Programme Brochure

for

MASTER OF SCIENCE

(Biotechnology)

(NEP 2020)

I & II Semester Examination 2025-26

(MSBU CAMPUS)

Maharaja Surajmal Brij University

Bharatpur

(Govt. of Rajasthan)

Department of Biotechnology
Institute of Applied Sciences
Maharaja Surajmal Brij University
Chak Sakeetra, Kumher, Deeg-321201, Rajasthan

(Dr. Archana Singh)

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(Dr. Arvind Kumar)

(Dr. Ashok Sharma)

M.Sc. BIOTECHNOLOGY

(NEP 2020)

Tow-Year Programme

About the Programme

M.Sc. Biotechnology offered by Maharaja Surajmal Brij University, Bharatpur (Raj.) is a four semester (2-year) duration programme with optional exit after completion of two semesters (one-year) with PG diploma in Biotechnology. The programme is teaching, academic research and industry oriented, and structured as per UGC NEP 2020 recommendations following the semester system. Various papers of programme are designed to include classroom teaching lecture, tutorials, practicals, project work, assignments, workshops, conferences participation/presentation and field trips. The overall course structure is designed in such a way to cover all the topics to fulfil need of various competitive exams such as CSIR, DBT, ICAR, ICMR etc. and industry as well. Each paper divided in three categories: Core paper (mandatory), Elective Courses (students have choice to opt anyone of the Elective Courses offered by the Department), and research project in the last semester (student can conduct research work either within the Department/or other Department/Institute/Laboratory/ Faculty of Interdisciplinary and Applied Sciences). The Core Courses are of four credits and include classroom as well as laboratory courses (practicals) with two credit each. A separate research-based course that leads to a dissertation in the fourth semester is also one of the Core Courses (mandatory). The Elective Courses (theory) are also of four credit and include two credit laboratory course (practical). The student is required to accumulate minimum credits in each semester, to fulfill the requirements for a Master of Science degree in Biotechnology.

The lecture rooms are equipped with the advanced interactive board/panels for high tech classes. The departmental laboratory offers student a vibrant in-house facility for learning while doing experiment for better understanding of biological reactions in *in-vitro* and *in-vivo* system. A central instrument facility with sophisticated instrument for advanced scientific-research is in developing phase.

Currently Department of Biotechnology enriched with well qualified faculties, Dr. Arvind Kumar (M.Sc. Biotechnology, Ph.D in Biotechnology., Awards: DSKPDF, NPDF, Research Associate-III, winner CV Raman Prize- 2025) (Assistant Professor & Course Coordinator) and Dr. Alok Sharma (Assistant Professor), and other visiting faculties.

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(Dr. Alok Sharma)

Abbreviations: used in the text are

CW: Class work[#]	VAC: Value Added Course
DSC: Discipline Specific Course	L: Lecture;
DSE: Discipline Specific Elective	T: Tutorial;
EoSE: End of the semester Exam	P: Practical;
ETE: End Term Exam	S: Self Study
MTE: Mid Term Exam	[#]include attendance, assignment, class test/quiz, power point presentation, play learn by fun activities, etc.
DIS: Dissertation/Project	
SEM: Seminar	

Definitions, Eligibility, and Duration of the PG Programme: -

- **Semester:** comprises minimum 17-18 weeks (90 working days) of teaching-learning session. Two consecutive (**One odd and One even**) semester will constitute one academic year. A semester will consist of minimum 90 days of academic work.
- **Credit:** A credit is the number of hours of instruction required per week for the given subject in a given semester of 17-18 weeks. One credit is equivalent to 15 hours of teaching (lecture or tutorial) or 30 hours of practice or field work or community engagement and service per Semester.
- **Credit Hours:** For lecture/Tutorial 1 credit equivalent to 1 hr/week while for practical 1 credit will be equivalent to 1 hr/week.
- **Centric Core Courses:** The centric core courses are those courses whose knowledge is deemed essential for the students registered for a particular programme of study. The core courses shall be mandatory for all the students registered for that particular programme.
- **Exit Option:** Exit option means the option exercised by the students, to leave the Programme at the end of any given Academic year.
- **Elective Courses:** The elective courses can be chosen from a pool of papers. The courses may be-
    - very specific or specialized or advanced or supportive to the discipline/ subject of study or which provide an extended scope
    - Offer an exposure to some other discipline/subject/domain.
    - Be aimed to mature the candidate's proficiency skill and values.

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- **Discipline Specific Elective (DSE) Course**: Elective course offered under the main discipline/subject of study is referred to as Discipline Specific Elective Course. The respective department may offer various DSE courses based on the requirements, scope and need of the programme. The department may also offer discipline related Elective courses of interdisciplinary nature.
- **Major Discipline:** Major discipline is the discipline or subject of main focus and the degree will be awarded in that discipline. Students should secure the prescribed number of credits through core courses in the major discipline. Major discipline means the core subject mandatory for the programme. Major discipline may be a single discipline or interdisciplinary/ multidisciplinary courses. **Example.** M.Sc. (Mathematics) M.A. (History) or M.Com. (Business Administration) etc.
- **Minor Discipline:** Minor discipline means allied or elective subjects to major discipline. Minor Discipline helps a student to gain a broader understanding beyond the major discipline.
- **Multidisciplinary / Interdisciplinary Courses:** The University's undergraduate program includes introductory-level courses that aim to broaden students' intellectual experience and contribute to a liberal arts and science education. These courses are mandatory for all undergraduate students and cover various broad disciplines.

Note: Students are not allowed to choose or repeat courses that they have already taken at the higher secondary level and as major/minor disciplines.

a. **Natural and Physical Sciences:** Students can choose basic courses from disciplines such as Biology, Botany, Zoology, Biotechnology, Biochemistry, Chemistry, Physics, Biophysics, Astronomy and Astrophysics, Earth and Environmental Sciences, and more.

b. **Mathematics, Statistics, and Computer Applications:** These courses provide students with tools and techniques applicable to their major and minor disciplines. The courses may involve training in programming software like Python and applications software like STATA, SPSS, Tally, etc. These courses are beneficial for data analysis and the application of quantitative tools in science and social science.

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c. **Library, Information and Media Sciences:** Courses in this category focus on recent developments in information and media science, including journalism, mass media and communication.

d. **Commerce and Management:** These courses cover areas such as business management, accountancy, finance, financial institutions, fintech and more.

e. **Humanities and Social Sciences:** This category includes courses related to Social Sciences, such as Anthropology, Communication and Media, Economics, History, Linguistics, Political Science, Psychology, Social Work, Sociology, and more.

These courses help students understand individuals, social behaviour, society, and the nation. The humanities courses cover subjects like Archaeology, History, Comparative Literature, Arts & Creative expressions, Creative Writing and Literature, language(s), Philosophy, and interdisciplinary courses. Interdisciplinary subjects like Cognitive Science, Environmental Science, Gender Studies, Global Environment & Health, International Relations, Political Economy and Development, Sustainable Development, Women's and Gender Studies, etc., provide insights into society.

- **Skill Enhancement courses (SEC):** The university offers skill enhancement courses alongside the academic curriculum to emphasize the importance of holistic development and the nurturing of well-rounded individuals. These courses provide students with additional skills and experiences. They include Understanding India, Environmental science/education, Courses in cutting-edge areas, Courses related to Health & Wellness, Yoga education, and engagement in activities. SEC aim to develop student's domain-specific skills, enhance their employability, and foster a spirit of entrepreneurship. The specific courses offered (As approved by the CoC of SEC) may vary from year to year, and students will be notified on the university's website to ensure that they have access to the latest and most relevant knowledge and skills.

- **Massive Open Online Courses (MOOCs):** The students may opt for the online courses offered through India's national Massive Open Online Course (MOOC) platform, viz. Study Web of Active Learning for Young Minds (SWAYAM) or any other online platform approved

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by UGC/regulatory body from time to time up to an extent as prescribed in the curriculum of an academic programme with the approval of the respective Board of Studies. The Departments may identify up to 40% MOOC courses from SWAYAM Portal or any other online platform approved by UGC/regulatory body from time to time for adoption in PG programmes in accordance with relevant UGC Guidelines.

- **Residence Time:** Residence time means the time a student spends for attending classes in the College/Institution (either Online/Offline) as a full-time student and enrolled in any Academic programme of the Institution.
- **Self-study Courses:** The self-study courses, if offered, are optional and not mandatory. Being non-credit courses, the performance of students in these courses shall be indicated either as "satisfactory" or as "unsatisfactory", instead of the Letter Grade and this shall not be counted for the computation of SGPA/CGPA.
- **Summer Term:** A summer term is for 4-6 weeks during summer vacation. Internship/apprenticeship/ work-based vocational education and training can be carried out during the summer term, especially by students who wish to exit after two semesters or four semesters of study. Regular courses may also be offered during the summer on a fast-track mode to enable students to do additional courses or complete backlogs in coursework. The HEIs can decide on the courses to be offered in the summer term depending on the availability of faculty and the number of students. Internships include working with government or private organizations, higher education institutions, universities, research and development labs/research organisations/non-government organisations, enterprises, centres involved in research, innovativeness and entrepreneurship, business organizations, local industry, artists, craftspeople and similar other entities for providing opportunities to students for active engagement in on-site experiential learning.

  The university should encourage faculty in the university and university-recognized research centres to engage PG students in the internship (A maximum 5 PG students/faculty may allow).
- **Vocational Courses (VOC):** A vocational course is focused on practical work, preparing students for a particular skilled profession. Such courses develop capacities for sustenance, work, and economic participation and develop values and sensibilities toward physical work and dignity of labour.

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- **Vocational Studies/Education:** This refers to set of activities for participation in an approved project or practical or lab, practices of application of scientific theories, studio activities involving students in creative artistic activities, workshop-based activities, field-based shopfloor learning, and Community engagement services, etc... (These courses are expected to enable students to incorporate the learned skills in daily life and start up entrepreneurship.)

Eligibility Criteria for Postgraduate Program: -

A student is eligible for a **PG** programme in a discipline corresponding to either Major or Minor(s) discipline in UG programme. University can admit the students in the PG programme based on the student's performance in the UG programme or through an entrance examination.

1. **Educational Qualifications:** To be eligible for admission to the postgraduate program, candidates must fulfil the following criteria:

   a) **Two-year Master programme** with the second year devoted entirely to research for those who have completed the 3-year Bachelor's programme.

   b) **One-year Master's programme** for students completing a 4-year Bachelor's programme (Honours) with/without Research.
2. **Minimum Marks:** Candidates must have obtained the minimum required marks or grades in the qualifying examination as specified by the university and the respective program of study.
3. **Subject Requirements:** Depending on the chosen program, candidates may be required to have studied specific subjects in their qualifying examination.

