Learning Outcomes based Curriculum Framework (LOCF)

For

M.Sc. (Biotechnology)
Postgraduate Programme

Department of Biotechnology
Chaudhary Devi Lal University
Sirsa-125055
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1. About the Department

The Department of Biotechnology, Chaudhary Devi Lal University, Sirsa was established in June, 2004 with major funding from the State Government. The Department is located at the first floor of CV Raman Bhawan of the University. The first batch of the students was admitted in August, 2004. So far the department has produced about 600 post graduate and 29 Ph.D. students, most of them have preferred to go for higher studies, some are actively engaged in jobs in various fields while some have developed their own business. Currently, department is running M.Sc. (two year) and Ph.D. programs. The Department of Biotechnology has two well-aerated classrooms for M.Sc. (Previous) and M.Sc. (Final) with defined sitting arrangement, electricity facility with power back up, projector and smart boards. Department has one bioinformatics lab having twenty computers with LAN internet facility. Department has two well-equipped laboratories for M.Sc. Programme and four separate air-conditioned research laboratories for Ph.D. programme.

2. Learning Outcomes based Curriculum Framework

The Choice Based Credit Scheme has evolved into learning outcomes based curriculum framework and provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective/minor or skill-based courses. The courses can be evaluated following the grading system, which is considered better than the conventional marks system. Grading system provides uniformity in the evaluation and computation of the Cumulative Grade Point Average (CGPA) based on student's performance in examinations, which enables the student to move across institutions of higher learning. The uniformity in evaluation system also enables the potential employers in assessing the performance of the candidates.

2.1 Objectives of the Programme

- To provide a multidisciplinary quality learning experience to students that will empower them for dreaming big.
- To provide skill based education to the students. For this, one Skill Certificate Course (Quality Control Chemist-microbiology) of LSSSDC has been included in the course curriculum as 'Embedded Course'. LSSSDC will conduct a separate assessment test for this certificate course and the successful candidates will get the 'Certificate'. The department will register such candidates on Skill India Portal and LSSSDC will help in their placement to concerned industries.

- To serve the society by catering the needs at local, national and international level with utmost commitment, integrity and enthusiasm.

2.2 Programme Outcomes (POs)

After completion of the programme, the students will have

PO1	*Knowledge*: Knowledge in the basic and advanced fields of the core and applied disciplines, for the fulfilment of professional requirements
PO2	*Critical Thinking*: Capability of critical thinking based on the contextual knowledge of living beings/organisms, non-living components and environmental basis of life, enabling them to critically analyse the day-to-day problems faced by the society.
PO3	*Interdisciplinary approach* & *Adaptation*: Understanding of the vital connections, within and among-the flora, fauna and the physical environment, enabling them to integrate and synthesize the acquired knowledge within their fields and beyond
PO4	*Application Development*: Understanding for the development of the applications of biological materials in food, health, medicine and environment for sustainable development of the society
PO5	*Ethics and Leadership*: Awareness about sound professional and character ethics as well as the qualities of leadership and team building skills
PO6	*Problem Solving*: Capability for developing innovative and solution cantered approach for handling any kind of problem and the paradigm of scientific temperament
PO7	*Skills and Inferential knowledge*: knowledge about various core and advanced skills for theoretical and practical understanding of different descriptive and inferential statistical tools and techniques
PO8	*Specialization and Employability*: specialization in various skills based on

	practical training, fields visits and project based vocational training as well as specialization for an entrepreneurial thinking and career-oriented approach in research as well as in industries

2.3 Programme Specific Outcomes (PSOs)

After completing the programme, the student will

PSO1	gain core and advanced knowledge in different areas of Biotechnology which will enable them to develop the powers of inquiry, critical analysis, logical thinking for finding solutions for biological problems
PSO2	become trained in high quality practical techniques and skills in various fields of biotechnology which will enable them to launch start-ups and become entrepreneurs for novel Biotechnology products and processes in various industries
PSO3	become acquainted with high standards of academic integrity, research ethics, bio-ethics, entrepreneurial values, statistical tools, life skills as well as with principles and concepts of applied areas of Biotechnology which will help them in emerging as strong personalities with good leadership qualities in academics, research as well as industry.
PSO4	become capable for conceptualization on the basis of acquired knowledge that will help them to design, review and execute any project. Students will develop qualities of critical thinking, methodology designing (for synthesis of core and advanced scientific concepts) and will learn the art of effective communication during project writing and presentation

3. Programme Structure

M.Sc. Biotechnology programme is a four-semester postgraduate programme consisting 108 credits weightage of Core Courses (CC), Discipline Specific Elective Courses (DSC), Skill Enhancement Courses (SEC) and Open Elective Courses (OEC).

Table 1: Courses and Credit Scheme

Semester	Core Courses (CC)		Discipline Specific Elective Courses (DSC)		Skill Enhancement Courses (SEC)		Open Elective Courses (OEC)		Grand Total Credits
	1	2	3	4	5	6	7		
	No. of Courses	**Total Credits**	**No. of Courses**	**Total Credits**	**No. of Courses**	**Total Credits**	A total of 12 credits are to be earned from other Departments or from MOOCs *Students have to opt open elective course in consultation with chairperson and Director, University Centre for Outreach Programmes and Extension*		**2+4+6+7**
I	6	**20**	-	**0**	2	**8**			
II	6	**22**	-	**0**	4	**8**			
III	6	**16**	2	**6**	1	**Non-credit**			**108**
IV	2	**4**	3	**12**	-	**0**			
Total	**Core Credits**	**62**	**Discipline Specific Elective Credits**	**18**	**Skill Enhancement Credits**	**16**	**Open Elective Credits**	**12**	**108**
Per-cent	**Core Credits**	**57.40**	**Discipline Specific Elective Credits**	**16.66**	**Skill Enhancement Credits**	**14.81**	**Open Elective Credits**	**11.11**	**100**

Table 2: Detailed break-up of Credit Courses

	Core Courses	Discipline Specific Elective Courses	Skill Enhancement Courses	Open Elective Courses	Total Courses
	CC	DSC	SEC	OEC	CC+DSC +SEC
Semester I	CC1 CC2 CC3 CC4 CC5 CC6	-	SEC1 SEC2	OECs offered by other departments or MOOCs **(May be enrolled in any of the four semesters)** *Students have to opt open elective course in consultation with chairperson and Director, University Centre for Outreach Programmes and Extension*	8
Semester II	CC7 CC8 CC9 CC10 CC11 CC12	-	SEC3 SEC4 SEC5 SEC6		10
Semester III	CC13 CC14 CC15 CC16 CC17 CC18	DSC1 DSC2	SEC7		9
Semester IV	CC19 CC20	DSC3 DSC4 DSC5	-		5

Table 3: Course code and Title along with credits detail

Sr. No.	Course Code	Course Title	Credits		
Semester I			**Theory**	**Practical**	**Total**
1.	MSc/BT/1/CC1	Introductory Biotechnology	2		2
2.	MSc/BT/1/CC2	Basic Microbiology	4		4
3.	MSc/BT/1/CC3	Structure and function of Biomolecules	4		4
4.	MSc/BT/1/CC4	Molecular Biology	4		4
5.	MSc/BT/1/CC5	Cell Biology	2		2
6.	MSc/BT/1/SEC1	Quality Control Chemist-Microbiology-I	4		4
7.	MSc/BT/1/SEC2	Lab Quality Control Chemist-Microbiology-I and Basic Microbiology		4	4
8.	MSc/BT/1/CC6	Lab Biochemistry & Molecular Biology		4	4
		Total	**20**	**8**	**28**
Semester II					
1.	MSc/BT/2/CC7	Genetic Engineering	4		4
2.	MSc/BT/2/CC8	Intermediary Metabolism	4		4
3.	MSc/BT/2/CC9	Basics in Genetics	2		2
4.	MSc/BT/2/CC10	Bioinformatics	4		4
5.	MSc/BT/2/SEC3	Quality Control Chemist-Microbiologist-II	2		2
6.	MSc/BT/2/CC11	Lab Bioinformatics		4	4
7.	MSc/BT/2/CC12	Lab Genetic Engineering		4	4
8.	MSc/BT/2/SEC4	Lab Quality Control Chemist-Microbiology-II		4	4
9.	MSc/BT/2/SEC5	Lab Quality Control Chemist-Microbiology-III		2	2
10.	MSc/BT/2/SEC6	On Job Training (80 hours)* (In summer vacation after exams of IInd Sem)	Non-credit		0
		Total	**16**	**14**	**30**
Semester III					
1.	MSc/BT/3/CC13	Cardinal Principles of Academic Integrity and Publications Ethics	2		2
2.	MSc/BT/3/CC14	Microbial Biotechnology	2		2
3.	MSc/BT/3/CC15	Animal Biotechnology	2		2
4.	MSc/BT/3/CC16	Plant Biotechnology	2		2
5.	MSc/BT/3/CC17	Immunology	4		4
6.	MSc/BT/3/DSC1	A. Biophysical Techniques	2		2

		B. Enzyme-technology			
		C. MOOC			
7.	MSc/BT/3/DSC2	A. Lab Microbial Biotech		4	4
		B. Lab Animal Biotech			
		C. Lab Plant Biotech			
8.	MSc/BT/3/CC18	Lab Immunology		4	4
9.	MSc/BT/3/SEC7	Life skills and Humanistic Values**	Non-credit		0
		Total	**14**	**8**	**22**
Semester IV					
1.	MSc/BT/4/CC19	Genomics & Proteomics	2		2
2.	MSc/BT/4/CC20	Bio-entrepreneurship, Intellectual Property Rights, Biosafety and Bioethics	2		2
3.	MSc/BT/4/DSC3	A. Dissertation		4	4
		B. Research Review Project			
		C. MOOC			
4.	MSc/BT/4/DSC4	A. Environmental Biotechnology	4		4
		B. Bioprocess Technology			
		C. Nanobiotechnology			
		D. MOOC			
5.	MSc/BT/4/DSC5	A. Lab Environmental Biotechnology		4	4
		B. Lab Bioprocess Technology			
		Total	**8**	**8**	**16**

Notes:

1. For one credit of theory, one hour of lecture will be delivered while for one credit of practical, two hours of laboratory work will be conducted, per week.
2. Practical will be conducted in groups; one group will have maximum of 20 students.
3. Evaluation of Non-credit courses will be entirely internal. Award will be submitted in the form of Satisfactory (S) (in case marks obtained are 60 % or more) or Unsatisfactory (US) (in case marks are less than 60 %) grades.
4. Besides credits from above courses, students will need to earn additional 12 credits from open elective courses (OECs) offered by other departments of the University or from MOOCs on SWAYAM portal. Students are free to get enrolled for this category courses in any of the semesters. Further, students may get enrolled in any of the various PG MOOCs available at SWAYAM portal for this category for the desired credits.
5. MOOC coordinator will display the list of MOOCs for each Discipline Specific Elective Course (DSC) before the commencement of respective semester.

6. A Discipline Specific Elective Course will be started only when least 10 students opt for a particular course.
7. *Students will need to submit a certificate declaring their successful completion of 'On Job Training' for the desired number of hours.
8. **Two classes per week will be held for 'Life skills and Humanistic values' course.
9. Students will have to appear in an assessment exam to be conducted by LSSSDC after completion of second semester and certificates will be issued by the LSSSDC only to the successful candidates.
10. Rules pertaining to Dissertation/Research-Review Project:
    i. Allotment of students for 'Dissertation/Research-Review Project' will be done in the beginning of third semester.
    ii. The work will commence with third semester and will continue till the last day of teaching term of fourth semester (as notified in Academic Calendar).
    iii. The last day of fourth semester (as notified in Academic Calendar), will be the last date for submission of dissertation/research-review project.
    iv If any student fails to submit within the stipulated period, an extension of three months may be granted by the chairperson by imposing a fine of Rs 500. Extension, beyond three months, may also be granted by the chairperson, but only under special circumstances and with a fine of Rs 1000.
    v 'Dissertation or Research-Review Project Report will comply by the Plagiarism Policy' of the University.
    vi. Three paperback copies and one soft copy of the Dissertation or Research-Review Project Report will be prepared. The soft copy will be sent to the library while the paperback copies will be one each for student, supervisor and department record.
    vii. Any patent/IPR based on the experimental work will be filed in the name of the University. The concerned student/s and guide will be the inventors.
    viii A publication based on dissertation or research review project should be with consent of guide only
    ix. Guidance of students for Dissertation/Research-Review Project will contribute towards 1 credit of workload for teachers if the number of students is less than 5. In case, number of students being guided by one teacher is 5 or more, teacher will be credited with workload of 2 credits.
    x. The Dissertation and Research-Review Project Report will be compiled in the following format:

Dissertation	**Research-Review Project Report**
Acknowledgement	Acknowledgement
Certificate of Supervisor	Certificate of Supervisor
Plagiarism Verification report	Plagiarism Verification report
Introduction	Introduction
Review of Literature	Overview of theme and Discussion in the light of available literature

Materials and Methods	Conclusions and Future Prospects
Results and Discussion	
Summary	
Bibliography	Bibliography

Table 4: Core Courses Offered by the Department

Course Code	Course Title	Credits
Core Courses		
MSc/BT/1/CC1	Introductory Biotechnology	2
MSc/BT/1/CC2	Basic Microbiology	4
MSc/BT/1/CC3	Structure and function of Biomolecules	4
MSc/BT/1/CC4	Molecular Biology	4
MSc/BT/1/CC5	Cell Biology	2
MSc/BT/1/CC6	Lab Biochemistry & Molecular Biology	4
MSc/BT/2/CC7	Genetic Engineering	4
MSc/BT/2/CC8	Intermediary Metabolism	4
MSc/BT/2/CC9	Basics in genetics	2
MSc/BT/2/CC10	Bioinformatics	4
MSc/BT/2/CC11	Lab Bioinformatics	4
MSc/BT/2/CC12	Lab Genetic Engineering	4
MSc/BT/3/CC13	Cardinal Principles of Academic Integrity & Research Ethics	2
MSc/BT/3/CC14	Microbial Biotechnology	2
MSc/BT/3/CC15	Animal Biotechnology	2
MSc/BT/3/CC16	Plant Biotechnology	2
MSc/BT/3/CC17	Immunology	4
MSc/BT/3/CC18	Lab Immunology	4
MSc/BT/4/CC19	Genomics & Proteomics	2
MSc/BT/4/CC20	Bio-entrepreneurship, Intellectual Property Rights and Biosafety and Bioethics	2
	Total	**62**

Table No. 5 Discipline Specific Courses offered by Department

MSc/BT/3/DSC1	A. Biophysical Techniques	2
	B. Enzyme-technology	
	C. MOOC	
MSc/BT/3/DSC2	A. Lab Microbial Biotech	4
	B. Lab Animal Biotech	
	C. Lab Plant Biotech	
MSc/BT/4/DSC3	A. Dissertation	4
	B. Research-Review Project	
	C. MOOC	
MSc/BT/4/DSC4	A. Environmental Biotechnology/	4
	B. Bioprocess Technology	
	C. Nanobiotechnology	
	D. MOOC	
MSc/BT/4/DSC5	A. Lab Environmental Biotechnology	4
	B. Lab Bioprocess Technology	
	Total	**18**

Table No. 6 Skill Enhancement Course offered by the Department

MSc/BT/1/SEC1	Quality Control Chemist-Microbiology-I	4
MSc/BT/1/SEC2	Lab Quality Control Chemist-Microbiology-I	4
MSc/BT/2/SEC3	Quality Control Chemist-Microbiology-II	2
MSc/BT/2/SEC4	Lab Quality Control Chemist-Microbiology-II	4
MSc/BT/2/SEC5	Lab Quality Control Chemist-Microbiology-III	2
MSc/BT/2/SEC6	On Job Training (80 hours) (In summer vacation after exams of IInd Semester)	Non-credit
MSc/BT/3/SEC7	Life skills and Humanistic Values	Non-credit
	Total	**16**

Table No. 7 Open Elective Courses offered by the Department

MSc/BT/9/OEC1	Biotechnology and Human Welfare-I	4
MSc/BT/9/OEC2	Biosafety, Bioethics and Intellectual Property Rights	4
	Total	**8**

4. Attainment Level

Table No. 8: CO-PO-PSO mapping matrix for all the courses

Course Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PSO 1	PSO 2	PSO 3	PSO 4
Semester-I												
MSc/BT/1/CC1	2	2	1.5	1.75	1.5	1.5	1.75	2.5	1.75	1.75	2	2
MSc/BT/1/CC2	3	2	1.5	2	1.75	1.75	1.75	2	3	2	2	2
MSc/BT/1/CC3	2.75	1.75	1.75	1.62	1.75	1.75	1. 5	2	2.75	2	2	1.75
MSc/BT/1/CC4	3	2	1.5	2	1.75	1.75	1.75	2	3	2	2	2
MSc/BT/1/CC5	3	2	2	1.75	1.5	2	1.5	1.75	3	2	2	2
MSc/BT/1/SEC1	2.75	2	1.5	1.5	1.75	1.5	1.75	1.75	2.75	2	2	2
MSc/BT/1/SEC2	3	2	2	2	1.75	2	3	2	3	2	2	1.5
MSc/BT/1/CC6	3	2	1.25	2.25	1.5	1.75	1.75	2	3	3	3	2
Semester-II												
MSc/BT/2/CC7	3	2	2	2	1.5	2	3	2	3	2	2	1.75
MSc/BT/2/CC8	2.5	1.75	1.25	1.75	1.5	1.75	2	1.75	2.5	2	2	1.75
MSc/BT/2/CC9	3	2	2	1.75	1.75	2	1.5	1.75	3	2	2	2
MSc/BT/2/CC10	3	1.5	2	1.75	1.75	2	1.75	2	3	2	2	2
MSc/BT/2/SEC3	2.5	2	2	1.5	1.75	1.5	1.5	2	2.5	1.5	1.5	1.5
MSc/BT/2/CC11	3	2	1.5	2.12	1.75	2	1.75	2	3	2	2	2
MSc/BT/2/CC12	3	2	2	2	2	2	3	2	3	2	2	2
MSc/BT/2/SEC4	3	2	2	2	2	2	3	2	3	2	2	3
MSc/BT/2/SEC5	2.5	2	2	1.5	1.75	1.5	1.5	2	2.5	2	1.5	2
MSc/BT/2/SEC6	2.5	2	2	1.5	1.75	1.5	1.5	2	2.5	2	1.5	2
Semester-III												
MSc/BT/3/CC13	3	2	2	1.75	3	1.75	1.75	1.75	1.75	1.75	1.75	1.5
MSc/BT/3/CC14	2.5	2	1.5	2.25	1.5	1.5	1.75	2	2.5	2	2.5	2
MSc/BT/3/CC15	3	2	2	1.75	1.75	2	1.5	1.75	3	1.5	2	2
MSc/BT/3/CC16	3	2	2	1.75	1.5	2	1.5	1.75	3	1.5	2	2
MSc/BT/3/CC17	3	2	1.5	2	1.5	1.75	1.75	2	3	1.75	1.75	2
MSc/BT/3/DSC1-A	3	2	1.5	2	1.75	1.75	1.75	2	3	2	2	2
MSc/BT/3/DSC1-B	2.5	2	1.75	1.5	1.5	1.75	1.5	2	2.5	2	2	2

MSc/BT/3/DSC2-A	2.5	1.75	1.5	1.75	1.75	1.25	1. 5	1.5	2.5	1.75	1.5	2
MSc/BT/3/DSC2-B	3	2	1.5	2.12	1.75	1.75	1.75	2	3	1.75	2	2
MSc/BT/3/DSC2-C	3	2	2	2	1.25	2	3	2	3	2	2	1.5
MSc/BT/3/CC18	3	2	2	2	1.5	2	3	2	3	2	2	1.5
MSc/BT/3/SEC7	1.75	1.75	1.75	1.75	3	1.75	1.75	1.75	1.75	1.75	3	2
Semester-IV												
MSc/BT/4/CC19	3	2	2	1.75	1.5	2	1.5	1.75	3	1.75	2	2
MSc/BT/4/CC20	3	2	2	1.75	1.5	2	1.5	1.75	3	1.75	2	2
MSc/BT/4/DSC3-A	2.5	2	1.25	2	1.75	1.25	1.75	2	2.5	3	2	2
MSc/BT/4/DSC3-B	2.5	2	1.25	2	1.75	1.25	1.75	2	2.5	3	2	2
MSc/BT/4/DSC4-A	2.5	2	1.25	2	1.75	1.25	1.75	2	2.5	2	1.5	3
MSc/BT/4/DSC4-B	2.5	2	1.25	2	1.5	1.25	1.75	2	2.5	2	1.5	3
MSc/BT/4/DSC4-C	2.5	2	1.25	2	1.5	1.25	1.75	2	2.5	2.5	3	3
MSc/BT/4/DSC5-A	2.5	2	1.25	2	2	1.5	1.5	2	2.5	2.5	3	2
MSc/BT/4/DSC5-B	2.5	2	1.25	2	2	1.5	1.5	2	2.5	2.5	2	2
Average	**2.75**	**1.96**	**1.68**	**1.86**	**1.74**	**1.71**	**1.88**	**1.94**	**2.71**	**2.05**	**2.03**	**2.02**

4.1 Attainment of COs:

Table No. 9: CO Attainment Levels for a Semester Examination of a course

Attainment Level	
1 (Low level of attainment)	50% of students obtained letter grade of A or above (for CBCS programs) or score more than 60% of marks (for non-CBCS programs) of a course.
2 (Medium level of attainment)	60% of students obtained letter grade of A or above (for CBCS programs) or score more than 60% of marks (for non-CBCS programs) of a course.

3 (High level of attainment)	70% of students obtained letter grade of A or above (for CBCS programs) or score more than 60% of marks (for non-CBCS programs) of a course.

The CO attainment level for all the courses of the program can be obtained in a similar manner.

