Microbial evolution and diversity, Types of diversity</li> <li>• Microbial Taxonomy: Introduction and overview, Taxonomic ranks of microorganisms, Classification systems</li> <li>• Major characteristics used in taxonomy</li> <li>• Assessing Microbial Phylogeny</li> </ul>	
<b>Unit. 2: Diversity in Prokaryotic Microbes</b>	<b>9 hrs</b>
<ul style="list-style-type: none"> <li>• <u>Gram negative bacteria</u> – General features of: <ul style="list-style-type: none"> <li>○ Aerobic/Microaerophilic motile, helical vibroid</li> <li>○ Non-motile curved bacteria</li> <li>○ Aerobic/Microaerophilic rods and cocci</li> </ul> </li> <li>• <u>Gram negative bacteria</u> – General features of: <ul style="list-style-type: none"> <li>○ Facultative anaerobes – rods, curved and helical bacteria</li> <li>○ Dissimilatory Sulphate reducers</li> </ul> </li> <li>• <u>Gram negative bacteria</u> – General features of: <ul style="list-style-type: none"> <li>○ Anaerobic cocci</li> <li>○ Phototrophic bacteria</li> </ul> </li> <li>• <u>Gram positive bacteria</u> – General features of: <ul style="list-style-type: none"> <li>○ Endospore forming rods and cocci</li> <li>○ Asporogenous rods</li> <li>○ Mycobacteria and Actinomycetes</li> </ul> </li> </ul>	
<b>Unit 3: Diversity of some unusual Prokaryotes</b>	<b>9 hrs</b>
<ul style="list-style-type: none"> <li>• <u>General Features of Bacteria with unusual morphology:</u> <ul style="list-style-type: none"> <li>○ Budding and appendaged bacteria</li> <li>○ Sheathed Bacteria</li> <li>○ Mycoplasma</li> </ul> </li> <li>• Bacteria with gliding motility,</li> <li>• Rickettsia and Chlamydia</li> <li>• Introduction to Archaea <ul style="list-style-type: none"> <li>○ Thermophiles</li> <li>○ Halophiles</li> <li>○ Acidophiles</li> <li>○ Barophiles</li> <li>○ Methanogens</li> <li>○ Psychrophiles</li> </ul> </li> </ul>	
<b>Unit. 4: Diversity in Eukaryotic microbes</b>	<b>9 hrs</b>
<ul style="list-style-type: none"> <li>• Fungi: General characteristics – Definition, occurrence, structure and Economic importance of fungi</li> <li>• Algae: General Characteristics – Definition, Occurrence, Ultra- Structure, Reproduction</li> <li>• General Characteristics – Definition, Occurrence, Ultra- Structure, Reproduction and Economic importance of Protozoa</li> <li>• Economic importance of Fungi, Algae and Protozoa</li> </ul>	



<b>Unit. 5: Akaryotic Diversity - Viruses</b>	<b>9 hrs</b>
<ul style="list-style-type: none"><li>• Introduction to Viruses: Definition, General features of viruses: Size, Capsids symmetry, Chemical Nature, Life cycle</li><li>• Overview of Bacterial Virus: T4 and Lambda</li><li>• Overview of plant Virus: TMV</li><li>• Overview of Animal viruses; HIV</li></ul>	

#### **Text Books:**

- Pelczar, M.J., Chan, E.C.S., Kreig, N.R. (1993). Microbiology, 5<sup>th</sup> Edition. New Delhi: Tata McGraw Hill Publishing Company Ltd.
- Prescott, M.J., Harley, J.P., Klein, D.A. (2002). Microbiology, 5<sup>th</sup> Edition, New York: WCB McGrawHill publication.

#### **Reference Books:**

7. Modi, H.A. Elementary Microbiology - Vol -I, Akta Prakashan, Nadiyad.
8. Modi, H.A. Elementary Microbiology – Vol-II, Akta Prakashan, Nadiyad.
9. Dubey, R.C.and Maheshwari, D.K., A Text Book of Microbiology, S. Chand Publications, New Delhi.
10. Tortora, Funke & Case. Microbiology-An Introduction, 8 Edition, Pearson Education, Delhi.
11. Powar and Dagainawala, General Microbiology Vol-II. Himalaya Publishing House, Mumbai.
12. Atlas. R.M., Principles of Microbiology- 2<sup>nd</sup> Edition ,

#### **Pedagogic tools:**

- Chalk and Board
- PPT and Videos.
- Assignment
- Class Activity: Think-Pair-Share / Class Test