PG Programmes in Light of NEP 2020

The characteristics of **Post graduate programme** as per UGC regulations are as follows: -

1. There may be a 2-year programme with the second year devoted entirely to research for those who have completed the 3-year Bachelor's programme.
2. For students completing a 4-year Bachelor's programme with Honours/Honours with Research, there could be a 1-year Master's programme; and
3. There may be an integrated 5-year Bachelor's/Master's programme with exit options.
4. There shall be two levels of Master's Programmes namely **level 6** (one-year PG Diploma) and **level 6.5** (One-year Master's degree after 4-year UG degree or a 2-year Master's degree after

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3-year UG degree) according to **National Higher Education Qualifications Framework (NHEQF)**

5. The PG framework shall be in sync with National Credit Framework (NCrF) for the creditization of all learning and assignment, accumulation, storage, transfer & redemption of credits, subject to assessment.

GUIDELINES FOR INTERNAL AND EXTERNAL ASSESSMENT

Internal Assessment Guidelines: -

1. The internal assessment work and the End-Semester examination shall have the weightage of 20% and 80%, respectively. For practical examination also, 80% of the marks will be awarded through an end semester practical exam and remaining 20 % of the marks will consist of continuous assessment to be awarded by concerned faculty member(s) of the department.
2. The medium of instruction and examination shall be mainly English. Regional Language (Hindi) medium may also be offered if feasible. The question paper shall be set in English. Bilingual question paper (s) may be provided, if possible. The students can write their answers in English/Hindi.
3. One credit is equivalent to 25 marks. Thus, four credit theory course equals to 100 marks, of which 20% marks shall be reserved for Internal Assessment [IA= (CA+MTE)] based on internal theory test Mid-Term-Exam (MTE), laboratory work, or continuous assessment (CA) such as oral quizzes, assignment, seminar, paper presentation etc. or any suitable course may be employed. Any student who fails to participate in the Internal Assessment exercises will be debarred from appearing in the end semester examination (EoSE) in the specific course and no Internal Assessment (IA) marks will be awarded. His/her Internal Assessment marks will be awarded in the next applicable semester only. No special classes will be conducted for him/her during other semesters.
4. The IA shall be divided in CA (50%) & MTE (50%)
   CA: Attendances: 5 marks + Assignment work: 5 marks
   MTE: written test of 10 marks.

Note: Continuous assessment will be the sole responsibility of the University/College teacher concerned. Departments/College are advised to keep records of Continuous assessment, Mid-Semester exams answer books, Attendance etc.

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External Examination Guidelines: -

1. Each theory paper at end of the semester shall carry 100 [20 (internal exam) + 80 (external exam)] marks. 40% marks will be the minimum passing marks (in each theory, practical and dissertation/research report) to avail degree or diploma course. The duration of exam shall be 3 hours. Each theory paper shall contain Part A and Part B.
2. Part "A" of theory paper shall contain 08 Short Answer Type Questions of 16 marks based on knowledge, understanding and applications of the topics/ texts covered in the syllabus. Each question will carry one marks for the correct answer.
3. Part "B" of paper will consist of four questions with internal choice (except in case where a different scheme is specified in the syllabus) of 16 marks each. Questions may split in subsections keeping total marks 16.
4. Each Laboratory EoSE will be of four-six hours duration and involve laboratory experiments/exercises.

Arrear exam: Students failing in one or more courses of end semester examinations will be entitled to clear them during the regular semester examinations of courses to be held in subsequent years.

EXAMINATION SCHEME:

MSBU have offered two types of schemes of the examination detail below.

Scheme Type-I: Scheme of the Examination for subjects having **Four credit theory** only:

1 Credit =25 marks for examination/evaluation (Total Marks =100)

- Each theory paper (100 marks) shall consist 20% (20 marks IA [CA+ MTE] and 80% End-Term exam at end of the semester shall carry 100 [20 (internal exam) + 80 (external exam)] marks.

Continuous assessment, in which sessional work and the terminal examination will contribute to the final grade. Each course in Semester Grade Point Average (SGPA) has two components- **Continuous assessment** (20% weightage) and (End of end-semester examination) **EoSE (80% weightage).**

Each Paper of EoSE shall carry 80% of the total marks of the course/subject. The EoSE will be of 3 hours duration.

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Part-A: Part A of the paper shall have short answer type and multiple-choice questions of equal marks. This first question shall be based on knowledge, understanding and applications of the topics/texts covered in the syllabus. There will be 8 questions. Each question carries 2 marks.

Part B: Part B of the paper shall consist of 4 questions with an internal choice of each unit. The two questions will be solved each of the units with internal choice. Second to fifth questions shall be based on applications of the topics/texts covered in the syllabus (60% weightage) and shall involve solving Problems (40% weightage) if applicable. Each question carries 16 marks or subsection with total marks of 16.

Scheme Type-II: Scheme of the Examination for subjects having **Four credit Practicals**:

1 Credit =25 marks for examination/evaluation (Total Marks =100)

Continuous assessment, in which sessional work and the terminal examination will contribute to the final grade. Each course in Semester Grade Point Average (SGPA) has two components- **Continuous assessment** (20% weightage) and (End of end-semester examination) **EoSE (80% weightage).**

Continuous assessment (20% weightage)

Components of internal Practical Evaluation

1. Class work= 10 Marks
2. Practical Record: 10 marks

Each Paper of EoSE shall carry 80% of the total marks of the course/subject. The EoSE will be of 6 hours duration.

END-SEMESTER PRACTICAL EXAMINATION: Maximum marks: 80

Components of External Practical Evaluation

1. Major Question (30-marks)
2. Practical Performance (20 marks)
3. Spotting (10 marks)
4. Practical Record & Viva (10+10 marks)

Programme Structure: (For 2-year PG course with an exit option of 'PG diploma in Biotechnology' after one-year):

The M.Sc. Biotechnology programme is a two-year course divided into four-semesters. The credits required to obtain PG Diploma or PG degree in Biotechnology are shown in below table.

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Semester/year and Exit points

Part	Year	Odd Semester	Even Semester	Exit option	Credits Required
Previous	1st year	Semesters-I	Semesters-II	PG Diploma in Biotechnology	48+4*
Final	2nd year	Semesters-III	Semesters-IV	M.Sc. Biotechnology	96+4*

* Summer internship of 4-6 weeks (04 credits)

Note:

1. A student can exit with PG Diploma in Biotechnology after completing semester I & II (one-year) subject to he/she secured 48 credits and 04 credits of summer internship. (***The student is required to declare in writing his/her choice for exit at Post Graduate Diploma level at least one month earlier to commencement of examination of the 2nd semester on completion of which he/she wants to exit, through respective Head of the Department.***)
2. A student will be eligible for PG degree in Biotechnology on successful completion of all four semesters (Condition: if he/she admitted in the P.G Biotechnology course after 3-year graduation programme) and secured 100 credits.

Rules For "Promoted", "Back Promoted" And "Not Promoted"

In this section detailed rule have been given for Pass; Promoted; Back Promoted and Not Promoted.

For students admitted in the first year:

I. Every student will be promoted from the first semester to the second semester.

II. In the first year the student can earn **48 or 52 credits**.

III. If a student secures a minimum of 48 credits in the first year, he/she will be promoted by the university with the remark "**Promoted**" in the second year. If he/she wants to exit after the first year with a "**Postgraduate Diploma in Discipline/Subject**" then he must secure minimum of 48 credits from the course and 4 credits from the internship.

IV. If the minimum number of credits acquired by the student in the first year is less than 48, then on securing a minimum of 20 credits (From total credits 36 in core subjects) and a minimum of 24 credits (50% of total credits 48) in the first year will be promoted with the remark "Back **Promoted**".

V. In his second year, he can again earn the required credits by appearing in the relevant subjects of the first and second semesters.

VI. Otherwise, the student will be awarded the remark "**Not Promoted**".

VII. In any year the student cannot appear in all the examinations of any one semester of the previous year.

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VIII. The maximum period to complete the first year is three years, and for this, the student must have earned a minimum of 48 credits.

Note:

1. If a student "Not Promoted" has passed all the Continuous Assessments in their courses with at least a D grade (40%), they are not required to take re-admission. The student can directly appear for the due papers in the examinations for that particular semester.
2. However, if a student "Not Promoted" has not cleared one or more Continuous Assessments with a minimum of D grade (40%), they will be required to take re-admission for that specific semester(s).

For students admitted in the Second year:

I. Every student will be automatically promoted from the third semester to the fourth semester.

II. In the second year also, the student can earn 48 or 52 credits.

III. Student with **"Promoted"** remark in the first year

If a student secures a minimum of 48 credits in the second year and 4 credits from the internship are to be earned. He/she will be eligible to receive the title of degree "**Master of <Discipline> in Subject**".

A **Summer Internship of 4 credits is mandatory in the IV Semester** for all the students.

If he/she is not able to secure the minimum credits of 48 in the Second year then-

(a) On securing a minimum of 20 credits (From total credits 36 in core subjects) and a minimum of 24 credits (50% of total credits 48) in the Second year will be promoted with the remark **"Back Promoted"**. In his second year, he can again earn the required credits by appearing in the relevant subjects of the first and second semesters.

IV. (b) Otherwise, the student will be awarded the remark "**Not Promoted**".

A student with the remark "Back Promoted" in the second year if-

Earns the required credits (total 48) of the first year and also the minimum 48 credits of the current year, then he/she will be promoted to the third year with the remark "Promoted".

If he/she wants to exit after the second year with a "**Postgraduate Diploma in Discipline/Subject"** then a minimum of 48 credits from the course and 4 credits from the internship are to be earned.

V. Otherwise, the **Ex-Student** will be there with the remark "**Not Promoted**".

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Note:

1. If a student (**"Not Promoted"**) has passed all the Continuous Assessments in their courses with at least a D grade (40%), they are not required to take re-admission. The student can directly appear for the due papers in the examinations for that particular semester.
2. However, if a student ("**Not Promoted**") has not cleared one or more Continuous Assessments with a minimum of D grade (40%), they will be required to take re-admission for that specific semester(s).