4.2 Calculation of Attainment values of POs and PSOs:

PO attainment value (for example for PO1) for a course (e.g. CC1) can be obtained as follows:

$$\text{AV for PO1} = \frac{(\text{MFCPO1})\text{X CO attainment value for the course CC1 (as per table 2)}}{3}$$

Where, AV = Attainment value
MFCPO1 = Mapping factor for course CC1 with PO1 as obtained from table 1

Likewise, PSO attainment value (for example for PSO1) for a course can be obtained as follows:

$$\text{AV for PSO1} = \frac{(\text{MFCPSO1})\text{X CO attainment value for the course(as per table 2)}}{3}$$

Where, AV = Attainment value
MFCPSO1 = Mapping factor for a course with PSO1 as obtained from table 1

After finding the attainment values of each PO and PSO for various courses, we may write them in table form as given below:

Table No. 10: The calculated PO and PSO Attainment Values for all the courses

Course Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PSO 1	PSO 2	PSO 3	PSO 4
Semester-I												
MSc/BT/1/CC1												
MSc/BT/1/CC2												
MSc/BT/1/CC3												

MSc/BT/1/CC4												
MSc/BT/1/CC5												
MSc/BT/1/SEC1												
MSc/BT/1/SEC2												
MSc/BT/1/CC6												
Semester-II												
MSc/BT/2/CC7												
MSc/BT/2/CC8												
MSc/BT/2/CC9												
MSc/BT/2/CC10												
MSc/BT/2/SEC3												
MSc/BT/2/CC11												
MSc/BT/2/CC12												
MSc/BT/2/SEC4												
MSc/BT/2/SEC5												
MSc/BT/2/SEC6												
Semester-III												
MSc/BT/3/CC13												
MSc/BT/3/CC14												
MSc/BT/3/CC15												
MSc/BT/3/CC16												
MSc/BT/3/CC17												
MSc/BT/3/DSC1-A												
MSc/BT/3/DSC1-B												
MSc/BT/3/DSC2-A												
MSc/BT/3/DSC2-B												
MSc/BT/3/DSC2-C												
MSc/BT/3/CC18												
MSc/BT/3/SEC7												
Semester-IV												
MSc/BT/4/CC19												
MSc/BT/4/CC20												
MSc/BT/4/DSC3-A												

MSc/BT/4/DSC3-B												
MSc/BT/4/DSC4-A												
MSc/BT/4/DSC4-B												
MSc/BT/4/DSC4-C												
MSc/BT/4/DSC5-A												
MSc/BT/4/DSC5-B												

The attainment of POs and PSOs is the average of individual PO and PSO attainment values. The PO and PSO attainment values obtained above will be compared with set target. The set target for each PO and PSO may be different and can be finalized by the staff councils of the departments/institutes as described in the following table:

Table No. 11: PO and PSO Attainment Values and Set Target values

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
PO attainment values	2.75	1.96	1.68	1.86	1.74	1.71	1.88	1.94	2.71	2.05	2.03	2.02
Target Values	2	1.5	1.5	1.5	1.5	1.5	1.5	1.5	2	2	2	2

If PO and PSO attainment value is less than the set target value then an action plan may be prepared for improvement in the subsequent academic session.

6. Course-wise contents details

The course-wise contents details are presented on following pages:

M.Sc. Biotechnology-1st Semester
MSc/BT/1/CC1- Introductory Biotechnology

Credits: 2 (Lectures: 30) **Marks: 50**
Duration of exam: 2 Hrs. **Theory: 30; IA: 20**

Objective: The objective of the course is to make the students understand the nature, fields and scope of biotechnology, and to make them aware about various career options.

Course outcomes (COs): At the end of the course, the students will:	
CO1	Have the understanding of the nature, scope and various fields of Biotechnology
CO2	Have the awareness and knowledge about various career options available after completing M.Sc. Biotechnology and will learn how to select and pursue for desired career option

Note for the paper setter: *The question paper will consist of five questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, four more questions will be set unit-wise comprising of two questions from each of the two units. The candidates are required to attempt two more questions selecting at least one question from each unit.*

Unit-I

Biotechnology-an overview: Definition, scope and applications; old biotechnology and modern biotechnology; historical development and major breakthrough research; an overview of different fields of biotechnology- plant biotechnology, animal biotechnology, microbial biotechnology, medical biotechnology, environmental biotechnology, food biotechnology, pharmaceutical biotechnology, industrial biotechnology, bioinformatics; societal implications and ethical issues in biotechnology.

Unit-II

Scope and Career in Biotechnology: Career options for biotechnology students in India and abroad; formulation and implementation of strategy for a desired career path; list of leading biotechnology research institutes/universities/industries in India and abroad; Indian biotechnology industry: status, opportunities and challenges; bio-entrepreneurship and start-ups; funding agencies for research and developments.

Suggested Readings:

Text/Reference Books:

1. Elements of Biotechnology (4th reprint), P. K. Gupta, Rastogi Publications, 2019-20.
2. Biotechnology-Expanding Horizons, B. D. Singh, Kalyani Publishers, 2015.
3. Textbook of Biotechnology, H.K. Das, John Wiley & Sons 2004.
4. Introduction to Biotechnology (3rd edition), W. J. Thieman & M. A. Palladino, Pearson Publications, 2014.
5. History of Modern Biotechnology, A. Fiechter (Ed.), Springer Publishing House, 2000.

6. DISHA-A career Resource Book for Life Science and Biotechnology students, Suman Govil, India Bioscience Publishers, Bangalore 2020.

Research/Review Papers:

1. Adetunji, A. I., & Olaniran, A. O. (2021). Production and potential biotechnological applications of microbial surfactants: An overview. Saudi Journal of Biological Sciences, 28(1), 669.
2. Kessenich, C., & Silvanovich, A. (2021). Challenges of automation and scale: Bioinformatics and the evaluation of proteins to support genetically modified product safety assessments. Journal of Invertebrate Pathology, 107587.
3. Ahmad et al., (2015) Ethical Issues of Biotechnology, Possible Risks and Their Management. Journal of Biology, Agriculture and Healthcare, 5, 11.

On-line Resources:

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2047326/
2. http://dbtindia.gov.in/schemes-programmes/translational-industrial-development-programmes/make-india-start-india
3. https://www.biotech.co.in/sites/default/files/2020-01/Bioentrepreneurship-Development.pdf

CO-PO-PSO Matrix of MSc/BT/1/CC1												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	2	2	2	1.5	1	2	2	2	2	2	2	2
CO2	2	2	1	2	2	1	1.5	3	1.5	1.5	2	2
Avg	**2**	**2**	**1.5**	**1.75**	**1.5**	**1.5**	**1.75**	**2.5**	**1.75**	**1.75**	**2**	**2**

M. Sc. Biotechnology – 1st Semester
MSc/BT/1/CC2- Basic Microbiology

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Objectives: The objective of this course is to introduce students to the field of Microbiology with special emphasis on historical developments in microbiology, microbial systematics & diversity, morphology, microbial physiology & genetics, nutritional requirements and their cultivation, methods of sterilization and control of microorganisms, host microbe interactions, diseases caused by microorganisms.

Course outcomes (COs): After successful completion of this course, students should be able to:	
CO1	Understand the historical developments and analyze the scope and importance of microbiology, exhibit the knowledge for classification, nomenclature and identification of microorganisms and their diversity.
CO2	Exhibit the knowledge for isolation, purification, and preservation of microbial cultures, methods of sterilization, discuss and analyze the nutritional requirements and how to control microbial growth.
CO3	Identify and demonstrate microbial growth and its measurement, types of microbial cultures, microbial recombination and gene transfer in bacteria.
CO4	Demonstrate and evaluate interactions between hosts and microbes, identify important microbial diseases, pathogenesis and understand various modes of disease transmission.

Note for the paper setter: *The question paper will consist of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each, selecting at least one question from each unit.*

Unit – I

History of Microbiology: Discovery of the microbial world; development of microbiology in twentieth century and contributions of A. V. Leeuwenhoek, Louis Pasteur, Edward Jenner, Robert Koch, Alexander Fleming and Joseph Lister; spontaneous generation versus biogenesis; scope of microbiology.
Microbial Systematics and Taxonomy: Microbial Taxonomy- Criteria used including morphological, physiological, biochemical and molecular biological tools; characteristics of primary domains of life; microbial phylogeny and current classification of bacteria (Bergey's Manual).
Microbial Diversity: Morphology and cell structure of major groups of microorganisms *e.g.* archaea, bacteria, fungi, algae, protozoa and uncultivable microbes; Viruses: general properties, viral structure, classification of viruses, sub-viral particles- viroids and prions; bacterial endospores.

Unit – II

Cultivation and Maintenance of Microorganism: Methods of isolation, purification and preservation of microorganisms; enrichment culture techniques for isolation of microorganisms.

Concepts of Microbial Nutrition: Culture media; elements of life; requirement for carbon, nitrogen, phosphorus, sulfur and growth factors; nutritional categories of microorganisms.
Control of Microorganism: Physical methods: dry heat, moist heat, radiations, filtration; chemical agents: characteristics of an ideal antimicrobial chemical agent, disinfectants and mode of action of antimicrobial chemical agents; sterilizing gases; factors affecting antimicrobial action; pattern of microbial death.

Unit – III

Microbial growth and physiology: Reproductive strategies; growth curve and generation time; mathematics of growth; measurement of microbial growth and factors affecting growth (temperature, oxygen concentration, pH, pressure, solute); biofilms.
Microbial genetics: Detection and isolation of mutants; transposable elements; bacterial plasmids' bacterial conjugation; bacterial transformation and transduction.

Unit – IV

Host-Parasite Relationship: Normal microbiota of skin, oral cavity, gastrointestinal tract; entry of pathogen into the host; colonization and factors predisposing to infections; microbial communication systems; bacterial quorum sensing; toxins: exotoxins, endotoxins, mycotoxins their structure and mode of action; virulence; pathogenicity islands.
Microbial Diseases: Disease reservoirs; infectious disease transmission; diseases caused by bacteria and viruses: Tuberculosis, Rabies, Plague, Dengue, Swine flu, Rickettsias, Covid-19, food and water borne human diseases.

Suggested Readings:

Text/Reference Books:

1. Microbiology 11th Revised Edition. Prescott's Microbiology by J. Willey, K. Sandman and D. Wood (2020) McGraw Hill, USA.
2. Microbiology. Pelczar Jr., M.J.; Chan, E.C.S. and Krieg, N.R. (2010) Tata McGraw Hill, New Delhi.
3. Brock Biology of Microorganisms 15th Edition (2018) W Matthew Sattley, Michael T. Madigan, David A. Stahl, Daniel H. Buckley and Kelly S. Bender, Pearson Press.
4. Microbiology -An Introduction, 11th Edition (2016) Tortora, G.J., Funke, B.R., Case, C.L. Pearson education Pvt. Ltd.
5. Microbiology: Principles and Explorations, 10th Ed. (2018) J.G. Black and L.J. Black John Wiley & Sons Inc.

Research/Review Papers:

1. Kolter, R. (2021). The History of Microbiology—A Personal Interpretation. *Annual Review of Microbiology*, *75*.
2. Cabezón, E., et al. (2015). Towards an integrated model of bacterial conjugation. *FEMS microbiology reviews*, *39*(1), 81-95.
3. Early, R., & Tamime, A. Y. (2017). Microbial Toxins–An Overview. *Microbial Toxins in Dairy Products*, 1.
4. Velavan, T. P., & Meyer, C. G. (2020). The COVID-19 epidemic. *Tropical medicine & international health*, *25*(3), 278.

On-line Resources

1. https://www.brainkart.com/article/Contributors-to-Microbiology_35211/

2. https://nios.ac.in/media/documents/dmlt/Microbiology/Lesson-01.pdf
3. https://micro.cornell.edu/research/epulopiscium/bacterial-endospores/
4. https://www.lekarski.umed.wroc.pl/sites/default/files/mikrobiologia/files/STERILIZATION_and_DESINFECTION_1.pdf
5. https://www.scientistcindy.com/microbial-nutrition-and-growth.html

CO, PO, PSO matrix of MSc/BT/1/CC2												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	2	1.5	2	2	3	2	2	2
CO2	3	2	1.5	2	2	1.5	1.5	2	3	2	2	2
CO3	3	2	1.5	2	1.5	2	1.5	2	3	2	2	2
CO4	3	2	1.5	2	1.5	2	2	2	3	2	2	2
Average	**3**	**2**	**1.5**	**2**	**1.75**	**1.75**	**1.75**	**2**	**3**	**2**	**2**	**2**

M.Sc. Biotechnology-1st Semester
MSc/BT/1/CC3 -Structure and Function of Biomolecules

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Objectives: The objective of the course is to introduce students to the world of basic biochemistry. This course covers structure and function of biomolecules, and details of physical and chemical basis of biomolecules involved in life processes.

Course outcomes (COs): At the end of this course, students will be able to:	
CO1	Understand cellular, organism basis and role of carbohydrates of living organisms.
CO2	Gain the fundamental knowledge about structure and functional relationships of biomolecules (proteins) significant to health of living beings.
CO3	Understand structure, function of lipids and quantitative test of fats.
CO4	Gain the knowledge of genetic material its function and role of vitamins in the body.

Note for the paper setter: *The question paper will consist of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each, selecting at least one question from each unit.*

Unit – I

Biomolecules: An introduction, general structure of biomolecule.
Carbohydrates: Structure, occurrence and biological importance of important monosaccharides, oligosaccharide and polysaccharide; Ring structure and anomeric forms; mutarotation, reactions of monosaccharides; homo, hetero and mucopolysaccharides.

Unit – II

Amino acid and proteins: Structure and properties of amino acids; essential and non-essential amino acids; peptide bond; type of proteins and their classification; forces stabilizing protein structure and shape; different levels of structural organization of proteins; structure of hemoglobin and myoglobin.

Unit – III

Lipids: Structure of fatty acids; classification of lipids; structure and functions of major lipid subclasses- acylglycerols, phospholipids, glycolipids, sphingolipids, waxes, terpenes, sterols and carotenoids; essential fatty acids; hydrolysis of fats, saponification value, rancidity of fats iodine number and acid value; cholesterol-its structure and biological function.

Unit – IV

Nucleic acids: Structure and properties of purine and pyrimidine bases; nucleosides and nucleotides; biologically important nucleotides; double helix model of DNA structure; structural polymorphism of DNA [A, B & Z] and RNA; biological function of nucleotides.
Vitamins: Structure and biochemical roles of vitamins and coenzymes in metabolism.

Suggested readings:

Books:

1. Lehninger; Principle of Biochemistry, 8th Edition by David L. Nelson and M.M Cox [2021] Free and company. New York.
2. Fundamental of Biochemistry. D. Voet and J. G. Voet [2013] John Wiley and Sons New York.
3. Biochemistry 9th Edition by L. Stryer [2019], W.H Freeman and New York
4. Biochemistry 6thEdition by R.H Garrett and C.M. Grisham[2017] Saunders college Publishing, New York
5. Biochemistry 4th edition by G. Zubay [1998] Wm .C Brown Publishers.
6. Outline of Biochemistry by Conn E.E, Stumpf P.K. Bruening G. and Dvi R.H [1999] John Wiley and Sons Inc New York and Toronto.
7. Fundamental of Biochemistry by J.L. Jain, Sanjay Jain, Nitin Jain (2004) S. Chand & Company Ltd.

Research/Review Papers:

1. Shakya, A. K. (2020). Unit-7 Polysaccharides. Indira Gandhi National Open University, New Delhi.
2. Postnikova, G. B., & Shekhovtsova, E. A. (2016). Hemoglobin and myoglobin as reducing agents in biological systems. Redox reactions of globins with copper and iron salts and complexes. *Biochemistry (Moscow)*, *81*(13), 1735-1753.
3. Kumar, G. A., & Chattopadhyay, A. (2016). Cholesterol: an evergreen molecule in biology. *Biomedical Spectroscopy and Imaging*, *5*(s1), S55-S66.
4. Shakya, A. K. (2020). Unit-12 Vitamins. Indira Gandhi National Open University, New Delhi.

On-line Resources

1. https://www.patnauniversity.ac.in/econtent/science/zoology/Carbohydrate(PG)_BiochemistryCC7_Zoology_Gajendra%20Azad.pdf
2. http://eagri.org/eagri50/BIC101/pdf/lec12.pdf
3. https://comis.med.uvm.edu/VIC/coursefiles/MD540/MD540-Protein_Organization_10400_574581210/Protein-org/Protein_Organization_print.html
4. https://www.onlinebiologynotes.com/classification-of-lipid/
5. https://www.ncbi.nlm.nih.gov/books/NBK26821/

CO, PO, PSO matrix of MSc/BT/1/CC3												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.75	2	1.75	1.75	1.5	2	3	2	2	2
CO2	3	2	1.75	1.5	1.75	1.75	1.5	2	3	2	2	1.5

CO3	2.5	1.5	2	1.5	2	1.5	1.5	2	2.5	2	2	1.5
CO4	2.5	1.5	1.5	1.5	1.5	2	1.5	2	2.5	2	2	2
Average	**2.75**	**1.75**	**1.75**	**1.62**	**1.75**	**1.75**	**1. 5**	**2**	**2.75**	**2**	**2**	**1.75**

M.Sc. Biotechnology-1st Semester
MSc/BT/1/CC4 – Molecular Biology

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Objective: The objective of the course is to make the students understand the basic concepts of molecular biology. Students will gain knowledge of molecular mechanisms of DNA replication, DNA repair, transcription, translation, and gene regulation in prokaryotic and eukaryotic organisms.

Course outcomes (COs): At the end of the course, the students will be able to describe:	
CO1	The structure of DNA and RNA, organization of prokaryotic and eukaryotic genomes
CO2	The mechanism of DNA replication and its regulation in prokaryotes and eukaryotes
CO3	The mechanism of synthesis of RNA molecules from DNA and its regulation.
CO4	The nature of genetic code and the mechanism of protein synthesis and its regulation

Note for the paper setter: *The question paper will consist of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each, selecting at least one question from each unit.*

UNIT I

The Nature of Genetic material: DNA as genetic material; chemical structure and base composition of nucleic acids; double helical structures; different forms of DNA; forces stabilizing nucleic acid structure; super coiled DNA, properties of DNA; renaturation and denaturation of DNA; Tm and Cot curves; structure of RNA; organization of prokaryotic and eukaryotic genomes- chromatin arrangement; nucleosome formation; satellite DNA.

UNIT II

DNA replication: General features of DNA replication; enzymes and proteins of DNA replication; models of replication; prokaryotic and eukaryotic replication mechanism; relationship between DNA replication and cell cycle; DNA copy number maintenance; replication in phages; reverse transcription, mechanism of DNA repair and recombination; CRISPR-Cas genome recombination system.

UNIT III

Transcription: Structure and assembly of prokaryotic and eukaryotic RNA polymerases, promoters and enhancers, mechanism of transcription in prokaryotes and eukaryotes, transcription factors as activators and repressor, regulation of transcription, post-transcriptional processing of tRNA, rRNA and mRNA (5' capping, 3' polyadenylation and splicing), antisense RNA, RNA as an enzyme- Ribozyme.

UNIT IV

Genetic code and Translation: Genetic code and its properties, deciphering the genetic code, wobble hypothesis, mitochondrial genetic code; translational mechanism in prokaryotes and eukaryotes; ribosome composition and assembly; regulation of translation; antibiotic inhibitors and translation; non-ribosomal polypeptide synthesis; post translational modification; transport; folding; chaperones; DNA binding protein motifs **(**zinc finger, leucine zipper, helix-turn-helix and other motifs).

Suggested Readings:

Text/Reference Books:

1. Kreb, J.E. & Goldstein, E.S., Lewin's GENE XII, Jones and Bartlett Publishers. 2017.
2. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A. & Martin, K.C., Molecular Cell Biology (8th Ed.). W. H. Freeman & Co. 2016.
3. Malacinski, G.M., Freifelder's Essentials of Molecular Biology (3rd Ed.). John and Bartlett Publishers. 2015.
4. Watson, J.D., Baker T.A., Bell, S.P., Gann, A., Levine, M., & Losick, R., Molecular Biology of the Gene (7 Ed.). Pearson Pub. 2013.
5. Klug, W.S., Cummings, M.R., Spencer C.A., Palladino, M.A. & Killian, D., Concept of Genetics (12th Ed.). Pearson Education, Singapore. 2019.
6. Krebs, J.E., Lewin, B., Kilpatrick, S.T. & Goldstein, E.S., Lewin's Genes XII. Burlington, MA: Jones & Bartlett Learning. 2017.
7. Alberts, B., Johnson, A.D., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014). Molecular Biology of the cell (6th Ed.). Garland Science.
8. Karp, G., Iwasa, J. & Marshall, W., Karp's Cell and Molecular Biology (9th Ed.). John Wiley & Sons. 2020.

Research/Review Papers:

1. Tilman Schneider-Poetsch and Minoru Yoshida (2018) Along the Central Dogma—Controlling Gene Expression with Small Molecules. Annual Review of Biochemistry 87(1). 10.1146/annurev-biochem-060614-033923
2. Change et al., (2020) The New Central Dogma of Molecular Biology https://www.researchgate.net/publication/340062231_The_New_Central_Dogma_of_Molecular_Biology

On-line Resources:

1. https://www.ncbi.nlm.nih.gov/books/NBK21120/
2. http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000035ZO/P000894/M017781/ET/1498717596StructuralorganizationofgenomeGenomestructureandorganizationQuad1.pdf

CO-PO-PSO Matrix of MSc/BT/1/CC4												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	2	1.5	2	2	3	2	2	2
CO2	3	2	1.5	2	1.5	1.5	1.5	2	3	2	2	2
CO3	3	2	1.5	2	1.5	2	1.5	2	3	2	2	2
CO4	3	2	1.5	2	2	1.5	2	2	3	2	2	2

Average	**3**	**2**	**1.5**	**2**	**1.75**	**1.75**	**1.75**	**2**	**3**	**2**	**2**	**2**

M.Sc. Biotechnology-1st Semester
MSc/BT/1/CC5- Cell Biology

Credits: 2 (Lecture: 30) **Marks: 50**
Duration of exam: 2 Hrs. **Theory: 30; IA: 20**

Objective: The objective of the course is to make the students understand the basic concepts of cell biology and to have knowledge of various aspects and processes involved in functioning and maintenance of cell-the basic unit of life.

Course outcomes (COs): At the end of the course, the students will:	
CO1	Have the knowledge and understanding of the fundamentals of cellular organization and cell signaling
CO2	Be able to understand the mechanism of protein sorting, cell division and cancer development

Note for the paper setter: *The question paper will consist of five questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, four more questions will be set unit-wise comprising of two questions from each of the two units. The candidates are required to attempt two more questions selecting at least one question from each unit.*

Unit – I

Introduction: Origin and evolution of cells; structural organization and diversity of eukaryotic and prokaryotic cells; various cellular organelles of animal and plant cells; plasma membrane, cell wall and their structural organization; transport of nutrients, ions, and macromolecules across membranes; chromosome and karyotype.
Cell Signaling: Signaling molecules and their receptors; mechanism of signal transduction, and cytoskeleton-a brief introduction; developmental abnormalities due to defective signaling pathways; signal transducing machinery as targets for potential drugs; cell adhesion, cell junctions, extracellular matrix.

Unit-II

Protein Sorting and Transport: Endoplasmic reticulum, golgi apparatus and lysosomes; mechanism of vesicular transport.
Cell cycle: Molecular events and model systems; cellular basis of differentiation and development – gametogenesis and fertilization; cell cycle and cancer, development and causes of cancer; tumor viruses; oncogenes; tumor suppressor genes; cell division controls and mechanism of apoptosis

Suggested Readings:

Text/Reference Books:

1. Molecular biology of cell 6th Edition Alberts, Bruce; Watson, JD (2015) Garland Science Publishing, New York.
2. Molecular cell biology 8th Edition, Lodish, H.; Berk, A.; Matsudaira, P.; Kaiser, C.A.; Krieger, M. *et al*. (2016) W.H. Freeman and Co., New York.