#### **Suggested reading / E-resources**

- Bacterial Growth Curve Protocol | Protocols | Microbe Notes
- NPTEL :: Biotechnology - Microbiology
- 9: Microbial Growth - Biology LibreTexts
- Lecture notes, lecture 1 - Micro Chapter The microbial world The microbes - StuDocu

#### **Suggested MOOCs**

- General Microbiology - Course (swayam2.ac.in)



**B.Sc. Honours/ Honours with Research in Microbiology**  
(NCrF Level- 4.5 First Year – Certificate in Microbiology)

**Semester-II**

Course Category	<b>MDC/IDC Practical - 2</b> In addition to courses mentioned in SOP basket; Recommended for Physical Science, Mathematical Science, Life science Programs
Title of the Course	<b>Microbiology – 2P - Introduction to Microbial Systematics and Diversity Practical - 2</b>
Course Credit	<b>01</b>
Teaching Hours per Sem.	<b>30</b>
Total Marks	<b>CCE- 25</b>

1	Employability/Entrepreneurship/Skill Development પર કેન્દ્રિત થયેલ છે કે નહિ ?	Yes/No				
2	Value added Courses Imparting Transferable and Life Skills ના ગુણો ધરાવે છે ?	Yes/No				
3	Major	Yes/No	Minor	Yes/No		
	Skill Enhancement Courses	Yes/No	Ability Enhancement Courses	Yes/No		
	Value Added Courses	Yes/No	Exit/ Vocational Courses	Yes/No		
4	Holistic Education	Yes/No	Multidisciplinary	Yes/No	Interdisciplinary	Yes/No
5	દિવ્યાંગ માટે વિષય અંતર્ગત આનુસાંગિક જોગવાઈ કરાયેલ છે ?	Yes/No				
6	New India Literacy Programme (NILP) મુજબનો વિષય છે ?	Yes/No				
7	Swayam પ્લેટફોર્મ પરના MOOC વિષય પર આધારિત આ વિષય છે ?	Yes/No				
8	ઇન્ડિયન નોલેજ સીસ્ટમ (IKS) પર આધારિત વિષય છે ?	Yes/No				

**Course Objectives:**

**At the end of the course, the student shall be able to:**

1. Acquire basic skill of isolation and cultivation of different microorganisms.
2. Use various methods of microbial identification, especially by biochemical and morphological characteristics
3. Perform Microscopic observation and study of microbial morphology and cellular structure to identify and distinguish microbes.
4. Perform qualitative and quantitative estimation of various biomolecules.
5. Identify sub-cellular organelles by microscopic observation of cells. .



## MDC/IDC Practical-2

Sr. No.	Experiment
1	Isolation of Gram negative bacteria from the given sample.
2	Identification of Gram negative bacteria from the given pure culture using biochemical media ( <i>E.coli</i> , <i>Enterobacter aerogens</i> , <i>Proteus</i> , <i>Salmonella</i> )
3	Isolation of Gram positive bacteria from the given sample.
4	Identification of Gram positive bacteria from the given pure culture using biochemical media ( <i>Bacillus megaterium</i> , <i>Bacillus subtilis</i> , <i>Staphylococcus aureus</i> )
5	Identification of Fungi on the basis of Morphological Characteristics.
6	Cultivation of yeast from different natural samples and its morphological characterization using microscopic observation.
7	Microscopic observation of different algae from the given samples.
8	Microscopic observation of different protozoa from the given sample.
9	Isolation and cultivation of bacteriophage of <i>E.coli</i> from the given sewage sample.

### Reference Books:

4. Jayaraman, J. (2011). Laboratory Manual in Biochemistry: New Age International Private Limited. India
5. Sawhney S.K., Singh, R. (2005). Introductory Practical Biochemistry: Alpha Science International.
6. Cappuccino, J.G., Sherman, N. (2004). International student edition: Microbiology- A laboratory Manual 4<sup>th</sup> edition: Benjamin Cummings publications

### Pedagogic tools:

- Chalk and Board
- Power point presentation
- Video

### Suggested reading / E-resources

- <https://www.youtube.com/watch?v=5YBdvAiKV24>
- <https://www.youtube.com/watch?v=-IEOxfIPWsk>
- <https://www.youtube.com/watch?v=omOjA-mIZVY>

### Suggested MOOCs

- <https://www.my-mooc.com/en/mooc/extremes-life-microbes-diversity-kyotoux-003x-0/>
- <https://www.mbl.edu/education/advanced-research-training-courses/course-offerings/microbial-diversity>
- <https://www.lunduniversity.lu.se/lubas/i-uoh-lu-BIOR18>