Credit Framework

TWO-YEAR PG DEGREE IN SCIENCE (BIOTECHNOLOGY)

M.Sc. (Semester-I, II, III & IV)

Sl. No	Year	Course Discipline	Course type	Credit details		Total (I+II)
				Sem-I (odd)	Sem-II (Even)	
1.	1st Year (Previous)	Centric Core Paper-I	Major	4	4	8
2.		Centric Core Paper-II	Major	4	4	8
3.		Centric Core **Elective** Paper-III	Major	4	4	8
4.		Centric Core **Elective** Paper-IV	Major	4	-	4
5.		**Practical paper**	Major	4	4	8
6.		Introduction to Research Methodology	Major	-	4	4
7.		Skill Enhancement Course (**SEC**)	Major/Minor	4	-	4
8.		Interdisciplinary Elective Course (**IEC**)	Major/Minor	-	4	4
9.		Summer Internship/workshop (4-6 weeks)	-	-	**4***	**4***
Total Credit (Semester Wise)				**24**	**24**	**48+4***

Sl. No	Year	Course Discipline	Course type	Credits details		Total (III+IV)
				Sem-III (odd)	Sem-IV (Even)	
1.	2nd year (Final)	Centric Core Paper-I	Major	4	4	8
2.		Centric Core Paper-II	Major	4	4	8
3.		Centric Core **Elective** Paper-III	Major	4	-	4
4.		Centric Core **Elective** Paper-IV	Major	4	-	4
5.		**Practical paper**	Major	4	4	8
6.		Skill Enhancement Course (**SEC**)	Major/Minor	4	-	4
7.		Interdisciplinary Elective Course (**IEC**)	Major/Minor	-	4	4
8.		Dissertation/ Fieldwork / Project / Seminar & Term Paper	Major		8	8
Total Credit (Semester Wise)				24	24	48

Total Credit= (48+48+4*=100)

***Internship (04 credits): It must be 4-6 Weeks (120 Hours) During Summer Vacation.**

Credit Framework

ONE-YEAR PG DEGREE IN SCIENCE (BIOTECHNOLOGY)

M.Sc. (Semester-I & II)

Sl. No	Year	Course Discipline	Course type	Credits details		Total (I+II)
				Sem-I (odd)	Sem-II (Even)	
1.	2nd year (Final)	Centric Core paper-I	Major	4	4	8
2.		Centric Core course paper-II	Major	4	4	8
3.		Centric Core **Elective** Paper -III	Major	4	-	4
4.		Centric Core **Elective** Paper -IV	Major	4	-	4
5.		**Practical paper**	Major	4	4	8
6.		Skill Enhancement Course (**SEC**)	Major/Minor	4	-	4
7.		Interdisciplinary Elective Course (**IEC**)	Major/Minor	-	4	4
8.		Summer internship/workshop (4-6 week)	-	**4***	-	**4***
9.		Dissertation/ Fieldwork / Project / Seminar & Term Paper	Major	-	8	8
Total Credit (Semester Wise)				**24**	**24**	**48+4***

Total Credit= (48+4*=52)

***Internship (04 credits): It must be of 4-6 Weeks (120 Hours) during Summer Vacation.**

Abbreviations:

SEC: Skill Enhancement Course (SEC)

IEC: Interdisciplinary Elective Course

L, Lecture; T, tutorial; and P, practical

Note: Student have choice to opt any electives in the given list of papers.

EXAMINATION SCHEME

FOR THEORY PAPER

Maximum Marks: 100 (Internal: 20 & External: 80)

Passing Marks (40%): in internal 08 out of 20 and external 32 out of 80 marks.

Internal Examination: Maximum Marks: 20

- Classwork (assignment/presentation/Attendance): 10 Marks
- Mid-Term Examination for 2.0 Hours duration shall be taken: 10 Marks

External examination (at end of the semester): Maximum Marks: 80.

- ETE Examinations shall be in two sections.
- Section-A: 08 compulsory questions (short one line and/or MCQs). Each of 02 marks.
- Section –B: 04 Questions (long type) with internal choice. Each of 16 Marks

FOR PRACTICAL PAPER &SEC

Maximum Marks: 100: (Internal: 20 & External: 80)

INTERNAL EXAMINATION: Maximum Marks: 20

Components of Internal Evaluation

1. Attendance/Classwork (10)
2. Practical Record (10)

END-SEMESTER PRACTICAL EXAMINATION: Maximum marks: 80

Components of External Evaluation

1. **Part A:** Major Question (30-marks)
   a. Aim – 2
   b. Principle - 5
   c. Materials required – 5
   d. Procedure - 15
   e. Result-3
2. **Part B:** Practical Performance (20)
   a. Performance 10 Marks
   b. Interpretation of result-10 marks
3. **Part C:** Spotting (5 x 2 =10 marks)
   a. Identification -1 mark

b. Description -1 mark

4. **Part D:** (20 Marks)
   a. Practical Record: 10 marks
   b. Viva-voce: 10 Marks

EVALUATION OF WORKSHOP/INTERNSHIP /FIELD WORK

Maximum Marks: 100 (Internal: 20 & External: 80)

INTERNAL EXAMINATION: [Maximum Marks: **20**]

a) Internship Report/Field visit report etc.	10 marks
b) Demo note/Work dairy / etc	10 marks

EXTERNAL EXAMINATION: [Maximum Marks: **80]**

a). Project Report	60 Marks
b) Oral Presentation cum viva	20 Marks

EVALUATION & EXAMINATION FOR RESEARCH PROJECT/WORK

Maximum Marks: 200 [Internal: 40 & External: 160]

INTERNAL EXAMINATION: [Maximum Marks: **40]**

a) Report evaluation.	25 marks
b) Oral presentation etc.	10 Marks
c) Viva	5 marks

EXTERNAL EXAMINATION: [Maximum Marks: **160]**

a) Project Report	130 Marks
b) Oral Presentation	20 Marks
c) Viva-voce	10 Marks

SEMESTER-WISE DETAILS OF M.Sc. BIOTECHNOLOGY COURSE

(First Year; Total Credits: 48)

Semester-I

Sl. No	Course code	Course Title	Course Type	Credit	Contact hours Per week			Weightage (%)			Max Marks
					L	T	P	CW	MTE	ETE	
1.	BTC 101	Advance Cell Biology	Major	4	4	0	0	10	10	80	100
2.	BTC 102	Advance Microbiology	Major	4	4	0	0	10	10	80	100
3.	BTE---	Elective paper-1	Major	4	4	0	0	10	10	80	100
4.	BTE---	Elective paper-2	Major	4	4	0	0	10	10	80	100
5.	SEC 101	Basic Bio-Techniques	Major	4	4	0	0	10	10	80	100
6.	BTP 111	Practical paper (based on core & opted elective paper)	Major	4	0	0	6	10	10	80	100
		Total required credits		**24**							

BTC, Core paper; BTE, Elective paper, SEC: Skill Enhancement Course

Elective papers: Student can opt any **"TWO"** papers from the given elective papers

Semester-II

Sl. No	Course code	Course Title	Course Type	Credit	Contact hours Per week			Weightage (%)			Max Marks
					L	T	P	CW	MTE	ETE	
1.	BTC 201	Molecular Biology	Major	4	4	0	0	10	10	80	100
2.	BTC 202	Biochemistry	Major	4	4	0	0	10	10	80	100
3.	BTC 203	Introduction to Research Methodology	Major	4	4	0	0	10	10	80	100
4.	BTE---	Elective paper-1	Major	4	4	0	0	10	10	80	100
5.	IEC	-	Minor	4	4	0	0	10	10	80	100
6.	BTP 211	Practical paper (based on core & opted elective paper)	Major	4	0	0	6	10	10	80	100
7.		Summer Internship/workshop (4-6 weeks)	-	**4***							
		Total required credits		**24**							

BTC, Core paper; BTE, Elective paper, SEC: Skill Enhancement Course

IEC: Interdisciplinary Elective Course

Elective & IEC papers: Student need to opt **"ONE course"** from the respective categories

Student secured 100 credits shall be eligible for **Postgraduate Degree in Biotechnology**

Total Credit= (48+4*=52)

***Internship (04 credits): It must be of 4-6 Weeks (120 Hours) during Summer Vacation.**

Elective Papers

Specialization clusters

Sl. No.	Course code	Course Title	Semester in which course available
1.	BTE 101	Genetics	I
2.	BTE 102	Bioprocess Engineering	I
3.	BTE 103	Enzyme Technology	I
4.	BTE 201	Industrial Biotechnology & Biosafety	II
5.	BTE 202	Applied Environmental Biotechnology	II

Interdisciplinary Elective Course (IEC)

Sl. No.	Course code	Course Title
1.	IEC 001	Virology
2.	IEC 002	Bioinformatics & Biostatistics
3.	IEC 003	Biodiversity, Ecology & Evolution

Useful links for self-study/certificate courses: -

1. **MOOC** (Massive Open Online Course): are **free or low-cost online courses** from top universities (like Harvard, Stanford) and companies, offering video lectures, assignments, and discussions for anyone to learn new skills for career growth, upskilling, or lifelong learning, with platforms like Coursera, edX, Udacity, with optional paid certificates.
   Web Link: https://www.my-mooc.com/en/

2. **SWAYAM** (Study Webs of Active-Learning for Young Aspiring Minds): is a major initiative by the Government of India's Ministry of Education to provide **free online education.** Learners can access more than **4,000 courses** developed by expert faculty from top Indian institutions like IITs, IIMs, and the UGC at no cost.
   Web Link: https://swayam.gov.in/

Course Wise Content Details for M.Sc. (Biotechnology) Programme

SEMESTER-I

Exam Duration: 03 hours

ADVANCE CELL BIOLOGY			Theory Paper
Paper Code	Course Discipline	Credits	Max. Marks
BTC 101	**Core**	**4**	**100 (IA:20 + EA:80)**

Objectives of the Course:

The course aims to strengthen the practical and theoretical knowledge of cell biology. Each topic will start with basic concepts and end with some recent advances in understanding of the topics covered in each unit. Practice questions will be given from time to time and discussed in class.

Learning Outcomes:

Upon completion of this course, the students will able to:

- Collect data and update the experimental process insistently.
- Assess the procedure and outcomes of an experiment qualitatively and quantitatively.
- Extend the scope of an experiment if or not results are as per expectation.
- Communicate the process and outcomes of an experiment.
- Perform an experiment collaboratively and ethically.

Content: -

UNIT-I (15 hrs): The Dynamics of Cell, Shape and Motility

1. **Cell Structure and Organization:** Structural organization of plant, animal and microbial cells.
2. **Cytoskeleton and Movements:** Cytoskeleton, microtubules, microfilaments and flagellar movements.
3. **Cell Wall and Membranes:** Structure and functions of cell wall, plasma membrane, plasmodesmata; biogenesis, growth models, ion carriers, channels, pumps and receptors.
4. **Cellular Organelles:** Structure and function of micro bodies, Golgi apparatus, ribosomes, lysosomes, endoplasmic reticulum, plant vacuole, chloroplasts and mitochondria and ATP synthase.

UNIT-II (15hrs): Nucleus and Cell Division Mechanisms

1. **Nucleus Structure:** Nuclear envelope, pores, lamina, nucleolus and nuclear matrix.