3. Cell and Molecular Biology 8th Edition, Robertis, EDP De & Robertis, EMF De (2002) lippincott Williams & Wilkins international student edition, Philadelphia.
4. Cell and Molecular Biology: concepts and experiments. Karp, Gerald (2012) John Wiley and sons, New York.
5. The Cell-a molecular approach, 3rd ed Cooper, GM and Hausman, RE (2004) ASM Press, Washington DC.
6. Lehninger; Principle of Biochemistry, 6th Edition by David L. Nelson and M.M Cox [2013] Free and company. New York.
7. Cell Biology: Organelle structure and function, Sadava, DE (2004) Panima pub., New Delhi

Research/Review Papers:

1. Nair et al., (2019). Conceptual Evolution of Cell Signaling. International Journal of Molecular Sciences. 20 (13), 3292. https://doi.org/10.3390/ijms20133292
2. Arata Yukinobu and Takagi Hiroaki (2019). Quantitative Studies for Cell-Division Cycle Control. Frontiers in Physiology. 10, 1022. https://doi.org/10.3389/fphys.2019.01022

On-line Resources:

1. Cooper GM. The Cell: A Molecular Approach. 2nd edition. Sunderland (MA): Sinauer Associates; 2000. Signaling Molecules and Their Receptors. Available from: https://www.ncbi.nlm.nih.gov/books/NBK9924/
2. http://dosequis.colorado.edu/Courses/MCDB3145/Docs/Karp-617-660.pdf
3. https://www.sciencedirect.com/topics/medicine-and-dentistry/signaling-molecule

CO-PO-PSO Matrix of MSc/BT/1/CC5												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	2	1.5	2	2	2	2	3	2	2	2
CO2	3	2	2	2	1	2	1	1.5	3	2	2	2
Average	**3**	**2**	**2**	**1.75**	**1.5**	**2**	**1.5**	**1.75**	**3**	**2**	**2**	**2**

MSc/BT/1/SEC1-Quality Control Chemist-Microbiology-I

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Objective: Quality Control Chemist-Microbiology-I course provide the information about organizational structure and employment benefits in life sciences industry.

Course outcomes (COs): After completion of this course, students will be able to:	
CO 1	Understand the rules and regulation of goods manufacturing, roles and responsibility of quality control chemist- microbiology.
CO 2	Familiars with guidelines regarding safety during handling, storage and disposal of spoil biological material/waste hazardous material. Develop the professional skills such as planning and organizing, problem solving, objection handling and critical thinking.
CO 3	Understand the basic principles and application of instruments/ techniques used in microbiological and analytical analysis of test samples.
CO 4	Indentify, characterize and classify the micro-organisms. Check the quality in QC lab. Know about software for sample analysis and lab management. Analysis the laboratory data statistically.

Note for the paper setter: *The question paper will consist of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each, selecting at least one question from each unit.*

Unit-I

Overview of life sciences industry and its sub sectors. Regulatory authorities and their rules & regulations pertaining to good manufacturing practices (GMP), good laboratory practices (GLP), good documentation practices (GDP) and 5S guidelines. Organizational structure and employment benefits in life sciences industry. Role and responsibilities of a quality control chemist-microbiology. Guidelines of GLP, pharmacopeia, instruments used in microbiological testing. API production and formulation process. Personal protection equipment (PPEs) used in quality testing and analysis. Concepts of safety including health, hazards, accidents, safety signs and signals. Clean room classifications and requirements, environmental monitoring and clean room behavior practices. Interpretation of material safety data sheet (MSDS) and process of safety analysis. Guidelines for handling and storage of hazardous material. EHS rules and Heinrich pyramid. Fire safety concepts in emergency in lab. Process for reporting critical information. Emergency and first aid measures.

Unit-II

Practice core and professional skills such as planning and organizing, problem solving, objection handling, and critical thinking. Steps for hygiene in QC microbiology laboratory. Measures of spillage of biological strains and samples, chemicals, media, culture etc. Disposal methods for waste and used/ unused solutions according to SOP. Assess of out of control situation and its reporting. Cleaning of lab area surfaces and equipment as per SOP. Methods as per GMP for various types of soiling and surface, GMP protocol and workplace SOPs related to accidental damage. Out of trend (OOT) and out of specification (OOS)

samples. Standards and guidelines for sample handling in life science industry. Sampling procedures as per SOP's using sampling tools. Sampling plans, sample handling and preparation of microbial samples. Guidelines for weighing of samples. Use of good storage practices (GSP) guidelines for storage of samples. Stability of sample and process of sample stabilization. Identification and report nonconformity of the sample as per SOP. Cleaning and sterilization of the samples.

Unit-III

Procedure and use of various equipment used in microbiological analysis, basic principles and application of analytical instruments for analysis of test sample. Calibration its importance and validation of analytical instrument as per SOP and manual. Maintenance procedure for instruments as per SOP. Sampling and procedure for conducting microbial test according to SOP. Basic techniques used in microbiology, labeling, preparation of different types of medium, broth and agar plates specific for microorganisms. Culturing of media (streaking and spread plate procedures). Validation procedure, monitoring and assess of samples from a range of sources. Bacterial endotoxin test (BET)/ Sterility test. Identification methods including molecular testing of test samples. Procedure to identify the reasons for unwanted growth of microorganisms. Define alert and action limits, maintenance of positive and negative controls during testing.

Unit-IV

Identification (phenotypic and genotypic methods) and classification of microorganisms in samples. Dynamic techniques (FAME) and static techniques. Bacterial cell structure and cytoplasmic organelle and their functions. Biochemical characterization of microbes by Gram stain and biochemical cards. Harvesting and processing of cells for the extraction of fatty acids, saponification and trans-esterification reactions. Procedure for preparation of FAME compounds. Extraction procedure of fatty acids and conversion into FAMEs. Quality check in QC lab.Computer software for sample analysis and lab management. Handling of equipment malfunction and report faults. Statistical analysis of laboratory data. Advance QC approaches. Identify critical quality attributes (CQA), critical process parameters (CPP) and critical process controls (CPC), Quality management system.

Suggested readings:

1. Microbiology 9thRevised Edition. Prescott L.M.; Harley J.P. (2013) Tata McGraw Hill, USA.
2. Microbiology. Pelczar Jr., M.J.; Chan, E.C.S. (2010) Tata McGraw Hill, New Delhi.
3. Brock Biology of Microorganisms 14th Edition. Madigan, M.T.; Martinko, J. M. and Parker, J. (2015), Prentice Hall, New Jersey.
4. General Microbiology. Stainer, R.Y.; Ingraham, J.L.; Wheelis, M.L. and Painter, P.R. (2003) The MacMillan Press.
5. Tortora, G.J., Funke, B.R., Case, C.L. (2012) Microbiology -An Introduction, 11thEdition, Pearson education Pvt. Ltd. Singapore.
6. Microbiology: Principles and Explorations, 8thEd. J.G. Black (2005) John Wiley & Sons Inc.
7. Study material provided by LSSSDC (will be given by the Dept. of Biotechnology, CDLU, Sirsa)

CO, PO, PSO matrix of MSc/BT/1/SEC1												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	1	2	1	1	2	2	2	2	2
CO2	3	2	1.5	2	2	2	2	2	3	2	2	2
CO3	3	2	1.5	2	1	1	2	1	3	2	2	2
CO4	2	2	1.5	1	2	2	2	2	2	2	2	2
Average	**2.75**	**2**	**1.5**	**1.5**	**1.75**	**1.5**	**1.75**	**1.75**	**2.75**	**2**	**2**	**2**

M.Sc. Biotechnology-1st Semester

MSc/BT/1/SEC2– Lab Quality Control Chemist-Microbiology-I and Basic Microbiology

Credits: 4 (Lab Hrs.120) **Marks: 100**

Duration of exam: 4 hrs.

Objective: The objective of the course is to make the students well versed in practical techniques involved in microbiological experimentation, quality control testing as well as practices of Life sciences industry.

Course outcomes (COs): At the end of the course, the students will be:	
CO1	Well acquainted with basic instrumentation used in Microbiology laboratory
CO2	Able to carry out experimentations involved in preparation of culture media as well as for isolation and characterization of microbes
CO3	Able to perform routine analysis in lab in line with good manufacturing practices (GMP) and good laboratory practices (GLP)
CO4	Well acquainted with procedures involved in workplace cleanliness and well versed with information technology skills

Practicals in Quality Control Chemist-Microbiology (95 hrs.)

(The contents of this course are based on Model Curriculum of Quality Control Chemist-Microbiology, developed and provided by LSSSDC. The same is attached at annexure I)

1. Practicals pertaining to Module 2 of Model Curriculum- GLP guidelines and production overview (16 hrs.)
2. Practicals pertaining to Module 3 of Model Curriculum-Health and Safety (16 hrs.)
3. Practicals pertaining to Module 4 of Model Curriculum- Workplace cleanliness (16 hrs.)
4. Practicals pertaining to Module 5 of Model Curriculum- Instrumentation in Microbiology (32 hrs.)
5. Practicals pertaining to Module 12 of Model Curriculum-Coordination with cross functional teams (3 hrs.)
6. Practicals pertaining to Module 13 of Model Curriculum-Information technology skills at work (12 hrs.)

Practicals in Basic Microbiology (25 hrs.)

1. Preparation of liquid and solid culture media for growth of microorganisms.
2. Pure Culture Techniques: Streak plate, pour plate, spread plate. Preparation of slants and stab cultures. Storage of microorganisms
3. Isolation and enumeration of microorganisms from soil and water and biochemical characterization of selected microbes
4. Measurement of microbial growth and study of effect of various factors on growth of microorganisms: temperature, pH, U.V. and carbon and nitrogen sources on growth.

Text/References Books:

1. Experiments in Microbiology, Plant Pathology and Biotechnology 4th Edition. Aneja, K.R. (2010) New Age International Publishers, New Delhi.
2. Microbiology- a laboratory manual 4th edition. Cappuccino J. and Sheeman N. (2000) Addison Wesley, California.
3. Environmental Microbiology – A laboratory manual. Pepper, I.L.; Gerba, C.P. and Brendecke, J.W. (2015) Academic Press, New York.
4. Introductory practical biochemistry by S. K. Sawhney and Randhir Singh (2000)-Narosha Publishing House, New Delhi.
5. Study material provided by LSSSDC.

CO-PO-PSO Matrix of MSc/BT/1/SEC2												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	2	2	2	2	3	2	3	2	2	1.5
CO2	3	2	2	2	2	2	3	2	3	2	2	1.5
CO3	3	2	2	2	1.5	2	3	2	3	2	2	1.5
CO4	3	2	2	2	1.5	2	3	2	3	2	2	1.5
Average	**3**	**2**	**2**	**2**	**1.75**	**2**	**3**	**2**	**3**	**2**	**2**	**1.5**

M.Sc. Biotechnology-1st Semester
MSc/BT/1/CC6– Lab Biochemistry & Molecular Biology

Credits: 4 (lab Hrs: 120) **Marks: 100**
Duration of exam: 4 Hrs.

Course Outcomes (COs): After completion of this Lab. course, students will be able to:	
CO1	Identify various laboratory equipments and describe their functioning
CO2	Prepare various solutions, reagents needed in the estimation of proteins, lipids, carbohydrates as well as for isolation of DNA, RNA and proteins
CO3	Carry out experiments of Thin Layer Chromatography, Agarose Gel Electrophoresis and spectrophotometry
CO4	Check enzymatic activity in different conditions and run PAGE set up

Biochemistry

1. Introduction to various instruments and their working principles used in biochemistry laboratory.
2. Qualitative estimation of amino acids and proteins.
3. Qualitative estimation of lipids.
4. Qualitative estimation of carbohydrates.
5. Quantitative estimation of protein by Lowry's method.
6. Determination of total soluble sugars by ferricyanide method (Volumetric procedure)
7. Separation of various components in the different lipid fraction by thin layer chromatography.
8. To measure the activity of enzyme (alpha-amylase) or any other enzyme.
9. To study the effect of temperature on enzyme activity.
10. To study the effect of substrate concentration on enzyme activity.

Molecular Biology

1. Introduction to various instruments and their working principles used in Molecular Biology laboratory.
2. Preparation of normal and molar solutions, buffers, pH setting etc.
3. Isolation of genomic DNA from bacteria.
4. Isolation of genomic DNA from plant/animal source.
5. Checking quality and quantity of DNA.
6. Gel electrophoretic separation of nucleic acids.
7. Molecular size determination of DNA samples by Agarose gel electrophoresis.
8. Isolation of total RNA.
9. Isolation of proteins.
10. Polyacrylamide Gel Electrophoresis (PAGE) for separation of Proteins.

Suggested Readings:

Text/References Books:

1. Experiments in Microbiology, Plant Pathology and Biotechnology 4th Edition. Aneja, K.R. (2010) New Age International Publishers, New Delhi.

2. Introductory practical biochemistry by S. K. Sawhney and Randhir Singh (2000)-Narosha Publishing House, New Delhi.
3. Principles and techniques of practical biochemistry by K. Wilson and Wolker (1994) Cambridge University Press, Cambridge.
4. Sambrook J, EF Fritech and T. Maniatis (2000) Molecular Cloning: A laboratory Manual, cold spring Harbor laboratory Press, New York.
5. Glover DM and BD Hames (2006), DNA cloning: A practical Approach, IRL Press, Oxford.
6. Priyanka Siwach and Namita Singh (2007) Molecular Biology, Theory and Practices, Laxmi Publication.
7. Lodish et al., Molecular Cell Biology Freeman and Company 2016.
8. Smith and Wood. Cell Biology, Chapman and Halls 1996.

Research/Review Papers:

1. Zou Y, Mason MG, Wang Y, Wee E, Turni C, et al. (2018) Correction: Nucleic acid purification from plants, animals and microbes in under 30 seconds. PLOS Biology 16(5): e1002630. https://doi.org/10.1371/journal.pbio.1002630
2. Drygin, Y. F., Butenko, K. O., & Gasanova, T. V. (2021). Environmentally friendly method of RNA isolation. Analytical Biochemistry, 620, 114113.
3. Soleimani-Delfan, A., Bouzari, M., & Wang, R. (2021). A rapid competitive method for bacteriophage genomic DNA extraction. Journal of Virological Methods, 293, 114148.

On-line Resources:

1. https://www.researchgate.net/publication/337864741_Estimation_of_Proteins_by_Lowry's_Method
2. https://agriculture.uq.edu.au/files/5650/plant-genomic-dna-extraction-by-ctab-2-fiona.pdf

CO-PO-PSO Matrix of MSc/BT/1/CC6												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	1.25	1.5	2	2	3	3	3	2
CO2	3	2	1	2	1.5	1.5	1.5	2	3	3	3	2
CO3	3	2	1	2.5	1.5	2	1.5	2	3	3	3	2
CO4	3	2	1.5	2.5	1.75	2	2	2	3	3	3	2
Average	**3**	**2**	**1.25**	**2.25**	**1.5**	**1.75**	**1.75**	**2**	**3**	**3**	**3**	**2**

M.Sc. Biotechnology-2nd Semester
MSc/BT/2/CC7 – Genetic Engineering

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Objectives: This course aims to introduce the students to field of Genetic Engineering including introduction, basic principles, milestones, scopes and advances.

Course Outcomes (COs): At the completion of this course:	
CO1	Students would understand basic concepts and requirements of Genetic Engineering including different methodologies used for manipulation of nucleic acids, gene cloning, PCR and will know its impact on society
CO2	They would be acquainted with the methodologies involved in introduction of foreign DNA into living cells and cloning of a specific gene
CO3	Students will know about various types of molecular markers, mapping of genomes and various methods for sequencing of genomes
CO4	Students will know how to carry out gene expression studies and about latest genome editing technologies.

Note for the paper setter: *The question paper will consist of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each, selecting at least one question from each unit.*

Unit – I

Introduction: Introduction and historical development of genetic engineering; impact of genetic engineering in modern society; advent and importance of gene cloning and polymerase chain reaction; purification of DNA from living cells- concept and principle; manipulation of purified DNA- DNA manipulative enzymes (nucleases, ligases, polymerases, DNA-modifying enzymes); enzymes for cutting DNA (Restriction endonucleases), joining of DNA molecules (enzymes, sticky ends, linkers, adaptors, homopolymer tailing), vectors for gene cloning- general architecture and examples (plasmids, bacteriophages, viruses, artificial chromosomes).

Polymerase Chain reaction: Principle of PCR; primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR.

Unit II

Introduction of DNA into living cells: Introduction of DNA into bacteria, transformation of individual cell and whole organism in case of non-bacterial cells, identification of recombinants,

Selection and screening of clones: Methods of selection, gene and cDNA libraires, method of clone identification- colony and plaque hybridization probing, preparation of radioactive and non-radioactive labelled probes, use of translation product identification for clone identification purpose, hybridization techniques (southern, northern and western blotting).

Unit III

Molecular markers and mapping: Various types of molecular markers, concept and mechanism of molecular mapping of genomes-linkage mapping, physical mapping

Sequencing Techniques: Sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; next generation sequencing methods: 454 FLX Roche genome analyzer platform, illumina solexa genome analyzer platform, pacific biosciences SMRT sequence analyzer platform, ion torrent platform, oxford nanopore sequencing platform, whole genome sequencing (a brief account)-shot gun method, clone contig approach

Unit IV

Studying Gene Expression and function: Studying RNA transcript of a gene; studying regulation of gene expression-identifying protein binding sites and control sequences; identifying and studying the translation product of a cloned gene, problems with production of recombinant proteins in *E.coli*, optimizing expression of foreign genes in *E. coli*

Gene Silencing and Genome Editing Technologies: Gene silencing techniques; introduction to siRNA; siRNA technology; micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy; genome editing by CRISPR-Cas with specific emphasis on Chinese and American clinical trials; DNA chip technology (a brief account).

Suggested Readings:

Text/Reference Books:

1. Brown TA (2011) Genome-3. John Wiley, New York.
2. Watson JD (2009) A passion for DNA: Genes, Genomes & Society. Cold spring harbor laboratory press (CSHL).
3. Brown T.A. (2010), Gene Cloning & DNA Analysis, 6nd Edition, Wiley-Blackwell, New York.
4. Glover DM and Hames BD (1995) DNA cloning: A practical Approach, IRL press, Oxford.
5. Old R W and Primrose S B (2007), Principles of Gene Manipulation-7th edition, Blackwell Publishing (MA).
6. Sambrook J, EF Fritech and Maniatis T. (2000) Molecular cloning: A laboratory Manual, cold spring Harbor Laboratory Press, New York.

Research/Review Papers:

1. Miao, G., Zhang, L., Zhang, J., Ge, S., Xia, N., Qian, S., ... & Qiu, X. (2020). Free convective PCR: from principle study to commercial applications—a critical review. Analytica chimica acta, 1108, 177-197.
2. Nuñez, J. K., Chen, J., Pommier, G. C., Cogan, J. Z., Replogle, J. M., Adriaens, C., ... & Weissman, J. S. (2021). Genome-wide programmable transcriptional memory by CRISPR-based epigenome editing. Cell, 184(9), 2503-2519.
3. Al-Samarai, F. R., & Al-Kazaz, A. A. (2015). Molecular markers: An introduction and applications. European Journal of Molecular Biotechnology, (3), 118-130.
4. Kang, T. S. (2019). Basic principles for developing real-time PCR methods used in food analysis: A review. Trends in Food Science & Technology, 91, 574-585.

5. Hu, T., Chitnis, N., Monos, D., & Dinh, A. (2021). Next-generation sequencing technologies: An overview. Human Immunology.

On-line Resources:

1. https://www.ncbi.nlm.nih.gov/probe/docs/applsilencing/
2. https://geneticeducation.co.in/what-is-gene-silencing-definition-process-techniques-and-applications/
3. https://www.sciencedirect.com/topics/neuroscience/whole-genome-sequencing

CO-PO-PSO Matrix of MSc/BT/2/CC7												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	2	2	1.5	2	3	2	3	2	2	2
CO2	3	2	2	2	1.5	2	3	2	3	2	2	2
CO3	3	2	2	2	1.5	2	3	2	3	2	2	1.5
CO4	3	2	2	2	1.5	2	3	2	3	2	2	1.5
Average	**3**	**2**	**2**	**2**	**1.5**	**2**	**3**	**2**	**3**	**2**	**2**	**1.75**

M.Sc. Biotechnology-2nd Semester
MSc/BT/2/CC8 –Intermediary Metabolism

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70: IA: 30**

Objectives: To build upon undergraduate level knowledge of biochemical principles with specific emphasis on different metabolic pathways.

Course outcomes (COs): At the end of the course, the students will be able to:	
CO 1	Gain fundamental knowledge of metabolism of carbohydrates, generation of energy and maintenance of blood glucose level in the body.
CO 2	Understand the oxidation and biosynthesis of fatty acids with special emphasis on synthesis of lipids and cholesterol
CO 3	Gain the knowledge about metabolism of amino acids and release of urea from the body.
CO 4	Acquire the knowledge about movement of electron in respiratory chain and generation of energy through phosphorylation.

Note for the paper setter: *The question paper will consist of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each, selecting at least one question from each unit.*

Unit – I

Metabolic concept: Metabolism and its type, intermediary metabolism, function of metabolism
Carbohydrate metabolism: Glycolysis; fate of pyruvate under aerobic and anaerobic condition; pentose phosphate pathway and its significance; gluconeogenesis pathway; biosynthesis of lactose, sucrose and starch; Glycogenolysis; glycogenesis and control of glycogen metabolism. Maintenance of blood glucose level. Glyoxylate cycle.

Unit – II

Lipid metabolism: Beta-oxidation of saturated fatty acid, oxidation of unsaturated and odd carbon fatty acids, alpha and omega oxidation of fatty acid; formation and utilization of keton bodies; degradation of triacylglycerols by lipases; biosynthesis, elongation and desaturation of saturated fatty acids; biosynthesis of triacylglycerols, phospholipids and cholesterol.

Unit – III

Amino Acids Metabolism: General reaction of amino acid metabolism –transamination; oxidative and non-oxidative deamination and decarboxylation; general pathways of amino acids degradation; urea cycle and its regulation.
Nucleic acids metabolism: Catabolism, de novo-biosynthesis and regulation of purine and pyrimidine nucleotide; salvage pathway; formation of deoxyribo nucleotides.

Unit – IV

Mitochondrial oxidative phosphorylation: Mitochondrial electron transport chain; hypothesis of mitochondrial oxidative phosphorylation; inhibitors and uncouplers of oxidative phosphorylation.
Secondary metabolites: Types and pathways- an overview
Integration of metabolism: Basic concept.