2. **Chromatin Organization:** Chromosome structure, DNA packaging, nucleosome organization, euchromatin, heterochromatin and specialized chromosomes.
3. **Cell Cycle:** Phases of the cell cycle, control mechanisms, role of cyclins and CDKs.
4. **Mechanics of Cell Division:** Cytokinesis, cell plate formation, events of M-phase, spindle assembly checkpoint from metaphase to anaphase.

UNIT-III (15hrs): Mitosis, Meiosis and Apoptosis

1. **Mitosis Mechanisms:** Roles of cohesins, condensins, microtubules, kinetochore, centrosome and sister chromatid separation.
2. **Meiosis:** Significance, chiasma formation, synaptonemal complex and recombination during meiosis.
3. **Apoptosis Mechanisms:** Molecular basis of programmed cell death.
4. **Apoptosis and Disease:** Apoptosis-inducing factors, cancer and Oncogenesis.

UNIT-IV (15 hrs): Cell Communication and Signal Transduction

1. **Overview of Cell Signaling:** Extracellular signaling, signal molecules and second messengers in signal transduction.
2. **Cell Surface Receptors:** Structure and function of G-protein coupled receptors, ion channel receptors and tyrosine kinase-linked receptors.
3. **Signal Transduction Pathways:** Intracellular signaling cascades.
4. **Two-Component Systems:** Bacterial and plant two-component signaling systems.

Suggested Laboratory Exercises: -

1. EM study of cell organelles.
2. Fluorescence staining with FDA for cell viability.
3. Cell wall staining with Calcofluor
4. Study of stages in cell cycle.
5. Mitosis and Meiosis.
6. Histochemical localization of protein, carbohydrate, fats, starch, lignin, nucleic acids
7. Isolation mitochondria and the activity of its marker enzyme, succinate dehydrogenase (SDH).
8. Karyotype analysis and banding patterns.

9. Polytene, Lampbrush, and B-chromosomes.
10. Preparation of Polytene chromosome from Chironomus larva/Drosophila larva
11. Orcein and Feulgen staining of the salivary gland chromosomes of Chironomus or Drosophila.
12. Any other practical based on theory syllabus.

Suggested Readings:-

1. Krishnamurthy, K. V. (2000). Methods in Cell Wall Cytochemistry. CRC Press, Boca Raton, Florida.
2. Reeve, ECR. (2001). Encyclopedia of Genetics, F. D. Publication, Chicago, USA
3. De, DN. (2000). Plant Cell Vacuoles: An Introduction. CSIRO Publication, Collingwood, Australia.
4. De Robertis, EDP. and De Robertis, E.M,F. (2006) Cell and Molecular Biology, (VIll Edition). Lippincott Williams and Wilkins, Philadelphia.
5. Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. (V Edition). ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
6. Becker, \V.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009), The World of the Cell. (VIJ Edition). Pearson Benjamin Cummings Publishing, San Francisco.
7. Kleinsmith, L.J. and Kish, V.M. (1995). Principles of Cell and Molecular Biology (2nd Edition).Harper Collins College Publishers, New York, USA.
8. Harris, N. and Oparka, K.J. (1994). Plant Cell Biology: A Practical Approach, IRL Press, at Oxford University Press, Oxford, U.K.
9. Gunning, B.E.S. and Steer, M.W. (19960. Plant Cell Biology: Structure and Function. Jones and Bartlett Publishers. Boston, Massachusetts.
10. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wilev & Sons.lnc.
11. Griffiths. A.J.F. et. al.(2000). An introduction to genetic analysis, W.F Freeman and Company, New York. USA.
12. Rana, S.V.S., (2012). Biotechniques, theory and practices (Third edition), Rastogi publications, Meerut.
13. Hall, JL. and Moore, AL. (1983). Isolation of Membranes and Organelles from Plant Cells. Academic Press, London, UK.
14. Roy, S.C. and De, KK. (1999). Cell Biology. New Central Book Agency (P) Ltd. Calcutta.
15. Hartl, D. L. (1994). Genetics. Jones and Bartlett Publishers International, USA.
16. Becker, W.M. Klcinsmith. L.J., Hardin. J. and Bertoni G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco. USA

Exam Duration: 03 hours

ADVANCE MICROBIOLOGY			Theory Paper
Paper Code	Course Discipline	Credits	Max. Marks
BTC 102	**Core**	**4**	**100 (IA:20 + EA:80)**

Objectives:

The major objective of this course is to understand the theoretical knowledge of Microbiology. It will introduce major group of microorganisms as biotechnological tool and will help to understand how biological, molecular or chemical sciences can be used to understand microbes and their applications to address human health, industry and environmental concerns.

Learning Outcomes:

Upon completion of this course, the students will able to:

1. Collect data and update the experimental process insistently.
2. Assess the procedure and outcomes of an experiment qualitatively and quantitatively.
3. Extend the scope of an experiment if or not results are as per expectation.
4. Communicate the process and outcomes of an experiment.
5. Perform an experiment collaboratively and ethically.

Content:

UNIT-I (20 hrs): Introduction to Microbiology

1. **History & Scope of Microbiology:** Discovery of microbial world and contributions of famous microbiologists.
2. **Bacterial taxonomy**: Bacterial nomenclature system, Whittaker's five kingdom system, three domain and eight kingdom system classification; Bergey's system of bacterial classification. Diversity in Bacteria.
3. **Prokaryotic Cell Structure:** Viruses & Mycoplasma, Yeast, Algae, Fungi: General Characteristics. Bacteria (Gram-positive and Gram-negative bacteria).
4. **Archaea:** as earliest life forms (halophiles, methanogens, thermophiles & hyperthermophiles).

UNIT-II (10 hrs): Medically important bacteria and pathogenecity

1. **Medically important bacteria**: Streptococcus, Staphylococcus, Micrococcus, Neisseria, Actinomyces, Clostridium, Vibrios, Aeromonas, Haemophilus, Bordetella, Enterobacteriaceae, Mycobacteria, Spirochetes, Chlamydiae, Rickettsiae.

2. **Bacterial Chemotaxis:** Mechanism and significance of bacterial movement in response to stimuli.
3. **Quorum Sensing:** Concept, role in bacterial communication and pathogenicity.
4. **Biofilm:** A brief Introduction.

UNIT-III (15 hrs): Culturing methods, Microbial Growth and Antimicrobials

1. **Bacterial Culture Techniques:** Types and preparation of media, sterilization methods, pure culture techniques, culture collection, maintenance and preservation.
2. **Microbial Growth:** Definition, growth curve, measurement of growth yield; factors affecting growth.
3. **Antimicrobial Agents:** Sulfa drugs, antibiotics (penicillin, cephalosporin), sources from prokaryotes and eukaryotes.
4. **Mechanism & Resistance:** Mode of action of antibiotics and mechanisms of microbial resistance.

UNIT-IV (15 hrs): Bacterial Genetics and Metabolism

1. **Genetic Recombination:** Transformation, conjugation, transduction; bacterial genetic map with reference to *E. coli.*
2. **Genetic Systems of Eukaryotic Microbes:** Overview of yeast and *Neurospora* genetic systems.
3. **Nutritional Classification:** Chemoautotrophs, chemoheterotrophs and photosynthetic microorganisms.
4. **Microbial Metabolism:** Photosynthesis, chemolithotrophy, nitrate and sulfate reduction, nitrogen metabolism and nitrogen fixation.

Suggested Laboratory Exercises: -

1. Preparation of liquid and solid media for growth of microorganisms.
2. Isolation and maintenance of organisms by plating, streaking and serial dilution methods, slants and stab cultures, storage of microorganisms.
3. Isolation of pure cultures of bacteria from soil and water.
4. Bacterial Growth curve, Measurement of bacterial population by turbidometry and serial dilution methods.
5. Effect of temperature, pH and carbon and nitrogen source on growth.
6. Microscopic examination of bacteria, yeast and molds.

7. Staining techniques to observe bacterial structure: Simple staining, Gram staining, Negative staining, Endospore staining, Capsule staining
8. Study of mutations by Ames test.
9. Biochemical characterization of selected bacterial strains.
10. Isolation and identification of pathogenic fungi from plants.
11. Isolation and identification of non-pathogenic fungi from soil.
12. Raising fungal pure cultures by hyphal tip culture & single spore culture.
13. Microbiological examination of milk: By Methylene-blue dye reduction test.
14. Other practical based on theory syllabus.

Suggested Readings:

1. Pelczar, M.J.Jr., Chan, E.C. S and Kreig, NR (2004) Microbiology (5th Ed). Tata McGraw Hill.
2. Maloy, S.R., Cronan, J. E.Jr. and Freifelder,D.Jones, Microbial Genetics Bartlett Publishers.
3. Benson. H.J. Microbiological, Applications, (A Laboratory Manual in General Microbiology). WCG;WmC. Brown Publishers,
4. Purohit,SS. Microbiology: Fundamentals and Applications Published by Agrobios, India.
5. Salle. AJ 1999). Fundamental Principles of Bacteriology, (7th ed.) Tata- McGraw Hill
6. Prescott, LM., (2005). Microbiology, (6th ed.) McGraw-Hill.
7. Kathleen Park Talaro & Arthur Talaro (2002) Foundations in Microbiology International edition. McGraw Hill.
8. Alexopoulos CJ, Mims C^A W, and Blackwell M. (1996). *Introductory Mycology*. 4th edition. John and Sons, Inc.
9. Atlas RM. (1997). *Principles of Microbiology*. 2nd edition. WM.T. Brown Publishers.
10. Cappucino J and Sherman N, (2010). *Microbiology. A Laboratory Manual*. 9th edition. Pearson Education limited.
11. Madigan MT, Martinko .YM and Parker J, (2009). Brock Biolov of Microorganisms. 12,th edition, Pearson/Benjamin Cummings.
12. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology, 5th edition. McMillan.
13. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9th edition. Pearson Education.
14. Vashishta BR and Sinha AK. (2008). Fungi. S. Chand and Company Ltd.
15. Black JG. (2008). Microbiology: Principles and Explorations. 7th edition. Prentice Hall
16. Srivastava S and Srivastava PS. (2003). Understanding Bacteria. Kluwer Academic publishers, Dordrecht
17. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9th. edition Pearson Education.
18. Willey JM. EM, and Woolverton CJ. (2008). *Prescott, Harley and Klein 's Microbiology*.

SEMESTER-II

Exam Duration: 03 hours

Molecular Biology			Theory Paper
Paper Code	Course Discipline	Credits	Max. Marks
BTC 201	**Core**	**4**	**100 (IA:20 + EA:80)**

Objectives of the Course:

The course aims to strengthen the practical and theoretical knowledge of Molecular biology. Each topic will start with basic concepts and end with some recent advances in understanding of the topics covered in each unit. Practice questions will be given from time to time and discussed in class.

Learning Outcomes:

Upon completion of this course, the students will able to:

- Collect data and update the experimental process insistently.
- Assess the procedure and outcomes of an experiment qualitatively and quantitatively.
- Extend the scope of an experiment if or not results are as per expectation.
- Communicate the process and outcomes of an experiment.
- Perform an experiment collaboratively and ethically.

Content:

UNIT-I (15 hrs): Genetic Material and DNA Replication

1. **Structure and Organization of Genetic Material:** Structure of DNA and RNA; types of DNA; organization of DNA in prokaryotes, viruses and eukaryotes.
2. **DNA Topology:** Supercoiling, DNA topology and the role of topoisomerases.
3. **Central Dogma:** Concept of information flow from DNA → RNA → Protein.
4. **DNA Replication:** Genome organization, prokaryotic and eukaryotic replication mechanisms, replicon concept, enzymes, origin and replication fork and fidelity of replication.

UNIT-II (15 hrs): Transcription and its Regulation

1. **Transcription Process:** Prokaryotic and eukaryotic transcription; RNA polymerases, transcription factors, and formation of initiation complex.
2. **Transcriptional Regulation:** Regulatory elements, activators, repressors, elongation, termination, attenuation, and anti-termination.

3. **RNA Processing:** RNA editing, capping, tailing, snRNA, snRNPs, spliceosome, introns (Type III), splicing mechanisms, structure and function of mRNA and RNA transport.
4. **Advanced Regulatory Mechanisms:** Signal transduction, gene battery activation, alternative splicing (e.g., Troponin gene) and gene silencing.

UNIT-III (15 hrs): Translation and Protein Modification

1. **Mechanism of Translation:** Prokaryotic and eukaryotic translation; genetic code; structure and function of ribosomal subunits.
2. **Stages of Translation:** Initiation, elongation and termination; role of tRNA and proof-reading mechanisms.
3. **Translational Inhibitors:** Mechanism and examples of compounds affecting translation.
4. **Protein Processing:** Co-translational and post-translational modifications and their biological significance.

UNIT-IV (15 hrs): Regulation of Gene Expression and RNA-based Technologies

1. **Gene Regulation:** Regulation of gene expression in prokaryotes and eukaryotes; operon concept; spatial and temporal regulation; tissue-specific expression.
2. **Protein Localization:** Synthesis of secretory and membrane proteins; intracellular trafficking and receptor-mediated endocytosis.
3. **Antisense Technology:** Molecular mechanism and applications of antisense molecules in gene regulation.
4. **Ribozyme:** Biochemistry and types of ribozymes (hammerhead, hairpin, RNase P, etc.); Ribozyme technology (applications in molecular biology and therapeutics).

Suggested Laboratory Exercises:

1. Preparation of culture medium (LB) for E. coli.
2. Isolation of genomic DNA and its quantificationn
3. Perform DNA amplification by PCR.
4. Isolation of RNA.
5. Demonstration of antibiotic resistance.
6. Metabolic labelling of proteins and immunoprecipitation.
7. Any other practical based on theory syllabus.

Suggested Readings:

1. .Voet, D. and Voet, JG. (2013). Biochemistry (4th cdition), John Wiley & Sons.
2. Segel, Il-I. (1976). Biochemical Calculations (2nd ed.), John wiley& sons inc.
3. Voot, D and Voet, JG. (2004). Biochemistry (4th ed.), J Wiley and Sons.
4. Berg J.M., Iymoczko JL. and Stryer L j 2002), Biochemistry, W.H.freeman
5. Frefilder, D 0. Physical biochemistry, W.H. Freeman & company.
6. Work. TLS. and 'Work, E. (1980). Laboratory Techniques in Biochemistry and Molecular Biology, online version.
7. Rao. CNR. (1999). Understanding Chemistry, Universities press, Hyderabad.
8. Wilson, K, & Goulding, KH. (1986), A Biologrst's Guide to principles and Techniques of practical biochemistry, ELBS Edition.
9. Cooper, TG. (1994), Tools of Biochemistry,
10. Malacinski5 GM. (2005). Essentials of Molecular Biology, Jones and Barllett. publications.
11. Creighton, TE. (1993). Proteins-Structure anc Molecular properties, WH freeman and company.
12. Branden, C. and Tooze, J. (1991). Introduction to protein structure, Garland publishing, New York.
13. Kendrew, J. (1994). Encyclopaedia of Molecular Biology, Blackwell scientific publications, oxford.
14. Cantor, CR. and Schimmel, PR. (1080). Biophysical chemistry, WH Freeman.
15. Marie-Claire Bellissent-Funel (ed.) (1992). Protein Structure by Max Perut Perutz. In: Hydration Processes in Biology: Theoretical and Experimental Approaches.
16. Gelvin. S.B. and Schilperoort, R.A. (eds.) (1994). Plant Molecular Biology Manual. 2nd edition, Kluwer Academic Publishers, Dordrecht. The Netherlands.
17. Glick B.R. and Thompson, J.E. (1993). Methods in Plant Molecular Biology and Biotechnology. CRC Press, Boca Raton, Florida.
18. Glover, D.M. and Hames, BD. (Eds.) (1995). DNA Cloning I: A Practical Approach, Core Techniques, 2nd edition. PAS, I RL Press at Oxford University, Press, Oxford.
19. Shaw, CH. (Ed.) (1988). Plant Molecular Biology: A Practical Approach, IR-L Press, Oxford.
20. Rana, S.V.S., 2012. Biotechniques, theory and practices (Third edition), Rastogi publications, Meerut.
21. Glick, BR. And Pasternak, Jl. (1994). Molecular Biotechnology Principles and Applications of Recombinant DNA. Panima Publishing Corp, New Delhi.
22. Watson, JD, Gilman, Ms, .Witkowski. J and Zollar, M. (1992). Recombinant DNA (Sec. Ed.). Scientific American Books, New York.

Exam Duration: 03 hours

BIOCHEMISTRY			Theory Paper
Paper Code	Course Discipline	Credits	Max. Marks
BTC 202	**Core**	**4**	**100 (IA:20 + EA:80)**

Objectives of the Course:

The course aims to strengthen the practical and theoretical knowledge of Macromolecules and Enzymes. Each topic will start with basic concepts and end with some recent advances in understanding of the topics covered in each unit. Practice questions will be given from time to time and discussed in class.

Learning Outcomes:

Upon completion of this course, the students will able to:

- Collect data and update the experimental process insistently.
- Assess the procedure and outcomes of an experiment qualitatively and quantitatively.
- Extend the scope of an experiment if or not results are as per expectation.
- Communicate the process and outcomes of an experiment.
- Perform an experiment collaboratively and ethically.

Content:

UNIT-I (15 hrs): Amino Acids, Proteins and Nucleotides

1. **Amino Acids:** Structure, function and Classification, physical & chemical properties.
2. **Protein** Structure and Function; Levels of protein structure, protein folding, glycoproteins and lipoproteins-structure and function; Hydrophobic and hydrophilic interactions,
3. Ramachandran plot, protein–protein interactions and protein sequencing methods; biological significance of proteins.
4. Nucleotides: Biosynthesis of purines and pyrimidines through de novo and salvage pathways.

UNIT-II (15 hrs): Biomolecules and Thermodynamics

1. **Carbohydrates:** Classification, reactions, structure and functions.
2. **Lipids:** Classification, structure and biological roles of phospholipids, sphingolipids and cholesterol.
3. **Secondary Metabolites:** Introduction, classification and importance of primary and secondary metabolites.
4. **Thermodynamics:** Basic laws and principles of thermodynamics relevant to biological systems.

UNIT-III (15 hrs): Enzyme Structure and Function

1. **Enzyme:** General feature, Classification; and nomenclature.
2. **Enzyme Structure:** Concept of holoenzyme, coenzyme, apoenzyme, isozymes and prosthetic groups; allosteric enzymes.
3. **Catalytic Role:** Physicochemical and biological properties; role of enzymes as catalysts and substrate specificity.
4. **Mechanism and Regulation:** Mechanism of enzyme action (active site, chemical modification) and regulatory control (Zymogens and Isozymes).

UNIT-IV (15 hrs): Enzyme Kinetics, Regulation and Applications

1. **Kinetics:** Michaelis-Menten equation, determination of *Km.*
2. **Enzyme Inhibition:** Types—irreversible, reversible, competitive, noncompetitive and uncompetitive inhibition.
3. **Catalysis and Immobilization:** Effect of organic solvents, substrate, temperature, pH and inhibitors on enzyme catalysis; enzyme immobilization and applications.
4. **Applications and Industrial Aspects:** Importance of enzymes in biotechnology and industrial enzymology.

Suggested Laboratory Exercises:

1. Separation and Characterization of macromolecules molecular shape and size; molecular weight; by liquid chromatography, electrophoresis and spectroscopy
2. Isolation, purity determination and quantitation of cholesterol.
3. Electrophoresis of proteins.
4. Quantification of proteins and/ or sugars.
5. UV- Visible spectroscopy- absorption spectra.
6. Separation techniques- Centrifugation, Chromatography (Ion exchange-TLC etc.)
7. Electrophoresis of DNA-Linear, circular.
8. Demonstration of HPLC.
9. Enzyme: Purification and Kinetic analysis.
10. Any other practical based on theory syllabus

Suggested Readings:

1. Murray.R.K.Granner.D.K,Mayes.P.A, V.W.HarperBiochemistry.27th ed. McGraw Hill, 2006.
2. Berg.J.M. Tymoczko.J.L, Stryer, L. Biochemžstry. 6 th ed. Freeman, 2006.
3. Nelson.D.L, Cox. M. M. Lehninger's Principle of Biochemistry. 4th ed,Freeman, 2004
4. Biochemistry, Voet and Voet, 2nd edition. 2004.
5. Principles of Biochemistry, Voet, Voet, and Pratt, Fourth addition, 2012.
6. Fundamentals of biochemistry: life at the molecular level,voet, voet, and pratt, 2008.
7. Principles and techniques of biochemistry and molecular biology, wilson and walker, 2010.
8. Adams. R.I., Knowler.J.Leader.D.P. Biochemistry of Nucleic Acids.Cambridge Press, 1998.
9. Dixon &Webb, Enzymes.3rd ed. Longmans, 1979.

Exam Duration: 03 hours

Introduction to Research methodology			Theory Paper
Paper Code	Course Discipline	Credits	Max. Marks
BTC 203	**Core**	**4**	**100 (IA:20 + EA:80)**

Objectives of the Course:

- To learn basic skills of using handling laboratory equipment and photography.
- To learn the basic computer skills and manage statistical data.
- To gain knowledge of scientific writing of research paper and poster

Learning Outcomes:

- Students will be able to learn basic skills of research fields.
- Learn safety measures in handling instruments.
- Learn computer software and data analysis.