Suggested readings:

Text/Reference Books:

1. Lehninger; Principle of Biochemistry, 8th Edition by David L. Nelson and M.M Cox [2021] Free and company. New York.
2. Fundamental of Biochemistry. D. Voet and J. G. Voet [2013] John Wiley and Sons New York.
3. Biochemistry 9th Edition by L. Stryer [2019], W.H Freeman and New York
4. Biochemistry 6thEdition by R.H Garrett and C.M. Grisham [2017] Saunders college Publishing, New York
5. Biochemistry 4th edition by G. Zubay [1998] Wm .C Brown Publishers.
6. Outline of Biochemistry by Conn E.E, Stumpf P.K. Bruening G. and Dvi R.H [1999] John Wiley and Sons Inc. New York and Toronto.
7. Fundamental of Biochemistry by J.L. Jain, Sanjay Jain, Nitin Jain (2004) S. Chand & Company Ltd

Research/Review Papers:

1. Shearer, M. J., & Okano, T. (2018). Key pathways and regulators of vitamin K function and intermediary metabolism. *Annual review of nutrition*, *38*, 127-151.
2. Stincone, A., et al. (2015). The return of metabolism: biochemistry and physiology of the pentose phosphate pathway. *Biological Reviews*, *90*(3), 927-963.
3. Wang, L., et al. (2015). Inhibition of oxidative phosphorylation for enhancing citric acid production by Aspergillus niger. *Microbial cell factories*, *14*(1), 1-12.
4. Guo, R., et al. (2018). Structure and mechanism of mitochondrial electron transport chain. *Biomedical journal*, *41*(1), 9-20.
5. Hildebrandt, T. M., et al. (2015). Amino acid catabolism in plants. *Molecular plant*, *8*(11), 1563-1579.

On-line Resources

1. https://www.ncbi.nlm.nih.gov/books/NBK556002/
2. https://biologydictionary.net/ketone-bodies/
3. https://pubmed.ncbi.nlm.nih.gov/19301095/
4. https://www.researchgate.net/publication/11319121_Regulation_of_enzymes_of_the_urea_cycle_and_arginine_metabolism
5. https://courses.lumenlearning.com/boundless-biology/chapter/oxidative-phosphorylation/
6. https://www.intechopen.com/books/secondary-metabolites-sources-and-applications/an-introductory-chapter-secondary-metabolites

CO, PO, PSO matrix of MSc/BT/2/CC8												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	1.5	1.5	2	2	3	2	2	1.5

CO2	3	1	1	2	1.5	1.5	2	2	3	2	2	1.5
CO3	2	2	1.5	1.5	1.5	2	2	1.5	2	2	2	2
CO4	2	2	1	1.5	1.5	2	2	1.5	2	2	2	2
Average	**2.5**	**1.75**	**1.25**	**1.75**	**1.5**	**1.75**	**2**	**1.75**	**2.5**	**2**	**2**	**1.75**

M.Sc. Biotechnology-2nd Semester
MSc/BT/2/CC9- Basics in Genetics

Credits: 2 (Lectures: 30) **Marks: 50**
Duration of exam: 2 Hrs. **Theory: 30; IA: 20**

Objective: The objective of the course is to make the students understand the basic concepts and principles of genetics

Course outcomes (COs): At the end of the course, the students will:	
CO1	Have the understanding of principles of heredity and variation and nature of genes and chromosomes
CO2	Have the knowledge of types and mechanism of mutations and will develop understanding of gene linkage and chromosome mapping

Note for the paper setter: *The question paper will consist of five questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, four more questions will be set unit-wise comprising of two questions from each of the two units. The candidates are required to attempt two more questions selecting at least one question from each unit.*

UNIT – I

Principles of heredity and variation: Mendel's laws and experiments, penetrance and expressivity, phenocopy.
Genes and chromosomes: Classical vs. modern concept of gene; general features of chromosomes, chromosomal theory of inheritance; sex determination, sex-linked, sex-limited and sex-influenced inheritance; chromosomal aberrations; extra-chromosomal inheritance; sex chromosomal abnormalities-syndrome and autosomal abnormalities.

UNIT – II

Mutation: Types of mutation and molecular mechanism; ames test for mutagenesis; mutagenesis by nitrous acid; hydroxylamine; alkylating agents; intercalators and UV; DNA repair mechanisms - excision, mismatch, SOS, photo-reactivation, recombination repair.
Gene Linkage and chromosome Mapping: Complete and incomplete linkage; recombination of genes in a chromosome; crossing over; gene mapping by 2-point and 3-point test crosses; chromosome map viewer as available on NCBI.

Suggested Readings:

Text /References Books:

1. Principles of Genetics, 8th ed., Gardener et al. (2001), John Weley, New York.
2. Genetics, 6th ed., Snustad P.D. and Simmons M.J. (2012), John Weley, New York.
3. Concept of Genetics, 10th ed., Klug and Cummings (2012), Pearson Education, Singapore.
4. Genetics: Analysis and Principles (2016), Brooker, RJ, McGraw Hill, New York.

5. Genetics: B.D. Singh (2004), Kalyani Publishers.
6. Genetics principles and analysis, 4th Edition (2012) DL Hart and EW Jones, Jones and Bartett Publishers, Massacheusetts, USA

Research/Review Papers:

1. Shi, M., Luo, H., Zhang, W., Jiang, Y., Chen, J., Cheng, Y., ... & Xia, X. Q. (2021). A genome-wide linkage map and QTL mapping for growth traits of Asian rice-field eel (*Monopterus albus*). Aquaculture, 536, 736394.
2. Baverstock, K. (2021). The gene: An appraisal. Progress in Biophysics and Molecular Biology.

On-line Resources:

1. https://www.biologydiscussion.com/gene/modern-concept-of-gene-with-diagram-cell-biology/39093
2. https://www.ncbi.nlm.nih.gov/books/NBK21322/
3. https://microbenotes.com/mendels-experiment-and-laws/
4. https://www.sciencedirect.com/topics/medicine-and-dentistry/sex-chromosome-aberration

CO-PO-PSO Matrix of MSc/BT/2/CC9												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	2	1.5	2	2	2	1.5	3	2	2	2
CO2	3	2	2	2	1.5	2	1	2	3	2	2	2
Average	**3**	**2**	**2**	**1.75**	**1.75**	**2**	**1.5**	**1.75**	**3**	**2**	**2**	**2**

M.Sc. Biotechnology-2nd Semester
MSc/BT/2/CC10-Bioinformatics

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Objectives: The aim of this course is to introduce the students from basics to advances of bioinformatics. This includes teaching the basis of the biological system via information and technology.

Course Outcomes (COs): The programme aims at providing students with the following:	
CO1	To get introduced to basic tools and concepts of Bioinformatics and their significance in applied and basic Biology. Students will also learn applications of various bioinformatics tools, biodiversity databases and biological resources.
CO2	Students will learn the management of biological data in various biological databases, and bioinformatics tools related to homology search, protein functional analysis and sequence analysis.
CO3	To acquire knowledge about DNA sequence analysis, genome mapping, *in silico* drug designing techniques and tools.
CO4	Overview about gene and promoter prediction and molecular phylogeny.

Note for the paper setter: *The question paper will consist of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each, selecting at least one question from each unit.*

Unit – I

Introduction to Bioinformatics: Definition, history, role and applications of bioinformatics.
Biodiversity databases: IUCN; Species 2000; FishBase; IPNI; ICTV; IT IS; Tree of life.
Biological materials resources: ATCC; MTCC; NCCS.

Unit – II

Biological databases: Primary, secondary and structural Protein and Gene Information Resources – PIR; SWISSPROT; PDB; Genbank; DDBJ; EMBL-EBI; Specialized genomic resources
Bioinformatics Tools: Homology and similarity tools (BLAST, FASTA, SSEARCH, or HMMER search); protein functional analysis tools (PfamScan, HMMER3 phmmer, Phobius, Pratt RADAR); sequence analysis tools

Unit – III

DNA sequence analysis: cDNA libraries and EST; EST analysis; Genome Survey Sequence; pairwise alignment techniques; database searching; multiple sequence alignment. Genome Mapping; Genome Sequence Assembly; Genome Annotation; Comparative Genomics. Human Genome analysis
Secondary database searching: building search protocol; basic principles of computer aided drug design; docking; QSAR.

Unit – IV

Gene and Promoter Prediction: Categories of Gene Prediction Programs; Gene Prediction in Prokaryotes and Eukaryotes; Promoter and Regulatory Elements in Prokaryotes and Eukaryotes.
Molecular Phylogenetics: Molecular Evolution and Molecular Phylogenetics; Terminology; Gene Phylogeny versus Species Phylogeny; Forms of Tree Representation; Finding a True Tree. Distance-Based Methods; Character-Based Methods; Phylogenetic Tree Evaluation; Phylogenetic Programs.

Suggested Readings:

Text/Reference Books:

1. Attwood TK &Parry-Smith DJ. (2003). Introduction to Bioinformatics. Pearson Education.
2. Bhatia, S.C. (2015). Bioinformatics. Shree.
3. Curran, B. G. & Walker, R. J. (2010). Bioinformatics. CBS
4. Jaing, Rui/Zhang, Xuegong. (2013). Basics of Bioinformatics. Springer.
5. Krane .2003. Fundamental concept of bioinformatics, Pearson Education, Singapore.
6. Nucleic Acids Research. Genome Database issue. 2001 Jan.
7. Pevsner, Jonathan. (2009). Bioinformatics and Functional Genomics. Wiley,Caneda
8. Rastogi SC, Mendiratta N & Rastogi P. (2004). Bioinformatics: Concepts, Skills and Applications. CBS.
9. Singh, Anupam & Singh, Vishwadeep. (2013). BioInformatics Power to Biotechnology. N.P.H.
10. Singh, Rand Sharma, R. (2010) Bioinformatics: Basics, Algorithms and Applications, Universities Press.

Research/Review Papers:

1. Pearson, W. R. (2016). Finding protein and nucleotide similarities with FASTA. *Current protocols in bioinformatics*, *53*(1), 3-9.
2. Medina-Rivera, A.,et al. (2015). RSAT 2015: regulatory sequence analysis tools. *Nucleic acids research*, *43*(W1), W50-W56.
3. Lappalainen, T., et al. (2019). Genomic analysis in the age of human genome sequencing. *Cell*, *177*(1), 70-84.
4. Lees, J. A., et al. (2018). Evaluation of phylogenetic reconstruction methods using bacterial whole genomes: a simulation based study. *Wellcome open research*, *3*.

On-line Resources

1. https://microbenotes.com/bioinformatics-introduction-and-applications/
2. https://www.ncbi.nlm.nih.gov/books/NBK21122/
3. https://www.frontiersin.org/articles/10.3389/fgene.2019.00286/full
4. https://www.ncbi.nlm.nih.gov/books/NBK21116/
5. https://libraryguides.mcgill.ca/bioinformatics/databases
6. https://www.ncbi.nlm.nih.gov
7. https://www.atcc.org/
8. https://www.rcsb.org/

CO-PO-PSO matrix of MSc/BT/2/CC10												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**

CO1	3	1.5	2	2	2	2	2	2	3	2	2	2
CO2	3	1.5	2	2	2	2	1.5	2	3	2	2	2
CO3	3	1.5	2	1.5	1.5	2	1.5	2	3	2	2	2
CO4	3	1.5	2	1.5	1.5	2	2	2	3	2	2	2
Average	**3**	**1.5**	**2**	**1.75**	**1.75**	**2**	**1.75**	**2**	**3**	**2**	**2**	**2**

M.Sc. Biotechnology-2nd Semester
MSc/BT/2/SEC3-Quality Control Chemist-Microbiology-II

Credits: 2 (Lectures:30) **Marks: 50**
Time: 2 Hrs. **Theory: 30IA: 20**

Objective: To provide the information about Quality management system for quality control in life sciences industry and employment benefits in this sector.

Course outcomes (COs): After completion of this course, students will be able to:	
CO 1	Know about principle and procedure of laboratory instruments, collation of new articles published in research newsletters, specialized computer software used for studies, research purposes and specific for microbiological processes.
CO 2	Prepare different types of reports in format as per SOP. Know about the validation process of document as per GMP protocols and procedure for maintaining online records.

Note for the paper setter: *The question paper will consist of five questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, four more questions will be set unit-wise comprising of two questions from each of the two units. The candidates are required to attempt two more questions selecting at least one question from each unit.*

Unit-I

Procedure to grow different strains of bacteria in various conditions for their molecular and cellular characterization, Identification procedure of different biomarkers. Applications of rapid microbial identification system (RMIS), FAME from different sources. Principle and procedure of laboratory equipment such as autoclave, Laminar airflow, Biosafety cabinet, sterility test apparatus, incubator etc. Detail about collation of new articles published on research newsletters. Specialized computer software used for studies, research purposes and specific for microbiological processes carried or in Lab.

Unit-II

General reporting process, protocol and escalation policy. Reports and testing related documents as per SOP. Techniques for collaborating with other groups and divisions. Importance of cGMP/QMS/ SOP related documentation. Correct method of documentation as per SOPs, GLP and GMP protocols. Prototypic report, polyphasic report and comprehensive reports. MIDI extraction procedure, MIS chromatogram, 2D Clustering. Report generation of 2D plot, histogram, dendrogram, phylogenetic tree from samples, neighbour joining tree. Validation process of document as per GMP protocols. Process for addressing audit queries from QA team, internal auditor and external auditor. Efficient and clear communication methods for reporting. Process for addressing audit queries from QA team, internal auditor and external auditor. IT tools for data entry in e-documents. Importance of confidentiality of the data and internal processes, security of information using of e-mail/other channels. Software (such as MIDI) to operate the QC instruments. Procedure for maintaining online records

Suggested readings:

1. Microbiology 9thRevised Edition. Prescott L.M.; Harley J.P. (2013) Tata McGraw Hill,

USA.
2. Microbiology. Pelczar Jr., M.J.; Chan, E.C.S. (2010) Tata McGraw Hill, New Delhi.
3. Brock Biology of Microorganisms 14th Edition. Madigan, M.T.; Martinko, J. M. and Parker, J. (2015), Prentice Hall, New Jersey.
4. General Microbiology. Stainer, R.Y.; Ingraham, J.L.; Wheelis, M.L. and Painter, P.R. (2003) The MacMillan Press.
5. Tortora, G.J., Funke, B.R., Case, C.L. (2012) Microbiology -An Introduction, 11thEdition, Pearson education Pvt. Ltd. Singapore.
6. Microbiology: Principles and Explorations, 8thEd. J.G. Black (2005) John Wiley & Sons Inc.
7. Study material provided by LSSSDC will be given by the Dept. of Biotechnology, CDLU, Sirsa

CO, PO, PSO matrix of MSc/BT/2/SEC3												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	2	1	1.5	1	1	2	2	1	1	1
CO2	2	2	2	2	2	2	2	2	3	2	2	2
Average	**2.5**	**2**	**2**	**1.5**	**1.75**	**1.5**	**1.5**	**2**	**2.5**	**1.5**	**1.5**	**1.5**

M.Sc. Biotechnology-2nd Semester
MSc/BT/2/CC11- Lab Bioinformatics

Credits: 4 (Lab Hrs. 120) **Marks: 100**
Duration of exam: 4 Hrs.

Course Outcomes (COs): After completion of this course, students will be able to:	
CO1	Understand the role of computers in biological research, format of various biological databases and bioinformatics tools.
CO2	Shall be able to search the gene/protein sequence in the database, learn to use various databases and their resources and tools to analyse the sequences
CO3	Shall be able to analyse the genomes, gene sequences and their functional annotation
CO4	Shall be able to work on various computational tools, software for analyzing, alignment, phylogenetic of any biological data.

Scope of computers in biological research: Operating systems – type of Windows, Internet and its applications. Creating a word document; excel worksheet; power point presentation; adding data, text, table, figure and external objects; navigating in document; changing the look of document etc.

Databases, Tools and Applications: Retrieval of Gene and Protein Sequences; ClustalW, Omega; NCBI and its resources, BLAST; FASTA; PIBWIN; ORF finder; NCBI map viewer; ATCC; MTCC; Species 2000; Tree of life; IPNI 1999; Fishbase 2001; ICTV; Web cutter; Translation tools

Genome analysis: Identification, measurement or comparison of genomic features such as DNA sequence; structural variation; gene expression or regulatory and functional element annotation at a genomic scale.

Molecular Phylogenetics: Retrieval of Gene and Protein Sequences; Analysis of sequences by DAMBE, PHYLIP; Different types of phylogenetic tree construction and evaluation; Introduction to latest and open-source bioinformatics softwares.

Suggested Readings:

1. A Text Book of Bioinformatics. Sharma, Munjal and Shanker (2016-17) Rastogi Publications, Meerut.
2. Basics of Bioinformatics. Jaing, Rui/Zhang, Xuegong. (2013). Springer.
3. Bioinformatics: Basics, Algorithms and Applications. Ruchi Singh and Richa Sharma (2010) Universities Press Pvt. Ltd.
4. Bioinformatics. Bhatia, S.C. (2015). Shree.
5. How computers work. Ron White. (2000). Tech media.
6. How the Internet works. Preston Gralla. (2000). Tech media.
7. Nucleic Acids Research. Genome Database issue. 2001 Jan.

Research/Review Papers:

1. Hug, L. A., et al. (2016). A new view of the tree of life. *Nature microbiology*, *1*(5), 1-6.
2. Xia, X. (2018). DAMBE7: New and improved tools for data analysis in molecular biology and evolution. *Molecular biology and evolution*, *35*(6), 1550-1552.
3. Lafita, A., et al. (2019). BioJava 5: A community driven open-source bioinformatics library. *PLoS computational biology*, *15*(2), e1006791.
4. Lefkowitz, E. J., et al. (2018). Virus taxonomy: the database of the International Committee on Taxonomy of Viruses (ICTV). *Nucleic acids research*, *46*(D1), D708-D717.

On-line Resources:

1. https://edu.gcfglobal.org/en/computerbasics/understanding-operating-systems/1/
2. https://www.webopedia.com/insights/windows-operating-system-history/
3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3531099/
4. https://www.ncbi.nlm.nih.gov/books/NBK209072/
5. https://vlab.amrita.edu/?sub=3&brch=274&sim=1447&cnt=1
6. https://www.ncbi.nlm.nih.gov
7. https://www.atcc.org/
8. https://www.rcsb.org/
9. https://google.com

CO-PO-PSO matrix of MSc/BT/2/CC11												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	1.5	2	2	2	3	2	2	2
CO2	3	2	1.5	2	1.5	2	1.5	2	3	2	2	2
CO3	3	2	1.5	2	2	2	1.5	2	3	2	2	2
CO4	3	2	1.5	2.5	2	2	2	2	3	2	2	2
Average	**3**	**2**	**1.5**	**2.12**	**1.75**	**2**	**1.75**	**2**	**3**	**2**	**2**	**2**

M.Sc. Biotechnology-2nd Semester
MSc/BT/2/CC12 – Lab Genetic Engineering

Credits: 4 (lab Hrs: 120) **Marks: 100**
Duration of exam: 4 Hrs.

Course Outcomes (COs): At the completion of this course, students will be able to:	
CO1	Isolate and quantify DNA and RNA samples
CO2	Carry out gene cloning experiments using plasmid vector and selection of transformed bacterial cell
CO3	Carry out PCR experimentation using different types of primers
CO4	Study gene expression study using RT-PCR and will be able to plant any project in genetic engineering

1. General Laboratory-safety and Bio-safety measures in genetic engineering laboratory
2. Introduction to various instruments, along with their working principles, used in genetic engineering experiments.
3. Isolation & quantitation of RNA
4. Isolation of plasmid DNA and quantification.
5. Restriction enzyme digestion and restriction mapping of DNA samples
6. Ligation of digested samples of DNA
7. Cloning in plasmid vectors.
8. Transformation of bacterial cells
9. Selection of recombinant cells
10. Preparation of single stranded DNA template
11. Demonstration of DNA sequencing
12. Polymerase Chain Reaction (PCR) using RAPD primers
13. Reverse Transcriptase- Polymerase Chain Reaction (RT-PCR) experiment
14. Demonstration of Southern blotting
15. Design of a project outline involving various experiments of genetic engineering

Suggested Readings:

Text/Reference Books:

1. Benjamin Lewin. Gene X, 10th Edition, Jones and Barlett Publishers 2010.
2. J D Watson et al., Biology of Gene, 6th Edition, Benjamin Cummings, publishers Inc. 2007
3. Alberts et al., Molecular Biology of the Cell, Garland, 2015
4. S B Primrose, R M Twyman, and R W Old. Principles of Gene manipulation. S B University Press, 2001
5. Brown T A. Genomes, Garland Science 2011.
6. J Sambrook and DW Russel, Molecular Cloning: A laboratory Manual Vols1-3. CSHL, 2001.
7. D.M. Glover and B D Hames, DNA cloning, Oxford 1995.

Research/Review Papers:

1. Barros, H. L., Moresco, G., & Stefani, V. (2018). A Simple Protocol for the Isolation, Quantification and Quality Assessment of DNA and RNA. Revista Virtual de Química, 10(5), 1119-1126.
2. Kalendar, R., Boronnikova, S., & Seppänen, M. (2021). Isolation and purification of DNA from complicated biological samples. In Molecular Plant Taxonomy (pp. 57-67). Humana, New York, NY.

On-line Resources:

1. https://projects.nfstc.org/workshops/resources/literature/Extraction/05_The%20Extraction,%20Purification%20and%20Quatification%20of%20DNA.pdf
2. https://library.um.edu.mo/ebooks/b28050393.pdf
3. https://www.csus.edu/indiv/r/rogersa/bio181/seqsanger.pdf

CO-PO-PSO Matrix of MSc/BT/2/CC12												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	2	2	2	2	3	2	3	2	2	2
CO2	3	2	2	2	2	2	3	2	3	2	2	2
CO3	3	2	2	2	2	2	3	2	3	2	2	2
CO4	3	2	2	2	2	2	3	2	3	2	2	2
Average	**3**	**2**	**2**	**2**	**2**	**2**	**3**	**2**	**3**	**2**	**2**	**2**

M.Sc. Biotechnology-2st Semester
MSc/BT/2/SEC4– Lab Quality Control Chemist-Microbiology-II

Credits: 4 (Lab Hrs.120) **Marks: 100**
Duration of exam: 4 hrs.

Objective: The objective of the course is to make the students well versed in practical techniques involved in microbiological experimentation as well as methods involved in experimentation of Quality Control Chemist-Microbiology.

Course outcomes (COs): At the end of the course, the students will be:	
CO1	Well acquainted with basic instrumentation used in Microbiology laboratory
CO2	Able to carry out experimentations involved in preparation of culture media as well as for isolation and characterization of microbes
CO3	Able to perform routine analysis in lab in line with good manufacturing practices (GMP) and good laboratory practices (GLP)
CO4	Well acquainted with procedures involved in workplace cleanliness and well versed with information technology skills

(The contents of this course are based on Model Curriculum of Quality Control Chemist-Microbiology, developed and provided by LSSSDC. The same is attached at annexure I)

1. Practicals pertaining to Module 6 of Model Curriculum-Test and analysis of incoming materials (32 hrs.).
2. Practicals pertaining to Module 7 of Model Curriculum- Sample preparation, preservation and storage (32 hrs.).
3. Practicals pertaining to Module 9 of Model Curriculum- Quality checks in quality control (24 hrs.).
4. Practicals pertaining to Module 10 of Model Curriculum- Reporting and documentation (16 hrs.).
5. Practicals pertaining to Module 11 of Model Curriculum- Research for development of new products (16 hrs.).

Suggested Readings:

1. Source and Study material provided by LSSSDC

CO-PO-PSO Matrix of MSc/BT/2/SEC4												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	2	2	2	2	3	2	3	2	2	3
CO2	3	2	2	2	2	2	3	2	3	2	2	3
CO3	3	2	2	2	2	2	3	2	3	2	2	3
CO4	3	2	2	2	2	2	3	2	3	2	2	3
Average	**3**	**2**	**2**	**2**	**2**	**2**	**3**	**2**	**3**	**2**	**2**	**3**

M.Sc. Biotechnology-2nd Semester
MSc/BT/2/SEC5- Lab Quality Control Chemist-Microbiologist-III

Credits: 2 (Lab Hrs. 60) **Marks: 100**
Duration of exam: 3 hrs.

Objective: The objective of the course is to make the students well versed in practical techniques involved in microbiological experimentation as well as methods involved in experimentation of Quality Control Chemist-Microbiology.

Course outcomes (COs): At the end of the course, the students will be:	
CO1	Able to carry out detailed inspection of incoming samples
CO2	Able to carry out coordination with cross functional teams.

(The contents of this course are based on Model Curriculum of Quality Control Chemist-Microbiology, developed and provided by LSSSDC. The same is attached at annexure I)

1. Practicals pertaining to Module 8 of Model Curriculum-Inspection of samples (55 hrs.)

2. Practicals pertaining to Module 12 of Model Curriculum-Coordination with cross functional teams (5 hrs.).

Suggested readings:

1. Study and Source material provided by LSSSDC

CO, PO, PSO matrix of MSc/BT/2/SEC5												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	2	1	1.5	1	1	2	2	2	1	2
CO2	2	2	2	2	2	2	2	2	3	2	2	2
Average	**2.5**	**2**	**2**	**1.5**	**1.75**	**1.5**	**1.5**	**2**	**2.5**	**2**	**1.5**	**2**

M.Sc. Biotechnology-2nd Semester
MSc/BT/2/SEC6- On Job Training (OJT)

Credits: Non-credit (80 hours) **Marks: 50**

Mode of Exam: Viva-Voce by internal members

Objective: The objective of this course to give an opportunity to the students for real work experience in commercial laboratories or relevant industries

Course outcomes (COs): At the end of the course, the students will be:	
CO1	Trained to work as professional
CO2	Trained to coordinate with the team

1. Perform sample preparation for analysing the samples received in the laboratory, Carry out analysis of incoming materials as per SOPs
2. Carry out regular observations for the tests performed and maintain records in logbooks
3. Assist in research work to support the development of new products
4. Carry out test procedures using correct testing equipment as per SOP
5. Maintain a healthy, safe and secure working environment in line with organizational procedures and policies
6. Ensure workplace cleanliness
7. Coordinate with shift supervisor, cross functional teams and within the team, Follow organizational reporting and documentation procedure

CO, PO, PSO matrix of MSc/BT/2/SEC6												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	2	1	1.5	1	1	2	2	2	1	2
CO2	2	2	2	2	2	2	2	2	3	2	2	2
Average	**2.5**	**2**	**2**	**1.5**	**1.75**	**1.5**	**1.5**	**2**	**2.5**	**2**	**1.5**	**2**

M.Sc. Biotechnology-3rd Semester

MSc/BT/3/CC13 – Cardinal Principles of Academic Integrity and Publications Ethics

Credits: 2 (Lectures: 30) **Marks: 50**
Duration of exam: 2 Hrs. **Theory: 30; IA: 20**

Course outcomes (COs): At the end of the course, the students will know:	
CO1	Academic Integrity, Plagiarism (prevention and detection) and UGC regulations
CO2	Research and Publications ethics and best practices

Note for the paper setter: *The question paper will consist of five questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, four more questions will be set unit-wise comprising of two questions from each of the two units. The candidates are required to attempt two more questions selecting at least one question from each unit.*

Unit I

Academic Integrity: Introduction; academic integrity values- honesty and trust, fairness and respect; responsibility and courage; violations of academic integrity-types and consequences; plagiarism: definition, plagiarism arising out of misrepresentation-contract cheating, collusion, copying and pasting, recycling, avoiding plagiarism through referencing and writing skills; UGC policy for academic integrity and prevention; plagiarism detection tools.

Unit II

Research and Publication ethics: Scientific misconducts; falsifications, fabrication and plagiarism (FPP); publication ethics- definition, introduction and importance; best practices/standard setting initiatives and guidelines-COPE; WAME; violation of publication ethics, authorship and contributor-ship; identification of publications misconduct, complains and appeals; conflicts of interest; predatory publisher and journals.

Suggested Readings:

Text/References Books:

1. MacIntyre A (1967) A short History of Ethics, London
2. Chaddah P (2018) Ethics in Competitive Research: Do not get scooped; do not get plagiarized. ISBN: 978-9387480865
3. National Academy of Sciences, National Academy of Engineering and Institute of Medicine (2009) On being a Scientist: A guide to Responsible Conduct in research: Third Edition. National Academics press.
4. Resnik D. B. (2011) What is ethics in research & why is it important. National Institute of Environmental Health Sciences, 1-10.
5. Beall J (2012). Predatory publishers are corrupting open access, Nature, 489 (7415), 179.
6. Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance (2019). ISBN: 978-81-939482-1-7.

7. UGC regulations (2018) for Promotion of Academic Integrity and Prevention of Plagiarism in Higher Educational Institutes.
8. Ulrike kestler, Academic Integrity, Kwantlen Polytechnic University.

Research/Review Papers:

1. Helgesson, G., Eriksson, S. (2015) Plagiarism in research. *Med Health Care and Philos* 18, 91–101, https://doi.org/10.1007/s11019-014-9583-8
2. Jensen, K. K. (2015). 2 General introduction to Responsible Conduct of Research. *RCR–A Danish textbook for courses in Responsible Conduct of Research*, 5.
3. Sengupta, S., & Honavar, S. G. (2017). Publication ethics. *Indian journal of ophthalmology*, *65*(6), 429. doi: 10.4103/ijo.IJO_483_17
4. Foltýnek, T., et al. (2020). Testing of support tools for plagiarism detection. *International Journal of Educational Technology in Higher Education*, *17*(1), 1-31.

On-line Resources:

1. https://iisc.ac.in/about/student-corner/academic-integrity/
2. https://instr.iastate.libguides.com/predatory
3. https://www.atlantis-press.com/policies/publishing-ethics-and-misconduct
4. https://www.dbuniversity.ac.in/pdfs/Anti_Plagiarism_and_Academic_Integrity_Policy.pdf
5. https://www.usf.edu/graduate-studies/students/academic-integrity-of-students/violations-of-academic-integrity.aspx

CO-PO-PSO Matrix of MSc/BT/3/CC13												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	2	2	2	3	1.5	2	1.5	2	2	1.5	1.5
CO2	1	2	2	1.5	3	2	1.5	2	1.5	1.5	2	1.5
Average	**3**	**2**	**2**	**1.75**	**3**	**1.75**	**1.75**	**1.75**	**1.75**	**1.75**	**1.75**	**1.5**

M.Sc. Biotechnology-3rd Semester
MSc/BT/3/CC14-Microbial Biotechnology

Credits: 2 (Lectures: 30) **Marks: 50**
Duration of exam: 3 Hrs. **Theory: 30; IA: 20**

Objectives: The objective of the course is to create general understanding amongst the students in the subject of microbial biotechnology. This course will take an in-depth look at how microbes and their metabolic pathways and products can be used in biotechnology. The objective of the course is to understand the general overview, concepts and basic principles in the subject of microbial biotechnology with emphasis on how to apply the knowledge in bioprocessing.

Course outcomes (COs): After successful completion of this course, students should be able to:	
CO 1	Evaluate the role of micro-organisms in specific biotechnological processes. Have insight about industrially important microbes, their improvement and designing of industrial strains and process technology for the production of different industrial important products.
CO 2	Attain knowledge about various strategies used for isolation, purification and processing of enzymes along with microbial genomics for industry and metabolic engineering

Note for the paper setter: *The question paper will consist of five questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, four more questions will be set unit-wise comprising of two questions from each of the two units. The candidates are required to attempt two more questions selecting at least one question from each unit.*

Unit – I

Microbial biotechnology: Scope, application and challenges.
Industrially important microbes: Ecological approaches to isolation; screening for new metabolites; test systems; inoculums development of industrially important microorganisms; improvement of industrially important microorganisms; selection of mutants; use of rDNA technology.
Production of microbial products: Process technology for production of wine, beer, enzymes (amylase and protease) and their applications.

Unit – II

Isolation and purification of enzymes: Extraction, preparation, purification and processing of enzymes.
Microbial genomics for Industry: Analysis of microbial genomes and their use for designing; microbial transformations; transformation of steroids; L-ascorbic acid and antibiotics; microbes in paper industry; biohydrometallurgy and biomineralization.
Metabolic engineering: Carotenoid, polyhydroxy-alkanoates and alkaloid biosynthesis; pathway analysis, metabolic control analysis.

Suggested Readings:

Text/References Books:

1. Biotechnology and Genomics. Gupta, P.K. (2010) Rastogi Publications,Meerut, India.
2. Principles of fermentation technology-3rd Edition, Stanbury, P.F.,Whitaker, A. and Hall, S.J.(2016), Elsevier.s
3. Manual of Industrial Microbiology and Biotechnology– third edition. Demain, A. L.and Davies, J.E. (2010) American Society for Microbiology Press, USA.
4. Industrial Microbiology-An introduction. Waites,M.J., Morgan,N.L., Rockey,J.S. and Higton, A.G. (2014) Blackwell Science Ltd. France.
5. Biotechnology–A text book of industrial microbiology (Second Edition) Crueger,W and Crueger, A. (2004) Panima Publishing Corporation, New Delhi.

Research/Review Papers:

1. Singh, R., et al. (2016). Microbial enzymes: industrial progress in 21st century. 3 Biotech, 6 (2), 1-15.
2. Waheed, M., et al. (2021). Biosynthesis of poly (Hydroxyalkanoates). Biological and Clinical Sciences Research Journal, 2021(1), e023-e023.
3. Watling, H. (2016). Microbiological advances in biohydrometallurgy. *Minerals*, *6*(2), 49.
4. Giorgi, V.,et al. (2019). Microbial transformation of cholesterol: reactions and practical aspects—an update. World Journal of Microbiology and Biotechnology, 35(9), 1-15.
5. Mezzomo, N., & Ferreira, S. R. (2016). Carotenoids functionality, sources, and processing by supercritical technology: a review. Journal of Chemistry, 2016.

On-line Resources

1. https://run.edu.ng/directory/oermedia/422231995398.pdf
2. https://www.fpl.fs.fed.us/documnts/pdf1996/kirk96a.pdf
3. https://microbenotes.com/scope-and-applications-of-microbiology/
4. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2447884/

CO, PO, PSO metrics of MSc/BT/3/CC14												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	3	1.5	2	2	3	2	2.5	2
CO2	2	2	1.5	2.5	-	1.5	1.5	2	2	2	2.5	2
Average	**2.5**	**2**	**1.5**	**2.25**	**1.5**	**1.5**	**1.75**	**2**	**2.5**	**2**	**2.5**	**2**

M.Sc. Biotechnology-3rd Semester
MSc/BT/3/CC15- Animal Biotechnology

Credits: 2 (Lectures: 30) **Marks: 50**
Duration of exam: 2 Hrs. **Theory: 30; IA: 20**

Objectives: This course is designed to teach students about the different scientific aspects of animal cell & tissue culture, stem cell technology, cloning and their applications. Also, the students will learn how the cell & tissue culture is established, propagated, characterized and used for welfare.

Course Outcomes (COs): After completion of this course, students will be able to:	
CO1	Apply knowledge of the animal cell culture for maintenance, characterization, development and establishment of an independent animal tissue culture laboratory.
CO2	Learn latest developments and applications of stem cell technology, animal cloning, transgenic animals for the welfare of human being.

Note for the paper setter: *The question paper will consist of five questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, four more questions will be set unit-wise comprising of two questions from each of the two units. The candidates are required to attempt two more questions selecting at least one question from each unit.*

Unit – I

Introduction: History, scope & applications of animal biotechnology.
Animal cell and tissues culture: Historical background, development, advantages and limitations of cell & tissue culture; applications of cell & tissue culture.
Primary Cell Culture and continuous cell lines: Aseptic culture techniques; culture substrates, vessels, equipment; cell culture media, growth supplements, BSS, cell culture reagents, establishment of primary cell culture, disaggregation of tissue & primary culture; characteristics of limited life-span cultures, maintenance of cell culture, establishment and properties of continuous cell lines.
Measuring parameters of growth, **viability and cytotoxicity:** Growth phase, cell counting, cell weight, DNA content, protein, rates of synthesis, growth cycle, pulsating efficiency, labeling index; cell cycle time (generation time); measurement of viability and cytotoxicity.

Unit – II

Gene transfer into Animal Cells: DNA transfer techniques into mammalian cells; Calcium phosphate precipitations; DEAE dextran procedure; microinjection; electroporation.
Stem Cell Technology: Definition and meaning of stem cells & function; adult, embryonic stem cells, hematopoietic, mesenchymal and neural stem cells; therapeutic cloning for embryonic stem cells; ethical issues.
Animal Cloning: Concepts, techniques and recent advancements; applications and ethical issues of animal cloning; Transgenic animals, Designer babies.
Recent advances and applications in animal biotechnology.

Suggested Readings:

Text/Reference Books:

1. Animal Biotechnology edited by Lombard, Sarah (2018) Callisto, USA.
2. Animal Biotechnology edited by Verma, Ashish S & Singh, Anchal (2017) Elesvier
3. Animal Biotechnology: Muray MooYoung (1989) Pergamon Press, Oxford.
4. Animal Cell Biotechnology: Spier, R.E. & Griffiths J.B. (1988) Academic Press.
5. Animal Cell Culture & Technology: Basics from Background to Bench, Butlor M (2004), Taylor & Francis.
6. Animal Cell Culture ED-Tech edited by Carter, Mell & Hunt (2019), Jordan UK
7. Animal Cell Technology: From Biopharmaceuticals to Gene Therapy. Edited By: Castilho, Moraes, Augusto & Butler. Taylor & Francis Press.
8. Animal Physiology and Biochemistry edited by Bradley, Alexis (2018) ETP, UK
9. Culture of Animal Cells: Freshney R.T. (2003), John Wiley & sons, New York.
10. Principles of Gene Manipulations 6th Edition, Primrose S. B., Twyman, R. & Old B. (2002) Blackwell Publishing.
11. Gahlawat, S.K., Duhan, J. S., Salar, R.K., Siwach, P. and Kumar, S. and Kaur, P. 2018. Advances in Animal Biotechnology and its Applications. Springer, Germany. pp. 1-401. ISBN978-981-10-4701-5.
12. Gahlawat, S.K. and Maan, S. 2021. Advances in Animal Disease Diagnosis. CRC Press. ISBN 9780367530518 pp. 1-306.

Research/Review Papers:

1. Yao, T., & Asayama, Y. (2017). Animal-cell culture media: History, characteristics, and current issues. *Reproductive medicine and biology*, *16*(2), 99-117.
2. Aslantürk, Ö. S. (2018). *In vitro cytotoxicity and cell viability assays: principles, advantages, and disadvantages* (Vol. 2, p. 64). InTech.
3. Volarevic, V., et al. (2018). Ethical and safety issues of stem cell-based therapy. *International journal of medical sciences*, *15*(1), 36.
4. Asatrian, G., et al. (2015). Stem cell technology for bone regeneration: current status and potential applications. *Stem cells and cloning: advances and applications*, *8*, 39.
5. Segers, S., et al. (2019). In vitro gametogenesis and the creation of 'designer babies'. *Cambridge Quarterly of Healthcare Ethics*, *28*(3), 499-508.
6. Rodrigues, A. F., Soares, H. R., Guerreiro, M. R., Alves, P. M., & Coroadinha, A. S. (2015). Viral vaccines and their manufacturing cell substrates: New trends and designs in modern vaccinology. Biotechnology journal, 10(9), 1329-1344.

On-line Resources

1. https://www.aboutbioscience.org/topics/animal-biotechnology/
2. ncbi.nlm.nih.gov/pmc/articles/PMC7325846/
3. https://microbeonline.com/continuous-cell-line/
4. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7252021/
5. https://www.nature.com/subjects/animal-biotechnology
6. https://www.nature.com/scitable/topicpage/recombinant-dna-technology-and-transgenic-animals-34513/
7. https://medcraveonline.com/JSRT/hematopoietic-amp-mesenchymal---the-two-lineages-of-bone-marrow-stem-cells.html
8. https://onlinelibrary.wiley.com/doi/10.1002/9780470649367.ch5

CO-PO-PSO matrix of MSc/BT/3/CC15												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**

CO1	3	2	2	2	1	2	2	1.5	3	1.5	2	2
CO2	3	2	2	1.5	1	2	1	2	3	2	2	2
Average	**3**	**2**	**2**	**1.75**	**1.75**	**2**	**1.5**	**1.75**	**3**	**1.5**	**2**	**2**

M.Sc. Biotechnology-3rd Semester
MSc/BT/3/CC16 – Plant Biotechnology

Credits: 2 (Lectures: 30) **Marks: 50**
Duration of exam: 2 Hrs. **Theory: 30; IA: 20**

Course outcomes (COs): At the end of the course, the students will:	
CO1	Understand basic techniques of plant transformation and plant tissue culture
CO2	Know various methods of producing genetically modified crops and their societal implications

Note for the paper setter: *The question paper will consist of five questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, four more questions will be set unit-wise comprising of two questions from each of the two units. The candidates are required to attempt two more questions selecting at least one question from each unit.*

Unit I

Plant Tissue Culture: Introduction, plasticity and totipotency; basic techniques in plant tissue culture, culture types (callus, cell suspension cultures, protoplasts, root culture, shoot tip and meristem culture, embryo culture, microspore culture), plant regeneration-somatic embryogenesis and organogenesis, applications.
Plant Transformation technology: Introduction and historical background of plant biotechnology; design of a typical transgene for plant cells; agrobacterium mediated transformation; binary vectors and co-integrate vector; use of 35S and other promoters; use of reporter genes, methods of nuclear transformation; viral vectors and their applications; direct DNA transfer in plant transformation.

Unit II

Genetically modified (GM) crops: Introduction, genetic manipulation for herbicide tolerance, pest resistance, disease resistance, abiotic stress tolerance; improvement in crop yield and quality; Molecular farming.
GM Crops and society: Public acceptance of GM crops-ethics, concerns and guidelines; regulation of GM crops and products; current status of commercialized GM crops worldwide.

Suggested Readings:

Text/Reference Books:

1. Slater A., Scott N W, Fowler M R (2010), Plant Biotechnology-the genetic manipulation of plants, Oxford Publishing House
2. Gahlawat et al. (2017) Plant Biotechnology: Recent Advancement and Developments, Springer Nature, Germany.
3. Bhojwani S.S. and Rajdan MK (2004) Plant Tissue Culture: Theory and Practice –A revised edition, Reed Elsevier, India, New Delhi.
4. Bhojwari SS (2003) Agrobiotechnology & Plant Tissue Culture.
5. Rajdan MK (2003), Plant Tissue Culture (2nd ed.) IBH Publishing House, New Delhi.

6. Glick BR and Pasternak J.J. (1998), Molecular Biotechnology: Principles and Applications, ASM Press, Washington DC.
7. Chawla H.S. Introduction to Plant Biotechnology (2nd edition), Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

Research/Review Papers:

1. Sharad V. (2015) Herbicides: History, Classification and Genetic Manipulation of Plants for Herbicide Resistance, Sustainable Agriculture Reviews (15), DOI 10.1007/978-3-319-09132-7_3
2. Johannes F. Buyel, (2018) Plant Molecular Farming – Integration and Exploitation of Side Streams to Achieve Sustainable Biomanufacturing (9): 1893. doi: 10.3389/fpls.2018.01893

On-line Resources:

1. https://www.intechopen.com/books/genetic-transformation-in-crops/agrobacterium-mediated-transformation
2. https://youtu.be/dFrx-t5J0PA
3. https://www.researchgate.net/publication/239939334_Plant_regeneration_-_Somatic_embryogenesis
4. http://nepad-abne.net/biotechnology/process-of-developing-genetically-modified-gm-crops/

CO-PO-PSO Matrix of MSc/BT/3/CC16												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	2	1.5	1.5	2	2	2	3	1	2	2
CO2	3	2	2	2	1.5	2	1	1.5	3	2	2	2
Average	**3**	**2**	**2**	**1.75**	**1.5**	**2**	**1.5**	**1.75**	**3**	**1.5**	**2**	**2**

M.Sc. Biotechnology- 3rd Semester
MSc/BT/3/CC17- Immunology

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Objective: The objective of the course is to make the students understand the basic concepts of immunology. Students will gain knowledge of cells and organ of immune system, antigen – antibody interaction, immune system cell regulation, different immunological techniques, disease and health condition.

Course outcomes (COs): At the end of the course, the students will be able to describe:	
CO1	The introductory concept of immunity and cells and organs of immune system
CO2	The nature of antigen and antibody and their interaction and mechanism of MHC
CO3	The Genomic organization of immune cell and its regulation and mechanism of cytotoxicity
CO4	The immunological techniques for detection and identification of disease

Note for the paper setter: *The question paper will consist of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each, selecting at least one question from each unit.*

Unit-I

Introduction: Phylogeny of immune system; innate & acquired immunity; clonal nature of immune system; primary & secondary lymphoid organs.
Cells of Immune System: Haematopoesis & differentiation; B-lymphocytes, T-lymphocytes, macrophages, dendritic cells, natural killer & lymphokine activated killer cells; eosinophils, neutrophils & mast cells; lymphocyte trafficking; humoral & cell mediated immune response.

Unit-II

Immune System: Nature & biology of antigens & superantigens; immunoglobulins-structure & functions of different classes; antigenic determinants (Isotype, Allotype & Idiotype); antigen-antibody interactions; antibody engineering.; MHC, structure of MHC I & II, genomic organization and MHC polymorphism; antigen processing & presentation;.