Content:

UNIT-I (15 hrs): Basic Concepts of Research

1. **Introduction to Research:** Definition, objectives and types of research—basic, applied and interdisciplinary.
2. **Review of Literature:** Methods of identifying, analyzing and summarizing scholarly and popular sources.
3. **Bibliography and Citations:** Preparation of references and use of appropriate citation styles (APA, MLA, etc.).

4. **Literature Review Writing:** Preparation of a 4–6 page review article based on at least 3 scholarly and 3 popular sources in an area of interest.

UNIT-II (15 hrs): Laboratory Practices and Calculations

1. **Good Laboratory Practices (GLP):** Safe handling of reagents, instruments and adherence to laboratory safety protocols.
2. **Chemical Calculations:** Concepts of molarity, normality, percentage, dilutions and preparation of standard solutions.
3. **Laboratory Techniques:** Proper use of micropipettes and handling of chemical reagents and solutions.
4. **Safety Measures:** Awareness of toxic chemicals and implementation of safety measures for risk prevention.

UNIT-III (15 hrs): Data Analysis, Biostatistics, and Visualization

1. **Data Presentation:** Principles of data organization and suitable formats for effective presentation.
2. **Graphical Representation:** Use of pie charts, bar graphs, line graphs, scatter plots and 3D Microsoft graphics for data visualization.
3. **Biostatistical Methods:** Concepts of population, sample, parameters; measures of central tendency and dispersion; chi-square test for goodness of fit.
4. **Scientific Research Tools:** Introduction to data mining, statistical software and computational tools for scientific analysis.

UNIT-IV (15 hrs): Scientific Writing, Presentation and Ethics

1. **Scientific Communication:** Principles of writing research papers, reports and abstracts; preparation of PowerPoint and poster presentations.
2. **Poster and Seminar Presentation:** Designing effective posters, using visuals, structuring seminars and presenting research findings clearly.
3. **Research Ethics:** Understanding plagiarism, copyright and academic misconduct; maintaining ethical standards in research.
4. **Research Methodology and Reporting:** Defining research problems, stating hypotheses, describing methodology and discussing data interpretation and significance.

Suggested Practicals: -

1. Basic calculations, Reagents preparation, pH meter calibration, preparation of standards etc.
2. Hands on training in Computer application, power-point presentation, data mining.
3. Poster presentation on any recent research topics.
4. Mini Review paper (2-4 pages) writing on topics assigned by faculty member

Suggested Readings: -

1. Scientific Writing and Communication: Papers, Proposals, and Presentations, 1st Edition, by Angelika Hoffman, 02010 Oxfora University Press, ISBN 978-0-19-539005.

2. The Craft of Scientific Presentations: Critical Steps to Success and Critical Errorsto Avoid by Michael Alley, C2013 Springer, ISBN 978-1441982780 3. Bennett. B, 2001.

3. The three P 's of scientific talks: Preparation, practice, and presentation. Society tar Economic Botany Newsletter. 15: 6-9. can be found on-line at: http://wwY&£QLbQt:gg(yeþmasteúuhs-D&p/issues/2001 spring.pdf.

Skill Enhancement Course (SEC)

Exam Duration: 03 hours

Basic Bio-Techniques			Theory Paper
Paper Code	Course Discipline	Credits	Max. Marks
SEC 101	**SEC**	**4**	**100 (IA:20 + EA:80)**

Content:

UNIT-I (15 hrs):

1. Buffers, cell disintegration methods, enzyme assays and controls, detergents
2. Proteins isolation & separation and purification.
3. Principles and applications of UV, Visible spectrophotometer, Raman Spectroscopy, Circular Dichroism and Fluorescence spectroscopy;
4. Principles and applications of Mass Spectrometry, NMR, PMR, ESR and Plasma Emission spectroscopy.

UNIT-II (15 hrs): Principles and Applications

1. Basics of TLC and Paper Chromatography;
2. Concepts of chromatographic separation of macromolecules.
3. Advanced Chromatographic Methods: Gel permeation, Ion exchange, Hydrophobic, Reverse-phase and Affinity chromatography.
4. Basics of HPLC, FPLC and criteria for protein purity.

UNIT-III (15 hrs):

1. **Electrophoretic Techniques:** Principles and applications of Polyacrylamide and Agarose gel electrophoresis;
2. **Advanced Techniques**: Capillary electrophoresis, 2D, Disc, Gradient and Pulsed Field Gel Electrophoresis.
3. **Centrifugation Principles:** Basic concepts, mathematics (RCF and different types of centrifuges—micro, high-speed and ultracentrifuges.
4. **Preparative Applications:** Differential and density gradient centrifugation for cell component isolation; analytical centrifugation principles.

UNIT-IV (15 hrs): Radioactivity and Isotopic Techniques

1. **Fundamentals of Radioactivity:** Principles, instrumentation and techniques.
2. **Detection Techniques:** Principles and working mechanism of scintillation counters, and autoradiography.
3. **Stable Isotope Measurement:** Falling drop method, applications of isotopes in biochemical and metabolic studies.
4. **Radiotracer Techniques and Applications:** Isotope dilution, distribution studies, metabolic tracing and radioimmunoassay.

Suggested Readings:

1. Freifelder D, Physical Biochemistry, Application to Biochemistry and Molecular Biology. 2nd Edition, W.H. Freeman & Company, San Fransisco, 1982.

2. Keith 'Wilson and John Walker, Principles and Techniques of Practical Biochemistrv. 5th Edition. Cambridge University Press. 2000.

3. D. Holme& H. Peck, Analytical Biochemistry, 3rd Edition, Longman, 1998. 4, R. Scopes.

4. Protein Purification - Principles & Practices, 3rd Edition, Springer Verlag, 1994.

5. Selected readings from Methods in Enzymology.

Elective Papers

Exam Duration: 03 hours

Genetics			Theory Paper
Paper Code	Course Discipline	Credits	Max. Marks
BTE 101	**Elective**	**4**	**100 (IA:20 + EA:80)**

Objectives of the Course:

The course aims to strengthen the practical and theoretical knowledge of Genetics. Each topic will start with basic concepts and end with some recent advances in understanding of the topics covered in each unit. Practice questions will be given from time to time and discussed in class.

Learning Outcome:

- Upon completion of this course, the students will able to:
- Get a strong foundation on the basic unit of life and functions of cell.
- Understand genetics and related modern DNA technology for disease diagnostics and therapy.

Content:

UNIT-I (15 hrs): Gene Structure and Expression

1. **Gene Organization:** Genetic fine structure, operon concept, introns and exons, gene family and fine structure analysis in eukaryotes.
2. **Inheritance Patterns:** Mendelian and non-Mendelian inheritance, gene interactions – types and significance.
3. **Extra-Nuclear Inheritance:** Cytoplasmic male sterility, inheritance of mitochondrial and chloroplast genes, Hardy-Weinberg law, gene and genotype frequency.
4. **Sex and Recombination:** Sex determination, sex-linked and sex-limited traits, sex reversal, multiple alleles, blood groups in man and genetic recombination.

UNIT-II (15 hrs): Mutation and DNA Damage

1. **Mutations:** Spontaneous and induced; lethal, conditional, biochemical, base substitution, frame-shift, germline vs. somatic mutations and transposons.
2. **Mutagens:** Physical and chemical mutagens – nature and effects.
3. **DNA Repair Mechanisms:** Direct repair, excision repair, post-replication repair, SOS repair and defects leading to inherited diseases.
4. **Mutagenesis Techniques:** Insertional, site-directed, in vitro mutagenesis, deletion techniques and Ames test for mutagenesis.

UNIT-III (15 hrs): Chromosome Mapping and Structural Variations

1. **Chromosome Mapping:** Linkage maps, mapping with genetic markers, molecular and restriction mapping, genetic vs. physical maps, somatic cell hybrid mapping.
2. **Chromosomal Alterations:** Structural changes – duplication, deficiency, inversion, translocation etc.
3. **Numerical Alterations:** Origin and production of haploids, aneuploid, euploids; autopolyploid and allopolyploids – genome constitution and segregation.
4. **Evolutionary Aspects:** Role of polyploidy and chromosomal changes in evolution of major crop plants.

UNIT-IV (15 hrs): Molecular Cytogenetics and Human Genetics

1. **Molecular Cytogenetics:** C-value paradox, cot curve, multigene families.

2. **Techniques in Cytogenetics:** In situ hybridization, computer-assisted chromosome analysis, microdissection, microcloning, flow cytometry and confocal microscopy.
3. **Cancer Genetics:** Proto-oncogenes, oncogenes and tumor suppressor genes.
4. **Human and Population Genetics:** Pedigree analysis, LOD score linkage testing, karyotypes, genetic disorders and inherited human diseases.

Suggested Laboratory Exercises: -

1. Study of Hardy-Weinberg Law using simulations (seeds).
2. Linear differentiation of chromosomes through banding techniques, such as G-banding, C-banding and Q-banding.
3. Working out the effect of mono- and trisomy on plant phenotype.
4. Induction of polyploidy using colchicine.
5. Different applications of Colchicine.
6. Study of variations in plants due to numerical alterations in chromosomes.
7. Isolation of chlorophyll mutants following irradiation and treatment with chemical mutagens.
8. Numericals based on inheritance and gene interactions.
9. Flow cytometry and confocal microscopy.
10. Any other practical based on theory syllabus.

Suggested Readings:

1. Atherly. AG., Girton JR. and McDonald, JF. (1999). The Science of Genetics. Saunders College Publishing, Fort Worth, USA,
2. Burnham, CR. (1962). Discussions in Cytogenetics. Burgess Publishing Co. Minnesota.
3. Busch, H. and Rothblum, L. (1982). Volume X. The Cell Nucleus rDNA Pan A. Academic Press.
4. Hartl, DL. and Jones, E W. (1998). Genetics: Principles and Analysis (4th edition). Jones & Bartlett Publishers, Massachusetts, USA.
5. Khush, GS. (1973). Cytogenetics of Aneuploids. Academic Press, New York, London.
6. Lewis R. (1997). Human Genetics: Concepts and Applications (2nd editions). WCB McGraw Hill, USA.
7. Russel, P.J, (1998). Genetics (5th edition). The Benjamin/Cummings Publishing Company INd., USA.
8. Fukui. K. and Nakayama, S. (1996). Plant Chromosomes: laboratory Methods. CRC Press, Boca ratan, Florida,
9. Sharma, AK. and Sharma, A. (1999). Plant Chromosome Analysis, Manipulation and Engineering. Hoarwood Academic Publisher, Australia.