Unit-III

Regulation of Immune Response: Genomic organization and generation of diversity of B-Cell and T-Cell receptors, B-Cell and T-cell Regulation.
Antibody dependent cell mediated cytotoxicity & macrophage mediated cytotoxicity, cytokines & their role in immune regulation, Complement system

Unit-IV

Immunological Techniques: Immunoprecipitation reactions; agglutination reactions; complement tests; ELISA; RIA; Immunofluorescences.
Immune System in Health & Diseases: Hypersensitive reactions; auto immunity; AIDS and other immunodeficiencies; tumor immunology –tumor antigens; immune response to tumors and tumor evasion of the immune system; cancer immunotherapy.

Text/references books:

1. Immunology, 8thEdition., Goldsby, R.A., Kindt T.J., Osborne B.A. (2012) W.H. Freedom & Comp, NY.
2. Essential of Immunology, 10th Ed. Riott, Ivon, Delves, Peter (2001) Blackwell Scientific Publications, Oxford.
3. Fundamentals of Immunology: Paul W.E. (Eds.) Raven Press, New York.
4. Immunology – A short course – Eli Benzamini, R Coico, G Sunshine (Wiley-Liss).
5. Immunology – An introduction 5th Edition (2013) Tizard I.R. Philadelphia Sauders College Press.
6. Basic Immunology, Sharon J (1998) Williams and Wilkins, Battimore.
   Janeway et al., Immunobiology, 8thEdition, Current Biology publications, 2012.

Research/Review Papers:

1. Buqué, A., & Galluzzi, L. (2018). Modeling tumor immunology and immunotherapy in mice. *Trends in Cancer*, *4*(9), 599-601.
2. Rosenblum, M. D., et al. (2015). Mechanisms of human autoimmunity. *The Journal of clinical investigation*, *125*(6), 2228-2233.
3. Ochoa, M. C., et al. (2017). Antibody-dependent cell cytotoxicity: immunotherapy strategies enhancing effector NK cells. *Immunology and cell biology*, *95*(4), 347-355.
4. Attaf, M., et al. (2015). αβ T cell receptors as predictors of health and disease. *Cellular & molecular immunology*, *12*(4), 391-399.
5. Saeed, A. F.,et al. (2017). Antibody engineering for pursuing a healthier future. *Frontiers in microbiology*, *8*, 495.

On-line Resources:

1. **https://www.ncbi.nlm.nih.gov/pmc/articles/PMC164256/**
2. https://www.ncbi.nlm.nih.gov/books/NBK27156/
3. https://www.ncbi.nlm.nih.gov/books/NBK27092/
4. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC497975/
5. https://www.researchgate.net/publication/320180727_Difference_Between_Humoral_and_Cell_Mediated_Immunity

CO-PO-PSO matrix of MSc/BT/3/CC17												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	1.5	1.5	2	2	3	2	1.5	2
CO2	3	2	1.5	2	1.5	1.5	1.5	2	3	2	1.5	2
CO3	3	2	1.5	2	1	2	1.5	2	3	1.5	2	2
CO4	3	2	1.5	2	2	2	2	2	3	1.5	2	2
Average	**3**	**2**	**1.5**	**2**	**1.5**	**1.75**	**1.75**	**2**	**3**	**1.75**	**1.75**	**2**

M.Sc. Biotechnology- 3rd Semester
MSc/BT/3/DSC1-A-Biophysical Techniques

Credits: 2 (Lectures: 30) **Marks: 50**
Duration of exam: 3 Hrs. **Theory: 30; IA: 20**

Objectives: This Biophysical Technique oriented course covers the various types of forces and interactions, techniques to purify proteins, principle and types of centrifugation, spectroscopy, chromatography and types of electrophoresis and its application. This foundation course will help the students to understand the modes of interaction of biological molecules, principle, methodology and applications of various analytical techniques like Chromatography, Electrophoresis, sand Spectroscopy.

Course Outcomes (COs): Students will be able to:	
CO 1	Understand and analyze the basic concept of biological interactions and centrifugation.
CO 2	Describe basic bioanalytical techniques and their application: HPLC, PFEC, FTIR, UV-VIS spectroscopy, SDS-PAGE etc.

Note for the paper setter: *The question paper will consist of five questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, four more questions will be set unit-wise comprising of two questions from each of the two units. The candidates are required to attempt two more questions selecting at least one question from each unit.*

Unit-I

Interactions in biological systems: Intra and inter-molecular forces; electrostatic interactions and hydrogen bonding; Vander waals and hydrophobic interactions; disulphide bridges; role of water and weak interactions; biophysical techniques to purify and study proteins; dialysis; salting out and precipitation by organic solvents.
Centrifugation: Basic principles, concept of RCF, types of centrifuges (clinical, high speed and ultracentrifuges; preparative centrifugation; differential and density gradient centrifugation; applications (isolation of cell components); analytical centrifugation; sedimentation coefficient; determination of molecular weight by sedimentation velocity and sedimentation equilibrium methods.

Unit-II

Bioanalytical Techniques: Ion exchange, gel filtration, reversed phase and HPLC; circular dichroism spectroscopy; X-ray diffraction; nuclear magnetic resonance; SEM/TEM, UV-Visible spectroscopy techniques; Beer's law - derivation and deviations; FTIR etc.
Electrophoresis: Migration of ions in electric field, Factors affecting electrophoretic mobility; paper electrophoresis, Gel electrophoresis, SDS-PAGE Electrophoresis and applications; Isoelectric focusing; Pulsed-field gel electrophoresis

Suggested Readings:

Text/Reference books:

1. Principles and techniques of Practical Biochemistry, 7th Edition,K.Wilson and J.Walker (2010), Cambridge University Press, Cambridge.
2. BophysicalChemistry: Principle and Techniques, 2nd Edition by A.Upadhyay, K. Upadhyay and N. Nath.(1998)Himalya Publication House.Delhi
3. Rietdorf, J. (2010) Microscopy Techniques, Springer, Berlin
4. Serdyuk, I. N., Zaccai, N. R., Zaccai, J., & Zaccai, G. (2017). *Methods in molecular biophysics*. Cambridge university press.

Research/Review Papers:

1. Garde, S. (2015). Hydrophobic interactions in context. *Nature*, *517*(7534), 277-279.
2. Ohlendieck, K., & Harding, S. E. (2018). Centrifugation and Ultracentrifugation. *Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology*.
3. Nandiyanto, A. B. D., et al. (2019). How to read and interpret FTIR spectroscope of organic material. *Indonesian Journal of Science and Technology*, *4*(1), 97-118.
4. Parizad, E. G., et al. (2016). The application of pulsed field gel electrophoresis in clinical studies. *Journal of clinical and diagnostic research: JCDR*, *10*(1), DE01.

On-line Resources:

1. https://learningcenter.unt.edu/sites/default/files/Transcript%20-%20Molecular%20Forces.pdf
2. https://www.ncbi.nlm.nih.gov/books/NBK21589/
3. https://www.coleparmer.com/tech-article/basics-of-centrifugation
4. https://lab-training.com/hplc/
5. https://ruo.mbl.co.jp/bio/e/support/method/sds-page.html
6. https://www.researchgate.net/publication/337674152_UV-VISIBLE_SPECTROMETRY

CO-PO-PSO Matrix of MSc/BT/3/DSC1-A												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	2	1.5	2	2	3	2	2	2
CO2	3	2	1.5	2	1.5	2	1.5	2	3	2	2	2
Average	**3**	**2**	**1.5**	**2**	**1.75**	**1.75**	**1.75**	**2**	**3**	**2**	**2**	**2**

M.Sc. Biotechnology-3rd Semester
MSc/ BT/3/DSC/1-B. Enzyme Technology

Credits: 2 (Lectures: 30) **Marks: 50**
Time: 3 Hrs. **Theory: 30; IA: 20**

Objectives: This Enzyme-Technology oriented course covers the applications of enzymes; classification of enzymes and their salient features; Strategies for immobilization and engineering of enzymes and how their structure can be modified to make them industrially suitable. This foundation course on Enzyme Technology will help the students to understand the nature, mechanism of action, kinetics, specificity of enzymes.

Course Outcomes (COs): After completion of this course, students will be able to:	
CO 1	Understand and analyze the importance of enzymes, classification, their salient features & categories of enzymes and exhibit the knowledge of enzyme activity-specific activity.
CO 2	Describe what enzymes do and how they do and their regulation in the living system. Exhibit the knowledge of enzyme kinetics along with the importance of enzymes in various sector.

Note for the paper setter: *The question paper will consist of five questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, four more questions will be set unit-wise comprising of two questions from each of the two units. The candidates are required to attempt two more questions selecting at least one question from each unit.*

Unit – I

Introduction, specificity and regulation of enzyme: Historical background; enzyme vs chemical catalyst; enzyme nomenclature and classification; units of enzyme activity; methods for enzyme assays; Holoenzyme, apo-enzyme, prosthetic group, cofactor and coenzymes; substrate and reaction specificity; lock and key hypothesis, induced fit hypothesis, wrong way binding hypothesis and three-point attachment hypothesis; mechanism of action of selected enzyme: chymotrypsin, trypsin, papain, lysozyme and ribonuclease; allosteric enzyme; sequential and symmetry model; covalently regulated enzymes.

Unit – II

Enzyme kinetics, engineering and use: Factor affecting velocity of enzyme catalyzed reaction; Michaelis-Menten hypothesis, transformation of Michaelis-Menten equation and determination of Km and Vmax, Haldane relationship; concept and methods of protein engineering; site directed mutagenesis; active site mapping and nature of active site; identification of functional groups at the active site; immobilized enzymes -methods and applications in food and chemical industries; therapeutic and medicinal uses.

Suggested readings:

1. Palmer, T. & Bonner, P., Enzymes: Biochemistry, Biotechnology and Clinical Chemistry (2nd Ed.). Howood Publishing Chishester, England. 2008.

2. Okotore, R.O. (2015) Essentials of Enzymology Xlibris, USA. 2015.
3. Bisswanger, H., Enzyme Kinetics: Principles and Methods (3rd Ed.). Willey-VCH. 2017.
4. Rocha-Martin, J., Immobilization of Enzymes and Cells: Methods and Protocols, Springer US. 2020.
5. Phillips, J., Fundamentals of Enzymology Ed-Tech Press, United Kingdom. 2019.
6. Marangoni A.G. (2003) Enzyme Kinetics-A Modern Approach.
7. Price N.C and Stevens L. (2014) Fundamental of Enzymology. Oxford University Press, New York.
8. Dixon M and Webb E.C. (1979) Enzyme 3rd edition. Academic Press, New York
9. Uhlig H. (1998) Industrial Enzyme and their Application, Jone Wiley, New York

Research/Review Papers:

1. Teboul, J. L., & Scheeren, T. (2017). Understanding the Haldane effect. *Intensive care medicine*, *43*(1), 91-93.
2. Saqib, S., et al. (2017). Sources of β-galactosidase and its applications in food industry. *3 Biotech*, *7*(1), 79.
3. Khan, M. R. (2021). Current and future role of immobilized enzymes in medical field.
4. Bhatia, S., & Bhatia, S. (2018). Introduction to enzymes and their applications. *Introduction to Pharmaceutical Biotechnology; IOP Publishing Ltd.: Bristol, UK*, *2*.
5. Das, D., & Das, D. (2021). Enzymatic Reaction Kinetics. *Biochemical Engineering: A Laboratory Manual*, 11.

On-line Resources

1. http://egyankosh.ac.in/bitstream/123456789/16231/1/Unit-9.pdf
2. https://www.life.illinois.edu/biochem/455/Lab%20exercises/B-gal/enzymology.pdf
3. https://biolympiads.com/wp-content/uploads/2018/09/Mechanism-of-Enzyme-Action.pd
4. https://www.intechopen.com/books/polymerase-chain-reaction-for-biomedical-applications/site-directed-mutagenesis-by-polymerase-chain-reaction
5. https://www.ncbi.nlm.nih.gov/books/NBK22399/
6. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2373627/s

CO, PO, PSO metrics of MSc/ BT/3/DSC/1-B												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	1	1.5	2	2	2	3	2	2	2
CO2	2	2	2	2	1.5	1.5	1	2	2	2	2	2
Average	**2.5**	**2**	**1.75**	**1.5**	**1.5**	**1.75**	**1.5**	**2**	**2.5**	**2**	**2**	**2**

M.Sc. Biotechnology-3rd Semester
MSc/BT/3/DSC2 –A - Lab Microbial Biotechnology

Credits: 4 (Lab Hrs.120) **Marks: 100**
Duration of exam: (4Hrs.)

Objectives: The objective of this laboratory course is to provide practical skills of the techniques related to fermentation technology and microbial biotechnology.

Course outcomes (COs): Students will be able:	
CO 1	To understand bio-safety measures related to microbial biotechnology techniques.
CO 2	To develop practical skill and acquaint with recent knowledge and techniques in the field of microbial biotechnology. They will be able to understand various biological aspects related to organismal, cellular, biochemical and molecular biological.
CO 3	To analyses and solve various problems related to microbial biotechnology and fermentations. They would be able to launch start-ups and become entrepreneurs for various products and processes.
CO 4	To imbibe the value of team spirit. They will be able to work independently, able to write and manage their research experimentation.

1. General laboratory-safety and bio-safety measures in microbial biotechnology laboratory.
2. Introduction to various instruments and their working principles used in microbial biotechnology.
3. Isolation of industrially important microorganisms for microbial processes.
4. Production of various products in the lab i.e. alcohol and wine.
3. Comparative studies of ethanol production using different substrates.
4. Microbial production of citric acid using *Aspergillus niger*.
5. Microbial production of antibiotics (penicillin) and testing of antimicrobial activity.
6. Isolation of streptomycin resistant mutants.
7. Isolation of U.V. induced auxotrophic mutants.
8. The Ames test: for detecting potential carcinogens.
9. Isolation of rhizobia from root nodules.
10. Production and estimation of alkaline proteases.
11. Production of sauerkraut by fermentation.

Suggested readings:

1. Experiments in Microbiology, Plant Pathology and Biotechnology 5th Edition. Aneja, K.R. (2018) New Age International Publishers, New Delhi.
2. Microbiology a laboratory manual 10th edition. Cappuccino, J. and Sheeman, N. (2016) Addison Wesley, California.
3. Environmental Microbiology– A laboratory manual 3rd Edition. Pepper, I.L.; Gerba, C.P. and Brendecke, J.W. (2015) Academic Press, New York

Research/Review Papers:

1. Zabat, M. A., et al. (2018). Microbial community analysis of sauerkraut fermentation reveals a stable and rapidly established community. *Foods*, *7*(5), 77.
2. Chatterjee, S. (2015). Production and estimation of alkaline protease by immobilized Bacillus licheniformis isolated from poultry farm soil of 24 Parganas and its reusability. *Journal of advanced pharmaceutical technology & research*, *6*(1), 2.
3. Wdowiak-Wróbel, S., et al. (2017). Diversity and plant growth promoting properties of rhizobia isolated from root nodules of Ononis arvensis. *Antonie van Leeuwenhoek*, *110*(8), 1087-1103.

On-line Resources

1. http://legacy.geneticsgsa.org/education/pdf/GSA_DeStasio_Ames_Student_Resources.pdf
2. https://www.researchgate.net/publication/8091547_Isolation_of_Auxotrophic_Mutants_of_Diploid_Industrial_Yeast_Strains_after_UV_Mutagenesis
3. https://www.researchgate.net/publication/258523492_Isolation_and_characterization_of_streptomycin-resistant_mutants_in_Nicotiana_plumbaginifolia
4. https://labmonk.com/fermentation-process-of-alcohol-production

CO, PO, PSO metrics of MSc/BT/3/DSC2-A												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	2	1	1	2	1.5	1	1	1	2	2	1	2
CO2	3	2	2	2	2	1	2	2	3	1.5	1.5	1.5
CO3	3	2.5	2	1.5	1.5	2	2	2	3	2	1.5	2
CO4	2	1.5	1	1.5	2	1	1	1	2	2.5	2	2.5
Average	**2.5**	**1.75**	**1.5**	**1.75**	**1.75**	**1.25**	**1. 5**	**1.5**	**2.5**	**1.75**	**1.5**	**2**

M.Sc. Biotechnology-3rd Semester
MSc/BT/3/DSC2-B-Lab Animal Biotechnology

Credits: 4 (Lab Hrs. 120) **Marks: 100**
Duration of exam: 4 Hrs.

Objectives: The objective of this laboratory course is to provide practical skills of the techniques related to animal biotechnology.

Course Outcomes (COs): After completion of this course, students will be able to:	
CO1	Learn good laboratory practices
CO2	Learn animal tissue culture techniques and handling, preparation of macrophages
CO3	Learn molecular techniques for isolation and amplifications of DNA
CO4	Determine the antimicrobial activity of probiotics and their use

1. General Laboratory-safety and Bio-safety measures in animal biotechnology laboratory
2. Aseptic techniques: elements of aseptic environment, sterile handling
3. Preparation of tissue culture medium & membrane filtration.
4. Sterilizing test of media and serum
5. Preparation of cell suspension culture.
6. Cell counting using haemocytometer.
7. Determination of cell viability
8. Preparation of macrophage from tissue
9. Trypsinization of monolayer & sub culturing
10. Cell disruption using Sonicator
11. Isolation of genomic DNA from blood sample
12. Designing of primer for PCR/ RT-PCR
13. Calculation of Tm of nucleic acid
14. LAMP/ PCR/ RT-PCR
15. Multiplex PCR
16. Determination of antimicrobial activity of probiotics

Suggested Readings:

Text/Reference Books:

1. Al- Rubeai, Mohamed. Animal Cell Culture. Springer, 2015.
2. Alberts et al., Molecular Biology of the Cell, Garland, 2002
3. Animal Cell Culture (1987). FreshneyR.T.IRLPress Oxford,Washington.
4. Animal Cell Culture and Technology: Basics from background to bench. Butlor M (2004).Taylor & Francis.

5. Benjamin Lewin. Gene X, 10th Edition, Jones and Barlett Publishers 2010.
6. Brown T A. Genomes, 3rd Edition, Garland Science 2006.
7. Culture of animal cells (2003).Freshney R.T.JohnWileyandsons,NewYork.
8. DM Glover and B D Hames, DNA cloning, Oxford 1995.
9. Freshney, R. Ian. Culture of Animals Cells, Wiley, 2010.
10. Gahlawat, S. K., Duhan, J. S., Salar, R. K., Siwach, P., Kumar, S., & Kaur, P. (Eds.). (2018). Advances in animal biotechnology and its applications. Springer.
11. J D Watson et al., Biology of Gene, 6th Edition, Benjamin Cummings, publishers Inc. 2007
12. J Sambrook and DW Russel, Molecular Cloning: A laboratory Manual Vols1-3. CSHL, 2001.
13. S B Primrose, R M Twyman, and R W Old. Principles of Gene manipulation. S B University Press, 2001
14. Singh B and Gautam S.K. Textbook of Animal Biotechnology. Teri, 2015.
15. Gahlawat, S.K., Duhan, J. S., Salar, R.K., Siwach, P. and Kumar, S. and Kaur, P. 2018. Advances in Animal Biotechnology and its Applications. Springer, Germany. pp. 1-401. ISBN978-981-10-4701-5
16. Gahlawat, S.K. and Maan, S. 2021. Advances in Animal Disease Diagnosis. CRC Press. ISBN 9780367530518 pp. 1-306.

Research/Review Papers:

1. Riss, T. L., et al. (2016). Cell viability assays. *Assay Guidance Manual [Internet]*.
2. Karimi, S., et al. (2018). The antimicrobial activity of probiotic bacteria Escherichia coli isolated from different natural sources against hemorrhagic E. coli O157: H7. *Electronic physician*, *10*(3), 6548.

On-line Resources

1. https://www.abcam.com/protocols/counting-cells-using-a-haemocytometer
2. https://www.assaygenie.com/blog/sonication-protocol-for-cell-lysis/
3. http://www.premierbiosoft.com/tech_notes/PCR_Primer_Design.html
4. https://www.iitg.ac.in/biotech/MTechLabProtocols/Determination%20of%20Tm%20of%20DNA.pdf
5. https://biocyclopedia.com/index/biotechnology_methods/tissue_culture_techniques/preparation_of_media_for_animal_cell_culture.php

CO-PO-PSO matrix of MSc/BT/3/DSC2-B												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	1.5	2	2	2	3	1.5	2	2
CO2	3	2	1.5	2	1.5	2	1.5	2	3	1.5	2	2
CO3	3	2	1.5	2	2	1.5	1.5	2	3	2	2	2
CO4	3	2	1.5	2.5	2	1.5	2	2	3	2	2	2
Average	**3**	**2**	**1.5**	**2.12**	**1.75**	**1.75**	**1.75**	**2**	**3**	**1.75**	**2**	**2**

M.Sc. Biotechnology-3rd Semester
MSc/BT/3/DSC2-C – Lab Plant Biotechnology

Credits: 4 (lab Hrs: 120) **Marks: 100**
Duration of exam: 4 Hrs.

Objectives: The objective of this laboratory course is to provide practical skills of the techniques related to plant biotechnology.

Course Outcomes (COs): At the completion of this course, students will be able to:	
CO1	Understand the basic design of a typical plant biotechnology laboratory
CO2	Carry out various basic experimentation of plant tissue culture.
CO3	Carry out plant transformation using *agrobacterium*- based vectors.
CO4	Carry out micropropagation and transplantation of *in vitro* regenerated plants.

1. To draw the basic requirements and design for a typical Plant Biotechnology laboratory.
2. To study the various sterilization techniques adopted while carrying out the various plant tissue culture experiments.
3. To prepare stock solutions of Murashige and Skoog's medium and growth regulators.
4. Induction of callus from meristematic and differentiated tissue.
5. Induction of direct organogenesis from various explants on different conditions
6. To induce somatic embryogenesis/organogenesis in the callus cultures obtained in expt. No.5 and to record the effect of different growth hormones in this process.
7. To carry out anther/pollen culture of Datura for production of haploids.
8. To perform the embryo culture of any available plant (*e.g.* wheat, rice, sweet corn, barley *etc.*) and to record the effect of ABA on embryo development *in vitro*.
9. Preparation and maintenance of cell suspension cultures of any available plant (*e.g. Nicotiana tabacum*, carrot etc.) and formation of growth curves.
10. Clonal production of plants through micropropagation and confirmation of genetic stability using molecular markers.
11. To carry out *Agrobacterium*-mediated transformation in plant cells and selection of recombinants using gus assay
12. To carry out transplantation of *in vitro* regenerated plants to pots and field conditions
13. To induce hairy root production in some given plant using wild strain of *Agrobacterium rhizogenes* L.
14. To carry out direct gene transfer method for genetic transformation of plants.
15. To carry out In Planta transformation of plants.