10. Gardner, EJ.. Simmons, MI., Snustad, DI). (2008). Principles of Genetics (VIIIed). John Wiley & Sons.
11. Snustad, D.P. and Simmons, M.J. (2009). Principles of Genetics (V Edition). John Wiley and Sons Inc. USA.
12. Klug, W.S.. Cummings, MR., Spencer, C.A. (2009). Concepts of Genetics (XI Edition). Benjamin Cummings Publishing Company INd., USA.
13. Russell, P. J. (2009), Genetics - A Molecular Approach.(Ill Edition). Benjamin Cummings Publishing Company md., USA.
14. Pevsner, J, (2009), Bioinformatics and Functional Genomics (Il Edition). John Wilev & Sons.
15. Griffiths, AJF. Wessler, SR., Lewontin, RC, and Carroll, SB (2008). Introduction to Genetic Analysis (IX Edition). W. H. Freeman & Co.
16. Arora, MP. Gurdarshan and Sandhu, S. (2004), Genetics.Himalaya Pub. House, New Delhi

Exam Duration: 03 hours

Bioprocess Engineering			Theory Paper
Paper Code	Course Discipline	Credits	Max. Marks
BTE 102	**Elective**	**4**	**100 (IA:20 + EA:80)**

Content:

UNIT-I (15 hrs): Introduction to Bioprocess Engineering

1. **Fundamentals of Bioprocess Engineering:** Concept and scope of bioprocess engineering; measurement and control of bioprocess parameters.
2. **Bioreactors:** Classification, design and types of bioreactors used in bioprocess industries.
3. **Fermentation Processes:** Principles and comparison of batch, fed-batch and continuous fermentation systems; biotransformation processes.
4. **Downstream Processing:** Overview of product recovery and purification methods from fermentation broth.

UNIT-II (15 hrs): Metabolic Engineering and Industrial Microbiology

1. **Metabolic Engineering Concepts:** Control mechanisms and manipulation of the shikimic acid pathway for product optimization.
2. **Industrial Microorganisms:** Methods for isolation, maintenance and preservation of production strains.

3. **Microbial Growth Kinetics:** Study of microbial growth and death kinetics in industrial systems.
4. **Media and Sterilization:** Composition of industrial media; Air and media sterilization techniques.

UNIT-III (15 hrs): Industrial Production Using Wastes

1. **Alcohol and Acid Production:** Industrial manufacture of ethanol, citric acid, acetic acid and gluconic acid.
2. **Solvents and Antibiotics:** Production of glycerol, acetone, butanol, penicillin and any other antibiotic.
3. **Amino Acids:** Industrial synthesis of lysine and glutamic acid.
4. **Single Cell Protein (SCP):** Concept, production and utilization of SCP from industrial and agricultural wastes.

UNIT-IV (15 hrs): Introduction to Food Technology

1. **Food Processing Principles:** Basic principles and importance of food processing in preservation and quality improvement.
2. **Canning and Packaging:** Elementary idea of canning, packing and sterilization methods for food products.
3. **Thermal Processing:** Pasteurization and sterilization techniques applied to food preservation.
4. **Food Product Technology:** Production technology and processing of typical food products—bread, cheese and related items.

Suggested Laboratory Exercises: -

1. Isolation and preservation of industrially important microorganisms for microbial processes.
2. Determination of thermal death point (TDP) and thermal death time (TDD of, microorganism design of a sterilizer.
3. Comparative studies of Ethanol production using different substrates.
4. Use of alginate for cell immobilization.
5. Microbial production of single cell protein.
6. Any other practical based on theory syllabus

Suggested Readings:

1. Aiba, Humphrey AE. and Millis, N.F. (1973). Biochemical Engineering (2nd Edition), University of Tokyo Press, Tokvo.
2. B. Atikinson (1974). Biochemical Reactors, Pion Ltd. London.
3. Casida Jr., LSE. (1996), Industrial Microbiology, New Age International (P) Ltd.
4. Bailey, JE- and Ollis, I)F, (1986) Biochemical Engineering Fundamentals, 2nd ed., McGraw Hill Book Co.,New York.
5. Enfors, SO. and Häggström, L. (2000). Bioprocess Technology: Fundamentals and Applications, KTH, Stockholm.
6. Jackson, AT., (1991). Process Engineering in Biotechnology, Prentice Hall, Engelwood cliffs, NJ, USA.
7. Shuler, ML. and Kargi, F., (1992). Bioprocess Engineering: Basic Concepts, Prentice Hall, Engelwood Cliffs.
8. Stanbury. F'F., Whitaker, A. and S. J. Hall, SJ. 995). Principles of. Fermentation Technology, Pergamon Press, Oxford.
9. 'Nielson. J. and Vissadsen, J. (). Bioreaction Engineering Principles, Plenum Press.
10. Doran, PM. (1995). Bioprocess Engineering Principles, Academic Press.
11. Shuler, ML.(Ed.), (1989). Chemical Engineering Problems in Biotechnology, AICIIE, New York.
12. Lee, JM. (2009). Biochemical Engineering, Prentice Hall Inc.
13. Vieth, WF., (1999). Bioprocess Engineering-Kinetics, Mass Transport, Reactors and Gene Expression, John Wiley. & Sons Inc.

Exam Duration: 03 hours

Enzyme Technology			Theory Paper
Paper Code	Course Discipline	Credits	Max. Marks
BTE 103	**Elective**	**4**	**100 (IA:20 + EA:80)**

Content:

UNIT-I (15 hrs): Introduction to Enzyme and Enzyme Technology

1. **Fundamentals and Scope:** History, scope, nomenclature of enzymes, enzyme activity units, enzyme business and major enzyme manufacturers in India and worldwide.
2. **Enzyme Kinetics:** Concepts of activation energy, transition state theory and mechanisms of enzyme catalysis.
3. **Kinetic Parameters:** Simple kinetics of enzyme action, determination of *Vmax* and *Km* values.

4. **Factors Affecting Enzyme Activity:** Influence of pH, ionic strength, temperature, pressure, reversible reactions and enzyme inhibition.

UNIT-II (15 hrs): Sources and Applications of Enzymes

1. **Enzyme Production:** Screening strategies for novel enzymes; media formulation for enzyme production.
2. **Enzyme Purification and Stability:** Methods for purification and concentration of intracellular and extracellular enzymes; factors affecting enzyme stability.
3. **Industrial Applications:** Use of enzymes in detergents, food processing, fruit juice clarification, wine, brewing and distilling industries.
4. **Specialized Uses:** Applications in textile, pharmaceutical and chemical industries; medical uses of enzymes.

UNIT-III (15 hrs): Immobilized Enzymes – Preparation and Kinetics

1. **Immobilization Techniques:** Methods of enzyme immobilization—physical adsorption, covalent binding, entrapment and microencapsulation.
2. **Kinetic Behavior:** Kinetics of immobilized enzymes and comparison with free enzyme kinetics.
3. **Mass Transfer Effects:** Influence of solute partition and diffusion on enzyme kinetics.
4. **Operational Stability:** Factors influencing reusability and stability of immobilized enzymes.

UNIT-IV (15 hrs): Immobilized Enzymes and Their Applications

1. **Enzyme Reactors:** Types—stirred tank, plug flow, continuous flow stirred tank, fluidized bed and membrane/hollow fiber reactors.
2. **Reactor Selection and Performance:** Criteria for selection, productivity and performance evaluation of enzyme reactors.
3. **Industrial Processes:** Use of immobilized enzymes in the production of high-fructose corn syrup, antibiotics, acrylamide, and in processes using invertase, lactase and raffinase.
4. **Biosensors:** Principles, construction and applications of enzyme-based biosensors.

Suggested Laboratory Exercise: -

1. Assay of some common enzymes (amylase, protease% pectinase, lipase etc.)
2. Microbial production of an enzyme.
3. Purification of enzyme, determination of Vmax and Km values.
4. Effect of temperature, pH, ionic strength and inhibitors.
5. Immobilization of enzymes/whole cells by adsorption, covalent linkage, entrapment methods.

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6. Enzyme reactions in biphasic aqueous - organic solvent.
7. Application of enzymes in detergents, chemical production, juice clarification and bioprocessing.

Suggested Books/References: -

1. Enzyme Technology M.F. Chaplin and D.C. Bucks
2. Industrial Enzymology — Godfrey and West
3. Enzyme — Copeland
4. Enzymes in Industry W. Gerhartz
5. Plant enzymology and plant histoenzymology. Malliek CP and Singh MB., Kalyani Publishers., New Delhi., (1980).

Semester-II: Electives

Exam Duration: 03 hours

Industrial Biotechnology & Biosafety			Theory Paper
Paper Code	Course Discipline	Credits	Max. Marks
BTE 201	**Elective**	**4**	**100 (IA:20 + EA:80)**

Content:

UNIT-I (15 hrs): Selection and Application of Industrial Microorganisms

1. **Industrial cultures:** Selection and cultivation of bacteria, algae, fungi and actinomycetes; strain development by mutation, selection and recombination.
2. **Immobilization of microbial cells:** Principles and industrial applications.
3. **Microorganisms as bio-resources:** Mushroom cultivation, biofertilizers, biopesticides, rhizobacteria and soil fungi in plant growth and disease management.
4. **Environmental and industrial applications:** Reclamation of mining wastelands, biodegradation of cellulosic waste, ethanol production, bioplastics, biopolymers and biosensors.

UNIT-II (15 hrs): Fermentation Process and Microbial Products

1. **Fermentation design:** Principles of aerobic and anaerobic fermentation; types of fermenter systems and factors affecting fermentation.
2. **Modes of fermentation:** Batch, continuous and semi-continuous processes; media design and selection of carbon and nitrogen sources.
3. **Microbial products:** Production of organic acids and amino acids.
4. **Industrial production:** Alcohols, beverages, enzymes and secondary metabolites.

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UNIT-III (15 hrs): Health Care Products, Food Additives and Metabolic Engineering

1. **Antibiotics:** Industrial production of penicillin, streptomycin and erythromycin.
2. **Vaccines:** Production of BCG, hepatitis-B and recombinant vaccines.
3. **Vitamins and dairy products:** Manufacture of vitamins (B_{12}, D, C), cheese, yogurt and related food additives.
4. **Metabolic engineering:** Role in industrial product development, health care and environmental biotechnology.

UNIT-IV (15 hrs): Biosafety and Laboratory Management

1. **Biosafety principles:** Security measures and Laboratory Information Management System (LIMS).
2. **Safety policies:** Handling of hazardous materials like xenobiotics, poisons, solvents, isotopes and biological strains.
3. **Waste management:** Storage and disposal of hazardous, biological and radioactive wastes; use of biosafety cabinets.
4. **Biosafety regulations:** National and international guidelines for laboratory and industrial safety.

Suggested Laboratory Exercises:

1. Isolation of industrially important microorganisms for microbial processes.
2. Comparative studies of Ethanol production using, different substrates.
3. Microbial production of citric acid using *Aspergillus niger*.
4. Microbial production of antibiotics (Penicillin).
5. Cultivation techniques of mushrooms.
6. Selection of efficient PGPR and mycorrhizae and their effect on growth
7. Preparation of list of the hazardous chemicals and their biosafety measures.
8. Any other practical based on theory syllabus.