Suggested Readings:
Text/Reference Books:

1. Bhojwani S.S. and Rajdan M.K. (2004), Plant Tissue Culture: Theory and Practice – A revised edition, Reed Elsevier, India, New Delhi.
2. Smith H.R (2000), Plant Tissue Culture: Techniques and Experiments – Secord edition, Academic Press.
3. Purohit S. S. (2006) A Laboratory Manual of Plant Biotechnology – Secord

revised edition, Agrobios (India).
4. Evans D.A. (2003), Plant Cell Culture, Taylor & Francis.

Research/Review Papers:

1. https://arccjournals.com/uploads/Final-attachment-published-R-1597.pdf
2. Hwang, H. H., Yu, M., & Lai, E. M. (2017). Agrobacterium-mediated plant transformation: biology and applications. *The Arabidopsis Book*, *15*.
3. G. Keshavareddy, et al. (2018), Methods of Plant Transformation- A Review *Int. J. Curr. Microbiol. App. Sci.* 7 (7): 2656-2668. DOI: https://doi.org/10.20546/ijcmas.2018.707.312

On-line Resources:

1. https://www.plantcelltechnology.com/pct-blog/preparing-murashigeskoog-media-step-by-step-procedure/
2. https://www.sigmaaldrich.com/IN/en/technical-documents/technical-article/cell-culture-and-cell-culture-analysis/plant-tissue-culture/growth-regulators

CO-PO-PSO Matrix of MSc/BT/3/DSC2-C												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	2	2	1	2	3	2	3	2	2	1.5
CO2	3	2	2	2	1	2	3	2	3	2	2	1.5
CO3	3	2	2	2	1.5	2	3	2	3	2	2	1.5
CO4	3	2	2	2	1.5	2	3	2	3	2	2	1.5
Average	**3**	**2**	**2**	**2**	**1.25**	**2**	**3**	**2**	**3**	**2**	**2**	**1.5**

M.Sc. Biotechnology- 3rd Semester
MSc/BT/3/CC18 – Lab Immunology

Credits: 4 (Lab Hrs.120) **Marks: 100**
Duration of exam: (4 Hrs.)

Objectives: The objectives of this laboratory course are to provide practical skills of the techniques related to identification and purification of cell and diagnostic method in immunology.

Course outcomes (COs): After completion of this Lab. course, students will be able to:	
CO 1	To understand bio-safety measures related to immunological diagnostic techniques.
CO 2	To develop practical skill and acquaint with recent knowledge and techniques in the field of immunology. Learning some of the simpler techniques used in the identification and purification of different cell populations.
CO 3	To differentiate immune diffusion technique, immune electrophoresis and ELISA technique
CO 4	To imbibe the value of team spirit. They will be able to work independently, able to write and manage their research experimentation.

1 General Laboratory-safety and Bio-safety measures in immunology laboratory.
2 Introduction to various instruments and their working principles used in immunology laboratory.
3 Blood film preparation and identification of cells
4 Lymphoid organs and their microscopic organization
5 Preparation and administration of antigens.
6 Isolation and purification of Immunoglobulins.
7 Quantification of immunoglobulins.
8 Immunodiagnostics (demonstration using commercial kits)
9 Immunodiffusion techniques:
a) Ouchterlony double diffusion
b) Radial immunodiffusion.
10 Immunoelectrophoresis:
   a. Counter current Immunoelectrophoresis
   b. Rocket Immunoelectrophoresis.
11 Latex agglutination technique.
12 ELISA technique
   a) Dot ELISA
   b) Sandwich ELISA

Suggested Readings:

Text/Reference Books:

1. A handbook of Practical Immunology (1983). Edited by G.P. Talwar, Vikas Publishing House Pvt. Ltd. New Delhi-110002.
2. Practical Immunology (1980), Hudson L. and Franks, C.H. Blackwell scientific Publication, Oxford.

3. Fundamental techniques in immunology and serology (2002) Singh A. International Book Distributing Co., Lucknow.
4. Current protocols in immunology, (1997), Marjorie, M. John Wiley and sons, Inc. USA.
5. Handbook of experimental immunology (1986). Bewesly, P. Blackwell Scientific publications, London.

Research/Review Papers:

1. Knight, J., & Nigam, Y. (2020). Lymphatic system 1: structure, function and oedema. *Nursing Times*, *116*, 39-43.
2. Wu, M.,et al. (2015). Isolation and purification of immunoglobulin G from bovine colostrums by hydrophobic charge-induction chromatography. *Journal of dairy science*, *98*(5), 2973-2981.
3. Michov, B. (2020). 2.3 Immunoelectrophoresis. In *Electrophoresis* (pp. 164-181). De Gruyter.

On-line Resources:

1. https://labtestsonline.org/tests/immunoglobulins-iga-igg-igm
2. https://microbenotes.com/radial-immunodiffusion/
3. http://tools.thermofisher.com/content/sfs/brochures/TR0065-ELISA-guide.pdf
4. http://www.ispybio.com/search/protocols/LatexAgglutination.pdf

CO-PO-PSO Matrix of MSc/BT/3/CC18												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	2	2	1	2	3	2	3	2	2	1.5
CO2	3	2	2	2	2	2	3	2	3	2	2	1.5
CO3	3	2	2	2	1	2	3	2	3	2	2	1.5
CO4	3	2	2	2	2	2	3	2	3	2	2	1.5
Average	**3**	**2**	**2**	**2**	**1.5**	**2**	**3**	**2**	**3**	**2**	**2**	**1.5**

M.Sc. Biotechnology-3rd Semester
MSc/BT/3/SEC7 – Life Skills and Humanistic Values

Credits: Non-credit (Lectures: 30) **Marks: 50**
Duration of exam: 2 Hrs. **Theory: 30, IA: 20**

Course outcomes (COs): At the end of the course, the students will know:	
CO1	Happiness, Mindfulness and Meditation
CO2	Principles of human behavior and relationships for affectivity and greatness

Note for the paper setter: *The question paper will consist of five questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, four more questions will be set unit-wise comprising of two questions from each of the two units. The candidates are required to attempt two more questions selecting at least one question from each unit.*

Unit I

Happiness and Life: Introduction, self-awareness; mindfulness; non-judgmental acceptance of self and others; self-love; letting-go; self-healing; meditation; the triad for happiness-sustainable happiness through learning and awareness; deeper happiness through harmony in feelings; momentary happiness through the senses.

Unit II

Principles and skills for affectivity and greatness: Seven habits of highly effective persons-be proactive; begin with the end in mind; do first things first; think win/win; seek first to understand then to be understood, synergize, sharpen the saw; whole body paradigm- concept and principles.

Suggested Readings:

Text/Reference Books:

1. Covey S. R. (2004) Seven habits of Highly Effective People, Simon $ Schuster
2. Covey S. R. (2004). The 8th Habit, ISBN: 0-7432-8793-2
3. Nagraj, A. (2015). Philosophy of Human Behaviour, Jeevan Vidya Prakashan, Amarkantak
4. Helliwell, J. F., Huang, H., & Wang, S. (2017). The Social Foundations of World Happiness. World Happiness Report.
5. Helliwell, J., Layard, R., & Sachs, J. (2018). Sustainable Development Solutions Network. World Happiness Report 2018.
6. O'brien, C. (2008). Sustainable happiness: How happiness studies can contribute to a more sustainable future. Canadian Psychology/Psychologie canadienne, 49(4), 289.

Research/Review Papers:

1. Cheung, R. Y., & Ng, M. C. (2019). Mindfulness and symptoms of depression and anxiety: The underlying roles of awareness, acceptance, impulse control, and emotion regulation. *Mindfulness*, *10*(6), 1124-1135.
2. Eckhaus, E., & Sheaffer, Z. (2019). Happiness enrichment and sustainable happiness. *Applied Research in Quality of Life*, *14*(4), 1079-1097.

3. Doorley, J. D., et al. (2020). The momentary benefits of positive events for individuals with elevated social anxiety. *Emotion*.
4. Puszko, K. (2021). Effectivity of Leadership. *European Research Studies*, *24*, 644-663.
5. Bakker, A. B., & Leiter, M. (2017). Strategic and proactive approaches to work engagement. *Organizational Dynamics*, *46*(2), 67-75.
6. Coyne, L. W., et al. (2020). First things first: parent psychological flexibility and self-compassion during COVID-19. *Behavior analysis in practice*, 1-7.

On-line Resources:

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4895748/
2. http://people.tamu.edu/~v-buenger/658/Steven_Covey.html
3. https://blog.hubspot.com/sales/habits-of-highly-effective-people-summary

CO-PO-PSO Matrix of MSc/BT/3/SEC7												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	2	1.5	1.5	2	3	2	1.5	1.5	2	2	3	2
CO2	1.5	2	2	1.5	3	1.5	2	2	1.5	1.5	3	2
Average	**1.75**	**1.75**	**1.75**	**1.75**	**3**	**1.75**	**1.75**	**1.75**	**1.75**	**1.75**	**3**	**2**

M.Sc. Biotechnology-4th Semester
MSc/BT/4/CC19 – Genomics and Proteomics

Credits: 2 (Lectures: 30) **Marks: 50**
Duration of exam: 2 Hrs. **Theory: 30; IA: 20**

Course outcomes (COs): At the end of the course, the students will understand:	
CO1	Advanced fields of genomics and comparative genomics
CO2	Advanced fields of functional genomics and proteomics

Note for the paper setter: *The question paper will consist of five questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, four more questions will be set unit-wise comprising of two questions from each of the two units. The candidates are required to attempt two more questions selecting at least one question from each unit.*

Unit I

Genomics: Human genome project, methodology, outcomes and lessons learnt; genome sequencing projects for microbes, plants and animals; accessing and retrieving genome project information from web; annotation of genome/gene sequence; synthetic genomes- current status and future prospects.
Comparative Genomics: Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing, SNPs; use of genomes to understand evolution of eukaryotes; track emerging diseases and design new drugs; determining gene location in genome sequence.

Unit II

Functional genomics: Transcriptome-introduction, various methods to study global patterns of gene expression analysis and mining functional genes in genomes- microarray, SAGE, RT-PCR.

Proteomics: Proteome-introduction**,** protein-protein and protein-DNA interactions; protein chips and functional proteomics; clinical and biomedical applications of proteomics; introduction to metabolomics.

Suggested Readings:

Text/Reference Books:

1. Brown T. A. Genomes 3 (2007) Garland Science Publishing, New York, USA.
2. Liebler, D. C. (2002). *Introduction to Proteomics: Tools for the New Biology*. Totowa, NJ: Humana Press.
3. Campbell, A. M., & Heyer, L. J. (2003). *Discovering Genomics, Proteomics, and Bioinformatics*. San Francisco: Benjamin Cummings.

Research/Review Papers:

1. Ian Sillitoe., et al. (2015) CATH: comprehensive structural and functional annotations for genome sequences, *Nucleic Acids Research*, 43,(D1), Pages D376–D381, https://doi.org/10.1093/nar/gku947
2. Michael, V. (2019). Human Genome Project (HGP): Nursing Outlook. *International Journal of Nursing Science Practice and Research*, *5*(2), 1-4.
3. Uetz, P., & Pohl, E. (2020). Protein–Protein and Protein–DNA Interactions. *An Introduction to Molecular Biotechnology: Fundamentals, Methods and Applications*.
4. Tan, S. Z., Begley, P., Mullard, G., Hollywood, K. A., & Bishop, P. N. (2016). Introduction to metabolomics and its applications in ophthalmology. *Eye*, *30*(6), 773-783.

On-line Resources:

1. https://www.azolifesciences.com/article/How-are-the-Metabolome-and-Proteome-Related.aspx
2. ncbi.nlm.nih.gov/books/NBK21136/
3. https://youtu.be/SijA4kiEiCQ
4. https://youtu.be/TMxPCgxIdHw
5. http://www.bioinfbook.org/
6. https://www.nature.com/scitable/knowledge/library/comparative-genomics-13239404/

CO-PO-PSO Matrix of MSc/BT/4/CC19												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	2	1.5	1.5	2	2	2	3	1.5	2	2
CO2	3	2	2	2	1.5	2	1	1.5	3	2	2	2
Average	**3**	**2**	**2**	**1.75**	**1.5**	**2**	**1.5**	**1.75**	**3**	**1.75**	**2**	**2**

M.Sc. Biotechnology- 4th Semester
MSc/BT/4/CC20 - Bio-entrepreneurship, Intellectual Property Rights, Biosafety and Bioethics

Credits: 2 (Lectures: 30) **Marks: 50**
Duration of exam: 3 Hrs. **Theory: 30; IA: 20**

Objectives: The objective of the course is to make the students understand concepts of entrepreneurship including identifying a winning business opportunity, intellectual property rights and their implications in biological research and product development, ethical issues, biosafety and risk assessment of products derived from biotechnology.

Course Outcomes (COs): Students will be able to:	
CO 1	Gain entrepreneurial skills, understand different types of intellectual property rights and protection of products derived from biotechnology research.
CO 2	Understand biosafety and bioethical aspects related to biological, biomedical, health care and biotechnology research.

Note for the paper setter: *The question paper will consist of five questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, four more questions will be set unit-wise comprising of two questions from each of the two units. The candidates are required to attempt two more questions selecting at least one question from each unit.*

UNIT- I

Innovation and Entrepreneurship in Bio-business: Introduction and scope in Bio-entrepreneurship; strategy and operations of bio-sector firms; factors shaping opportunities for innovation and entrepreneurship in bio-sectors; business implications of those opportunities, entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make in India etc.).
Intellectual Property Right: Introduction to intellectual property, types of IP, patents, trademarks, copyright rights, industrial design, geographical indications; protection of new GMOs.

UNIT-2

Biosafety: Biosafety and Biosecurity – introduction, historical background, biological safety cabinets, primary containment for biohazards, biosafety levels; GRAS organisms; biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; GMOs & LMOs; National Biosafety policy and laws, Cartagena protocol on biosafety.
Bioethics: Introduction, ethical conflicts in biological sciences - interference with nature; bioethics in research – cloning and stem cell research; human and animal experimentation; animal rights/welfare; agricultural biotechnology-genetically engineered food, environmental risk, labeling and public opinion; sharing benefits and protecting future generations - protection of environment and biodiversity, biopiracy.

Suggested Readings:

Text/Reference books:

1. Adams, D.J. & Sparrow, J.C., Enterprise for Life Scientists: Developing Innovation sand Entrepreneurship in the Biosciences. Bloxham: Scion. 2008.
2. Karhad, P., How to Patent an Idea in India: From Idea to Granted Patent in Quickest Time, Saving Costs and Making Money with Your Patented Invention; A Step by step guideline on Intellectual Property in India. 2018.
3. Chopra, R.K., Indian Patent System. Himalaya Publishing House. 2010.
4. Patzelt, H. & Brenner, T., Handbook of Bioentrepreneurship: 4 (International Handbook Series on Entrepreneurship). Springer. 2010.
5. Shimasaki, C.D. Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier. 2014.
6. Jordan, J.F., Innovation, Commercialization, and Start-Ups in Life Sciences. London: CRC Press. 2014.
7. Veatch, R.M., & Guidry-Grimes, L.K. (2019). The Basics of Bioethics (4th ed.). Routledge. https://doi.org/10.4324/9780429507

Research/Review Papers:

1. VijayRaghavan, K., & Saberwal, G. (2017). Bio-business in brief: the case for ambitious action in the public sector. *Current Science*, 1841-1845.
2. Edoho, F. M. (2016). Entrepreneurship paradigm in the new millennium: A critique of public policy on entrepreneurship. *Journal of Entrepreneurship in Emerging Economies*.
3. Jajpura, L., Singh, B., & Nayak, R. (2017). An introduction to intellectual property rights and their importance in Indian Context.
4. Kumar, S. (2015). Biosafety and biosecurity issues in biotechnology research. *Biosafety*, *4*(01), 153.
5. Zhou, D., et al. (2019). Biosafety and biosecurity. *Journal of Biosafety and Biosecurity*, *1*(1), 15-18.

On-line Resources:

1. https://bbb.rcb.res.in/bio-entrepreneurship/
2. https://www.asiabiotech.com/15/1505/0034_0035.pdf
3. https://www.foodcircle.com/magazine/biopiracy-bioprospecting-definitions-agriculture-examples
4. https://www.eubios.info/Papers/AGBIO.htm
5. https://thegrittifund.com/entrepreneurship-definition/describe-principles-concept-scope-entrepreneurshi

CO-PO-PSO Matrix of MSc/BT/4/CC20												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	2	1.5	1.5	2	2	2	3	1.5	2	2
CO2	3	2	2	2	1.5	2	1	1.5	3	2	2	2
Average	**3**	**2**	**2**	**1.75**	**1.5**	**2**	**1.5**	**1.75**	**3**	**1.75**	**2**	**2**

M.Sc. Biotechnology- 4th Semester
MSc/BT/4/DSC3-A Dissertation

Credits: 4 **Marks: 100**

Mode of Examination: As per guidelines of the University

Objectives: The objective of the course is to make the students capable of hypothesizing and carrying out a research project.

Course outcomes (COs): By the end of the course, the student should be able to:	
CO 1	Hypothesize about any research problem.
CO 2	Carry out exhaustive review of literature.
CO 3	Plan and execute the required experimentation
CO 4	Write and document the entire study in dissertation form

CO, PO, PSO metrics of MSc/BT/4/DSC3-A												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	2	1.5	1.5	2	3	3	2	2
CO2	2	2	1	2	2	1	1.5	2	2	3	2	2
CO3	3	2	1	2	1.5	1.5	2	2	3	3	2	2
CO4	2	2	1.5	2	1.5	1	2	2	2	3	2	2
Average	**2.5**	**2**	**1.25**	**2**	**1.75**	**1.25**	**1.75**	**2**	**2.5**	**3**	**2**	**2**

M.Sc. Biotechnology- 4th Semester
MSc/BT/4/DSC3-B Research-review Project

Mode of Examination: As per guidelines of the University

Objectives: The objective of the course is to make the students capable of hypothesizing and writing about a review project.

Course outcomes (COs): By the end of the course, the student should be able to:	
CO 1	Hypothesize about any research problem.
CO 2	Carry out exhaustive review of literature.
CO 3	Carry out documentation of the work
CO 4	Write the entire study in report form

CO, PO, PSO metrics of MSc/BT/4/DSC3-B												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	1.5	1.5	1.5	2	3	3	2	2
CO2	2	2	1	2	1.5	1	1.5	2	2	3	2	2
CO3	3	2	1	2	2	1.5	2	2	3	3	2	2
CO4	2	2	1.5	2	2	1	2	2	2	3	2	2
Average	**2.5**	**2**	**1.25**	**2**	**1.75**	**1.25**	**1.75**	**2**	**2.5**	**3**	**2**	**2**

M.Sc. Biotechnology- 4th Semester
MSc/BT/4/DSC4-A. Environment Biotechnology

Credits: 4 (Lectures: 60) **Marks: 100**
Time: 3 Hrs. **Theory: 70; IA: 30**

Objectives: The proposed course is designed to teach students, the scientific and engineering principles of microbiological treatment technologies to clean up contaminated environments and to generate valuable resources for the human society. Also, it is desired to make them understand the role of biotechnology in environment for prevention, remediation and monitoring of pollutants.

Course outcomes (COs): By the end of the course, the student should be able to:	
CO 1	Have an overview of the developments in the field of environmental biotechnology with special emphasis on the role of microbes in solid waste management.
CO 2	Describe the role of microbes in liquid waste management, gaining knowledge of various methods employed in waste water treatment.
CO 3	Understand the role of microbes in bioremediation of waste land and degradation of environmental pollutants
CO 4	Understand the application of biotechnology in development of eco-friendly product, processes and also in solving the global environment problems

Note for the paper setter: *The question paper will consist of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each, selecting at least one question from each unit.*

Unit – I

Environment biotechnology: Introduction, issues and scope of environmental biotechnology.
Solid waste: Sources and management (composting, vermicomposting and methane production).

Unit – II

Waste water treatment: Microbiology of waste water treatment; biological processes of industrial effluent treatment; aerobic and anaerobic biological treatments; periodic biological reactor; membrane bioreactor; use of immobilized enzyme and microbial cells.
Pollution: Air pollution and its control through biotechnology; metal pollution and its bio-abatement; bioleaching and biosorption.

Unit – III

Bioremediation: Bioremediation and its type; bioremediation of contaminated soil and wasteland; role of biosensors for detection of pollutants.
Biodegradation of xenobiotic: Xenobiotic compounds and recalcitrance; aerobic vs anaerobic degradation, sequential degradation; bio-oxidation/degradation of phenolic

compounds, pesticides, hydrocarbons and halogenated compounds; microbial treatment of oil spills and treatment of hazardous waste.

Unit – IV

Bioproducts for environmental health: Biopesticides; biofertilizers; bioenergy & fuel and biodegradable plastics.

Global environmental problems: Ozone depletion; greenhouse effect acid rain their impacts and biotechnological approaches for management (a brief account).

Suggested readings:

1. Environmental Biotechnology: Principles and Applications, Second Edition (2020). By Bruce E. Rittman, Perry L. McCarty. Pub. Mc Graw Hills
2. Environmental Biotechnology: Biodegradation, Bioremediation, and Bioconversion of Xenobiotics for Sustainable Development. By Jeyabalan Sangeetha, Devarajan Thangadurai, Muniswamy David, Mohd Azmuddin Abdullah (2016) Pub. Apple Academic Press.
3. Advanced Environmental Biotechnology by Agarwal S.K. (2005), APH Publishing Corp., New Delhi.
4. Microbial Biotechnology; Fundamental of Applied Microbiology by Glazer and Nikaido (2007) WH Freeman & Company, New York.
5. Singh A. and Ward O.P. (2004) Biodegradation and Bioremediation: Soil Biology, Springer.
6. Foster, C.F. and Wase, D.A.J (1987). Environmental Biotechnology. Ellis H. Halsted Press
7. Yadav, P.R. and Tyagi R. (2006) Environmental Biotechnology. Discovery Publishing House, New Delhi.
8. Mohapatra, P.K. (2006). Text Book of Environmental Biotechnology. I.K. International Publishing House Pvt. Ltd .New Delhi.
9. Cheremisinoff, N.P (2003) Biotechnology for Waste and Waste Water Treatment. Prentice Hall Pvt. Ltd. New Delhi.
10. Fulekar M.H. (2014) Environmental Biotechnology. Science Pub.

Research/Review Papers:

1. Vigneswaran, S.,et al. (2016). Sustainable operation of composting in solid waste management. *Procedia Environmental Sciences*, *35*, 408-415.
2. Dadrasnia, A., et al. (2017). Microbial Aspects in Wastewater Treatment–A Technical. *Environmental Pollution and Protection*, *2*(2), 75-84.
3. Bouabidi, Z. B., et al. (2019). Immobilization of microbial cells for the biotreatment of wastewater: a review. *Environmental Chemistry Letters*, *17*(1), 241-257.
4. Azubuike, C. C., et al. (2016). Bioremediation techniques–classification based on site of application: principles, advantages, limitations and prospects. *World Journal of Microbiology and Biotechnology*, *32*(11), 1-18.
5. Nigam, V. K., & Shukla, P. (2015). Enzyme based biosensors for detection of environmental pollutants-a review. *Journal of microbiology and biotechnology*, *25*(11), 1773-1781.

On-line Resources

1. https://studylib.net/doc/7708086/environmental-biotechnology-definition-and-scope
2. https://www.researchgate.net/publication/323830155_Biological_approaches_to_tackle_heavy_metal_pollution_A_survey_of_literature
3. https://www.hindawi.com/journals/btri/2011/941810/
4. https://www.bio-fit.eu/q8/lo1-why-biofertilizers?start=4
5. https://www.greenpeace.org/static/planet4-eastasia-stateless/84075f56-biodegradable-plastics-report.pdf

CO, PO, PSO metrics of MSc/BT/4/DSC4-A												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	1.5	1.5	1.5	2	3	3	1.5	3
CO2	2	2	1	2	1.5	1	1.5	2	2	3	1.5	3
CO3	3	2	1	2	2	1.5	2	2	3	3	1.5	3
CO4	2	2	1.5	2	2	1	2	2	2	3	1.5	3
Average	**2.5**	**2**	**1.25**	**2**	**1.75**	**1.25**	**1.75**	**2**	**2.5**	**3**	**1.5**	**3**

M. Sc. Biotechnology – 4th Semester
MSc/BT/4/DSC4-B-Bioprocess Technology

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Objectives: The objectives of this course are to make students to learn about the fundamental concepts of bioprocess technology and its related applications, thus preparing them to meet the challenges of the new and emerging areas of biotechnology industry.

Course Outcomes (COs): After successful completion of this course, students should be able to:	
CO1	Understand the relevance of microorganisms in biotechnology industry, present unit operations together with the fundamental principles for basic methods in production techniques for bio-based products, analyze kinetics of microbial growth and death, models of fermentation.
CO2	Calculate the yield and production rates in a biological production process and also interpret data, understand fluid mechanics, calculate the need for oxygen and oxygen transfer in cellular systems, give an account of design and operations of various fermenters.
CO3	Identify the scope of downstream processing in biotechnology, learn various techniques for product recovery and purification, critically analyze any bioprocess from market point of view.
CO4	Give an account of important microbial/enzymatic industrial processes in health care food, fuel and pharma industry.

Note for the paper setter: *The question paper will consist of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each, selecting at least one question from each unit.*

Unit – I

History and Basic principles: History and role of bioprocess engineering in biotechnology industries; concept of unit operation and unit processes; fermentation processes and products; isolation, screening and maintenance of industrially important microorganisms; strain improvement for increased yield and other desirable characteristics.
Growth Kinetics and fermentation processes: Microbial growth and death kinetics, analysis of batch, continuous and fed-batch fermentation processes; mixed microbial cultures: major classes, models, mixed cultures in nature; industrial utilization of mixed cultures with examples.

Unit – II

Fluid Mechanics: Principle of microbial nutrition; formulation of culture media; selective media; factors influencing the choice of various carbon and nitrogen sources, vitamins, minerals precursors and antifoam agents; sterilization of gases and nutrient solutions; gas-liquid mass transfer in cellular system, heat transfer, agitation; Newtonian and non-Newtonian fluids.

Bioreactors: Mechanical design of bioreactors; types of bioreactors: stirred tank reactor, air lift fermenter, deep jet fermenter, fed batch reactors, immobilized cell systems; measurement and control of bioprocess parameters.

Unit – III

Downstream processing: Introduction, history and scope of downstream processing in biotechnology; separation of particulates by filtration, centrifugation, settling, sedimentation; decanting and micro filtration primary isolation method including solvent extraction, sorption, precipitation, ultra filtration and reverse osmosis; fractional precipitation; electrophoresis and various kinds of chromatography; drying; crystallization, storage and packaging.

Fermentation economics: Market analysis, equipment and plant costs; recovery costs; water usage and recycling effluent treatment and disposal.

Unit – IV

Industrial production of chemicals: Alcohol (ethanol); acids (citric, acetic and gluconic); solvents (glycerol, acetone, butanol); amino acids (lysine, glutamic acid); single cell protein (Quorn).

Health Care Products: Production of antibiotics (penicillin, streptomycin, tetracycline); recombinant therapeutic peptides and proteins (insulin and interferon).

Suggested Readings:

Text/Reference Books:

1. Bioprocess Engineering – Basic Concepts, second edition, Shuler ML; Kargi F (2002), prentice Hall PTR, New Jersey
2. Biochemical Engineering Fundamentals 2nd Edition (2017) Bailey, H.W. and Ollis, D.F., McGraw Hill Education
3. Bioprocess Engineering: Systems, equipments and facilities. Eds. Lydersen K.B., D'elia, N.A. and Nelson K.L. (1994), John Wiley and Sons, New York.
4. Principles of fermentation technology. Stanbury et al. (2016), Butterworth-Heinemann; 3rd edition.
5. Unit operations of Chemical Engineering 7th ed. McCabe, W.L; Smith J.C. and Harriott P. (2017) McGraw Hill Education, New York.
6. Separation Process Principles, 3rd Edition. Seader, J.D., Henley, E.J. and Roper D.K. (2013) John Willey and Sons, Oxford.
7. Bioseparations Science and Engineering, Harrison R.G.; Todd P.; Rudge S.R. and Petrides D.P. (2006). Oxford University Press.
8. Bioseparation: Downstream Processing for Biotechnology (2011). Belter, P.A., Cussler E.L. and Hu W.S. Wiley India Edition

Research/Review Papers:

1. Forghani, F., et al. (2018). Long-term survival and thermal death kinetics of enterohemorrhagic Escherichia coli serogroups O26, O103, O111, and O157 in wheat flour. *Applied and environmental microbiology*, *84*(13), e00283-18.
2. Mani, A. (2018). Food Preservation by Fermentation and Fermented food products. *International Journal of Academic Research & Development*, *1*, 51-57.

3. Behera, B. K., & Varma, A. (2017). Downstream Processing. In *Microbial Biomass Process Technologies and Management* (pp. 109-214). Springer, Cham.
4. Netzker, T., et al. (2018). Microbial interactions trigger the production of antibiotics. *Current opinion in microbiology*, *45*, 117-123.

On-line Resources

1. http://microbio.du.ac.in/web3/uploads/Microbiology%20Uploads/Reading%20material/MBOE-201%2002.%20strain%20improvement.pdf
2. https://www.researchgate.net/publication/343068647_Fermentation_Economics_and_Future_Prospects
3. https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/single-cell-protein
4. https://www.biologydiscussion.com/biotechnology/bioprocess-technology/bioreactors-types-6-types-of-bioreactors-used-in-bioprocess-technology/10090

CO, PO, PSO metrics of MSc/BT/4/DSC4-B												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	2	1.5	1.5	2	3	2	1.5	3
CO2	2	2	1	2	2	1	1.5	2	2	2	1.5	3
CO3	3	2	1	2	1	1.5	2	2	3	2	1.5	3
CO4	2	2	1.5	2	1	1	2	2	2	2	1.5	3
Average	**2.5**	**2**	**1.25**	**2**	**1.5**	**1.25**	**1.75**	**2**	**2.5**	**2**	**1.5**	**3**

M. Sc. Biotechnology 4th Semester
MSc/BT/4/DSC4-C- Nanobiotechnology

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Objective: The course aims at providing a general and broad introduction to multi-disciplinary field of nanotechnology and its applications.

Course Outcomes (COs): Upon completion of the course student shall be able to:	
CO1	Describe basic science behind the properties of materials at nanometre scale
CO2	the principles behind advanced experimental and computational techniques for studying nanomaterials. .
CO3	Describe synthesis methods of nanomaterials
CO4	biological synthesis of nanocomposite biomaterials for biological applications

Note for the paper setter: *The question paper will consist of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each, selecting at least one question from each unit.*

Unit – I

Introduction to Nanobiotechnology: Introduction to Nanotechnology Nanobiotechnology; Concepts, historical perspective, Insights and intervention into the Nanoworld, Historical Background, Applications of Nanotechnology in different fields- Agriculture, medical applications, Environmental applications, Space, Food processing, consumer durables, textiles, cosmetics etc, Natural nanomaterials: Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures.

Unit – II

Nanomaterials: Nanomaterials- Types, Properties and applications; Synthesis methods- Physical, Chemical and Biological methods of synthesis; Carbon Nanotubes – Synthesis methods and applications; Nanowires- synthesis methods, properties and applications. Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers.

Unit – III

Applications of Nanoparticles: Nanoparticles for diagnostics and imaging (theranostics); implications in cancer therapy, Nanomaterials in Sensing applications, Nanodevices-MEMS & NEMS, Microfluidics and Lab-on-a-chip concept. Carbon nanotubes in healthcare applications. Novel materials for healthcare applications- Graphene, Quantum dots etc.;

Nano-based smart formulations for agriculture applications. Nanonutraceuticals, Polymeric nanocomposites for healthcare and agriculture applications- Nanovesicles; Nanospheres; Nano capsules etc.

Unit – IV

Nano-materials and Nano Toxicity: Nanomaterials for catalysis-Nano biocatalysts, application of nanoscaffolds in synthesis, applications of nanobiocatalysis in the production of drugs and drug intermediates. Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment; Fate of nanomaterials in different strata's of environment; Ecotoxicity models.

Suggested Readings:

Text/Reference Books:

1. GeroDecher, J., & Schlenoff, B., Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials, Wiley-VCH Verlag GmbH & Co. KGaA. 2003.
2. Goodsell, D.S., Bionanotechnology: Lessons from Nature; Wiley-Liss. 2004.
3. Malsch, N.H., Biomedical Nanotechnology, CRC Press. 2005.
4. Hermanson, G.T., Bioconjugate Techniques (3rd Ed.). Elsevier. 2013.
5. Kulkarni, S.K., Nanotechnology- Principles and Practices (3rd Ed.). Capital Publishing Company. 2014.
6. Vajtai, R., Handbook of Nanomaterials, Springer. 2013.
7. Nalwa, H.S., Encyclopedia of Nano Science & Nanotechnology. American Scientific Publishers. 2011.
8. Balzani, V., Credi, A. & Verturi, M., Molecular Devices and Machines- A Journey into Nanoworld. Wiley-VCH Verlag. 2003.
9. Wolfson, J.R., Social and Ethical Issues in Nanotechnology: Lessons from Biotechnology and Other High Technologies. Biotechnology Law Report, **22**, no 4, 376-96. 2003.
10. Bharat, B., Handbook of Nanotechnology. Springer. 2004.

CO-PO-PSO matrix of MSc/BT/4/DSC4-C												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	1	1.5	1.5	2	3	2.5	3	3
CO2	2	2	1	2	1	1	1.5	2	2	2.5	3	3
CO3	3	2	1	2	2	1.5	2	2	3	2.5	3	3
CO4	2	2	1.5	2	2	1	2	2	2	2.5	3	3
Average	**2.5**	**2**	**1.25**	**2**	**1.5**	**1.25**	**1.75**	**2**	**2.5**	**2.5**	**3**	**3**

M.Sc. Biotechnology-4th Semester
MSc/BT/4/DSC5-A. Lab Environment Biotechnology

Credits: 4 (Lab Hrs: 120) **Marks: 100**
Duration of exam: (4 Hrs.)

Objectives: The objective of this laboratory course is to provide practical skills of the techniques related to environment biotechnology.

Course outcomes (COs): At the end of this course, the students will have:	
CO 1	The knowledge and hands on training of techniques used in the field of Environment Biotechnology.
CO 2	Practical knowledge of methods to test the potability of different water Samples
CO 3	Practical understanding of techniques to test various qualitative aspects of diverse water samples.
CO 4	The ability to choose most appropriate technique for testing and degradation of pollutants and to imbibe the value of team spirit while working together in team during practical sessions.

1. Introduction to various instruments and their working principles used in environment biotechnology laboratory.
2. Testing of tap and pond water for its purity to potable by MPN/any other method.
3. Testing of total dissolved solids of water.
4. Testing of dissolved oxygen concentration of water sample.
5. Testing of biological oxygen demand (BOD) of sewage sample.
6. Testing of chemical oxygen demand (COD) of sewage sample.
7. Isolation of xenobiont degrading bacteria by selective enrichment technique.
8. Test for the degradation of aromatic hydrocarbon by bacteria.
9. Effect of sulphur dioxide on crop plants.
10. Estimation of nitrate in drinking water.

Suggested readings:

1. Environmental Microbiology – A laboratory manual, L.L. Gerba, C.P. and Brendeeke. J.W. (1995) Academic Press, New York.
2. Experiments in Microbiology, Plant Pathology and Biotechnology 5th edition Aneja K.R. (2018) New Age International Publisher – New Delhi.
3. Microbiology – A laboratory manual 10th edition. Cappuceino J. and Sheeman N. (2016) Addison Wesley, California.
4. Environmental Microbiology – A laboratory manual. Pepper, I.L.; Gerba, C.P. and Brendecke, J.W. (2015) Academic Press, New York.

Research/Review Papers:

1. Rusydi, A. F. (2018, February). Correlation between conductivity and total dissolved solid in various type of water: A review. In *IOP conference series: earth and environmental science* (Vol. 118, No. 1, p. 012019). IOP Publishing.
2. Alegbeleye, O. O., et al. (2017). Bioremediation of polycyclic aromatic hydrocarbon (PAH) compounds:(acenaphthene and fluorene) in water using indigenous bacterial species isolated from the Diep and Plankenburg rivers, Western Cape, South Africa. *Brazilian journal of microbiology*, *48*, 314-325.

On-line Resources

1. https://serc.carleton.edu/microbelife/research_methods/environ_sampling/oxygen.html
2. https://www.euro.who.int/__data/assets/pdf_file/0016/123091/AQG2ndEd_10effso2.pdf
3. https://archive.epa.gov/water/archive/web/html/vms52.html

CO, PO, PSO metrics of MSc/BT/4/DSC5-A												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	2	2	1	2	2	1	1	2	2	2.5	3	2
CO2	3	2	1	2	2	1	1	2	3	2.5	3	2
CO3	2	2	1.5	2	2	1	2	2	2	2.5	3	2
CO4	3	2	1.5	2	2	2	2	2	3	2.5	3	2
Average	**2.5**	**2**	**1.25**	**2**	**2**	**1.5**	**1.5**	**2**	**2.5**	**2.5**	**3**	**2**

M. Sc. Biotechnology – 4th Semester
MSc/BT/4/DSC5-B-Lab Bioprocess Technology

Credits: 4 (lab Hrs: 120) **Marks: 100**
Duration of exam: 4 Hrs.

Course Outcomes (COs): After completion of this lab course, the students will be able to:	
CO1	Understand the working & handling of various equipments for microbiological work, safety measures and protocols for microbial work
CO2	Investigate, design and conduct experiments, analyze and interpret data, and apply the laboratory skills to solve complex bioprocess technology problems.
CO3	Apply skills and knowledge gained will be useful in solving problems typical of bio industries and research.
CO4	Learn upstream and downstream unit operations typical of fermentation industry.

1. Introduction to various instruments and their working principles used in bioprocess technology laboratory.
2. Study of mechanical design of a bioreactor.
3. Determination of Thermal Death Point (TDP) and Thermal Death Time (TDT) of microorganisms for design of a sterilizer.
4. Isolation of microorganisms from soil samples.
5. Determination of growth curve of a supplied microorganism.
6. Compute specific growth rate (m), growth yield (Yx/s) from the above experiment.
7. Scale up from frozen culture to agar plate to shake flask culture.
8. Determination of substrate degradation profile.
9. Use of alginate for cell immobilization.
10. Purify a bacterial protein
    a) Separation of cells from broth by different methods.
    b) Cell lysis by different methods.
    c) Column purification by molecular weight, charge, metal affinity.
    d) Dialysis.
    e) Solvent extraction.
    f) Crystallization.
    g) Lyophilization

Suggested Readings:

Text/Reference Books:

1. Experiments in Microbiology, Plant Pathology, Tissue Culture and Microbial Biotechnology 5th Edition (2018). Aneja, K.R. New Age International Publishers, New Delhi.
2. Microbiology- a laboratory manual 10th edition (2016). Cappuccino J. and Sheeman N. Pearson education.
3. Environmental Microbiology – A laboratory manual. Pepper, I.L.; Gerba, C.P. and

Brendecke, J.W. (2015) Academic Press, New York.
4. Bioseparation: Downstream Processing for Biotechnology (2011). Belter, P.A., Cussler E.L. and Hu W.S. Wiley India Edition

Research/Review Papers:

1. Wingfield, P. T. (2015). Overview of the purification of recombinant proteins. *Current protocols in protein science*, *80*(1), 6-1.
2. Raveling, A. R., et al. (2018). A 3D printed mechanical bioreactor for investigating mechanobiology and soft tissue mechanics. *MethodsX*, *5*, 924-932.
3. Shehadul Islam, M.,et al. (2017). A review on macroscale and microscale cell lysis methods. *Micromachines*, *8*(3), 83.

On-line Resources

1. https://www.thermofisher.com/in/en/home/life-science/protein-biology/protein-biology-learning-center/protein-biology-resource-library/pierce-protein-methods/dialysis-methods-protein-research.html
2. https://sphinxsai.com/2014/vol6pt5/5/(2925-2928)S-2014.pdf
3. https://user.eng.umd.edu/~nsw/ench485/lab11.htm

CO, PO, PSO metrics of MSc/BT/4/DSC5-B												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	2	2	1	2	2	1	1	2	2	2.5	2	2
CO2	3	2	1	2	2	1	1	2	3	2.5	2	2
CO3	2	2	1.5	2	2	1	2	2	2	2.5	2	2
CO4	3	2	1.5	2	2	2	2	2	3	2.5	2	2
Average	**2.5**	**2**	**1.25**	**2**	**2**	**1.5**	**1.5**	**2**	**2.5**	**2.5**	**2**	**2**

M. Sc. Biotechnology
MSc/BT/9/OEC1- Biotechnology and Human welfare

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Objective: The objective of the course is make the students familiar with basic biotechnology and its role in human welfare.

Note for the paper setter: *The question paper will consist of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each, selecting at least one question from each unit.*

Unit – I

Biotechnology: Introduction, scope, application, social and ethical issues in biotechnology.
Microbial Biotechnology: Introduction to microorganisms (bacteria, fungi, algae and virus), fermented food, SCP, ethanol, vitamins, probiotics and prebiotics.

Unit – II

Environment Biotechnology: Role of biotechnology in waste water treatment and solid waste management, Overview of Bioremediation, Biofertilizers, Biopesticides and Biofuels.

Unit – III

Animal Biotechnology: *In-vitro* fertilization and embryo transfer in humans and livestock, animal cloning and its applications.

Unit – IV

Food Biotechnology: An overview, importance and scope.
Protein engineering its methods, Targets and applications in foods. Impact of Biotechnology on microbial testing of foods-current/traditional methodology and new approaches.

Suggested Readings:

1. http://patentoffice.nic.in
2. Salar et al. (2013) Biotechnology: Prospects and Applications. Springer, Germany.
3. Principles of fermentation technology- 3rd Edition, Stanbury, P.F., Whitaker, A. and Hall, S.J. (2016), Elsevier
4. Biotechnology – A text book of industrial microbiology (Second Edition) Crueger, W and Crueger, A. (2004) Panima Publishing Corporation, New Delhi.
5. Animal Biotechnology: Muray Moo Young (1989) Pergamon Press, Oxford.
6. Yadav, P.R. and Tyagi, R. (2006) Environmental Biotechnology. Discovery Publishing House, New Delhi.
7. Das H.K. (2004), Textbook of Biotechnology, Willey Dreamtech. Pvt. Ltd, New Delhi.
8. Kumar H.D. (2004), A Text Book of Biotechnology, Eastern Willey Press, New Delhi.
9. Gupta P.K. (2010), Biotechnology & Genomics, 5th Reprint, Rastogi Publications Meerut.
10. Singh B.D. (2010), Biotechnology, 4th edition, Kalyani Publication.

M. Sc. Biotechnology

MSc/BT/9/OEC2- Biosafety, Bioethics and Intellectual Property Rights

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Objective: The objective of the course is make the students familiar with ethical issues, biosafety and risk assessment of products derived from biotechnology and regulation of such products and also provide basic knowledge on intellectual property rights and their implications in biological research and product development.

Note for the paper setter: *The question paper will consist of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each, selecting at least one question from each unit.*

Unit – I

Biosafety and risk assessment issues, regulatory framework, National biosafety policies and law, The Cartagena protocol on biosafety, cross border movement of germplasm, risk management issues-containment.

Unit – II

General principles for the laboratory and environmental biosafety, health aspects, toxicology, allergenicity, antibiotic resistance etc. Impact on environment, gene flow in natural and artificial ecologies, source of gene escape, tolerance of target organisms, superweeds.

Unit – III

Ecological aspects of GMOs and impact on biodiversity, monitoring strategies and methods for detecting transgenics, radiation safety and non-radio isotonic procedure, benefits of transgenics to human health, society and the environment

Unit – IV

The WTO and other international agreements, introduction to intellectual property, copyrights, trademarks, trade secrets, patents, geographical indications etc. protection of plant variety and farmers right act, implications of intellectual property rights on the commercialization of biotechnology products.

Suggested Readings:

Text/Reference Books:

1. Singh BD. 2007. *Biotechnology: Expanding Horizon*. Kalyani.
2. Chopra, R.K., Indian Patent System. Himalaya Publishing House. 2010.
3. Ganguli, P., Intellectual Property Rights: Unleashing the Knowledge Economy. New Delhi. 2001.

Research/Review Papers:

1. Ahuja, V. (2018, July). Regulation of emerging gene technologies in India. In BMC proceedings (Vol. 12, No. 8, pp. 5-11). BioMed Central.
2. Wolt, J.D., Keese, P., Raybould, A., Fitzpatrick, J.W., Burachik, M., Gray, A., Wu, F. Problem Formulation in the Environmental Risk Assessment for Genetically Modified Plants. Transgenic Research, 19(3), 425-436. doi:10.1007/s11248-009-9321-9. 2009.
3. Lucht, J. M. (2015). Public acceptance of plant biotechnology and GM crops. Viruses, 7(8), 4254-4281.
4. Shukla, M., Al-Busaidi, K. T., Trivedi, M., & Tiwari, R. K. (2018). Status of research, regulations and challenges for genetically modified crops in India. GM crops & food, 9(4), 173-188.

On-line Resources

1. http://patentoffice.nic.in
2. www.wipo.org
3. www.dbtindia.nic.in
4. http://www.wipo.int
5. http://www.ipindia.nic.in/. 2010.