Suggested Readings:

1. Aiba, S., Humphrey AE. and Millis, N.F. 1973. Biochemical Engineering, Univ.of Tokyo Press, Tokyo.
2. Atkinson, B. (1974). Biochemical Reactors, Pion Ltd. London.
3. BailvJ.E. and Oils,D.F., (1986). Biochemical Engineering fundamentals, McGrow Hill Book Co.,New York.
4. Enfors SC). &Haggstrom L. 2000. Bioprocess Technology:Fundamentals and Applications, KTH,Stockholm.
5. Jackson, AT., (1991) Process Engineering in Biotechnology, Prentice Hall, Engëlwood cliffk.
6. Shuler, ML. and Kargi, F, (1992). Bioprocess Engineering: Basic Concepts, Prentice Hall,Engelwood Cliffy
7. Stanbury, PF. and Whitaker, (1995). Principles of Fermentation Technology, Pergamon Press, Oxford. London.
8. Nielson, J. and Vissadsen, J., Bioreactor, Engineering Principles, Plenum Press.
9. Shuler,ML.(Ed.),(1989). Chemical Problems in Biotechnology, AIC-HE.
10. Lee, JM. (2C()9). Biochemical Engineering, Prentice Hall Inc.
11. Vieth, WF., (1999). Bioprocess Engineering-Kinetics, Mass Transport, Reactors and Gene Expression. John Sons Inc.
12. Rai, B. and Dkkhar. MS. (1998). New trends in Microbial Ecology, Deptt. Of Botany, NE hill Univ. Shillong & ISCON Varanasi.
13. Rai B. Upadhyays RS. andDubey, NK. (1998). Trends in Microbial Exploitaticn.ISCGN, Varanasi.
14. Click, BR. And Pasternak, 1994). Molecular Biotechnology Principles and Applications of Recombinant DNA. Panima Publishing New Delhi.
15. Watson, JD, Gilman. M. Witkowski, J and (1992). Recombinant DNA (Sec, Ed.), Scientific American Books, New York.
16. Kumar. (1998). Modern Concept of Biotechnology, Vikas Pubilishing House, New Delhi.

Exam Duration: 03 hours

Applied Environmental Biotechnology			Theory Paper
Paper Code	Course Discipline	Credits	Max. Marks
BTE 202	**Elective**	**4**	**100 (IA:20 + EA:80)**

Content:

UNIT-I (15 hrs): Bioremediation and Phytoremediation

1. **Bioremediation:** Concept, biofeasibility and applications in environmental cleanup.
2. **Bioreduction:** Mechanisms and microbial role in pollutant transformation.
3. **Phytoremediation:** Use of plants in removing or neutralizing pollutants.
4. **Biogeochemical cycles:** Role of microorganisms in elemental cycling.

UNIT-II (15 hrs): Bioabsorption and Bioleaching of Heavy Metals

1. **Heavy metal removal:** Bioabsorption and bioleaching of cadmium, lead, and mercury.
2. **Metal–microbe interaction:** Metal binding targets, organisms involved and biomethylation of mercury and arsenic.
3. **Commercial biosorbents:** Types, uses and metal precipitation.
4. **Bioleaching process:** Mechanism, advantages and disadvantages.

UNIT-III (15 hrs): Wastewater Treatment

1. **Biological treatment systems:** Oxidative, aerobic, anaerobic, facultative and aerated ponds.
2. **Activated sludge treatment:** Microbial pollution control and functioning of percolating filters.
3. **Biofilm-based systems:** Mechanism and applications in wastewater purification.
4. **Industrial effluent treatment:** Schemes for dairy, distillery, tannery, sugar, fertilizer, refinery, chemical and antibiotic wastes.

UNIT-IV (15 hrs): Solid Waste Pollution and Management

1. **Solid waste management:** Current practices and challenges.
2. **Composting systems:** Conventional composting and vermicomposting methods.
3. **Sewage treatment:** Stages and biological role in purification.
4. **Anaerobic digestion and landfilling:** Principles and environmental implications.

Suggested Laboratory Exercises:-

Visit to Sewage waste water treatment plant. Farms doing floriculture, vegetable farming Dairy/sugar/dye industry treatment plants, Krishi vaigyan kendras (KVK) for composting Report writing of various visits.

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Suggested Readings: -

1. Industrial Waste Water Treatment (2008) By A D Patwardhan, Prentice Hall Of, India. New Delhi.

1. Applied Bioremediation And Phyto-remediation(2004) Ed By Ajay Singh And Owen P Ward, Springer.

2. The Complete Book On Organic Farming And Production Of Organic Compost (2008) By Npcs Board Of Consultants And Engineers. Asia Pacific Business Press Inc.
3. The Complete Technology Book On Biofertilizer And Organic Farming (2nd Revised Edition) [Nil 151 By Niir Board,.
5- The Complete Technology Book On Vermiculture And Vermicompost [Nil 16) By Npcs Board Of Consultants And Engineers.
6. Biopesticides Handbook [Ni210] By Npcs Board of Consultants & Engineers,
7. Manufacture of Biofertilizer and Organic Farming [Ni239] By H. Panda.
8. Integrated Organic Farming Handbook INi248] By Dr. H, Panda.

Interdisciplinary Elective Course (IEC)

Exam Duration: 03 hours

Virology			Theory Paper
Paper Code	Course Discipline	Credits	Max. Marks
IEC 001	**IEC**	**4**	**100 (IA:20 + EA:80)**

Content:

UNIT-I (15 hrs): Innate and Adaptive Immunity

1. **Innate Immunity:** Activation of innate immunity through TIR-mediated signaling pathways.
2. **Adaptive Immunity:** Role of T and B cells in adaptive immune responses.
3. **Immune Response to Infections:** Mechanisms of immune defense during bacterial, viral and parasitic infections.
4. **Correlates of Protection:** Understanding protective immune responses and immune correlates of protection.

UNIT-II (15 hrs): Vaccination and Immune Memory

1. **Immune Responses During Infection:** Appropriate and inappropriate immune responses during infections.
2. **T Cell Memory:** Development and roles of $CD4^+$ and $CD8^+$ memory T cells.

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3. **B Cell Memory:** Generation and maintenance of memory B cells.
4. **Antigen Presentation:** Role of dendritic cells in initiating and regulating immune responses.

UNIT-III (15 hrs): Adjuvants and Mucosal Immunity

1. **Adjuvants in Immunization:** Induction of Th1 and Th2 responses using suitable adjuvants.
2. **Types of Adjuvants:** Microbial, liposomal and microparticle-based adjuvants.
3. **Cytokines and Chemokines:** Role of soluble mediators in enhancing immune responses and vaccination efficacy.
4. **Mucosal Immunization:** Principles and importance of oral immunization and mucosal immunity.

UNIT-IV (15 hrs): Conventional and New Vaccine Technologies

1. **Traditional Vaccines:** Bacterial vaccines, live attenuated and inactivated vaccines, subunit vaccines and toxoids; peptide vaccines.
2. **Modern Vaccine Approaches:** Rationally designed vaccines, DNA vaccination and mucosal vaccination strategies.
3. **Advanced Vaccine Delivery:** New delivery systems and engineered viral vectors for improved vaccination.
4. **Vaccines for Major Diseases:** Development and current status of vaccines for tuberculosis, malaria and HIV.

Suggested readings:

1. Edited by Stefan H.E. Kaufmanñ, Novel Vaccination Strategies, Wiley-VCH Verlag GmbH & Co. KgaA, 2004 or later edition.
2. Topley& Wilson's, Microbiology and Microbial Infections Immunology Edited by Stefan H.E. Kaufhlann and Michael W Steward Holder Arnold, ASM Press. 2005 or later edition.
3. Edition Charles A Janeway. Jr, Paul Travers, Mark Walport and Mark J Shlomchik, Immuno Biology, The Immune system in health and Disease, 6th Edition, Garland Scierice, New York, 2005 or later edition..
4. Annual Review of Immunology : Relevant issues
5. Annual Review of Microbiology ; Relevant issues

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Exam Duration: 03 hours

Bioinformatics & Biostatistics

Theory Paper

Paper Code	Course Discipline	Credits	Max. Marks
IEC 002	**IEC**	**4**	**100 (IA:20 + EA:80)**

Content:

UNIT-I (15 hrs): Concepts of Bioinformatics

1. **Introduction to Bioinformatics:** Concept, scope and future prospects; applications in genomics and proteomics.
2. **Public Databases:** Overview of biological databases with emphasis on Gene Bank.
3. **Sequence Retrieval and Similarity Searching:** Tools and algorithms—BLAST and FASTA.
4. **Sequence Alignment and Functional Analysis:** Multiple sequence alignment using CLUSTALW; motif, domain and open reading frame (ORF) prediction.

UNIT-II (15 hrs): Applications of Bioinformatics

1. **Computational Methods:** Phylogenetic analysis, sequence translation, restriction enzyme mapping and secondary structure prediction.
2. **Bioinformatics Tools:** Primer designing tool(s), DNA manipulation, MEGA.
3. **Biological Databases:** Types, structure and applications of major databases—Gen Bank, EMBL, DDBJ, PIR-PSD, SWISS-PROT.
4. **Protein Databases:** Protein structure databases and their applications in bioinformatics research.

UNIT-III (15 hrs): Fundamentals of Statistics

1. **Measures of Central Tendency:** Arithmetic mean, median and mode.
2. **Measures of Variation:** Standard deviation, variance and coefficient of variation.
3. **Correlation and Regression:** Basic concepts.
4. **Regression Analysis:** Derivation of regression lines using the least squares method.

UNIT-IV (15 hrs): Test of Significance and Probability

1. **Hypothesis Testing:** Null hypothesis, standard error, level of significance and degrees of freedom.
2. **Statistical Tests:** t-test for small samples, F-test for comparing variances and chi-square test for categorical data.
3. **Analysis of Variance (ANOVA):** One-way and two-way ANOVA applications.
4. **Probability:** Basic probability concepts and their application in biostatistics.

Suggested Reading;

1. Introduction to Bioinformatics, Arthur M. Lesk. Oxford University Press.
2. Introduction to Bioinformatics, Attwood, Pearson Education.
3. A Textbook of Systems Biology, E Klipp, W. Liebenneister, C. Wierling,
4. Axel Kowald, H. Lehrach, R. Herwig (2009), Wiley,VCH Verlag GmbH &Co.
5. Bioinformatics: Sequence and Genome Analysis, David W. Mount (2001), Cold Spring Harbor (CSH) Laboratory Press.
6. Plant Svstem Biology, Coruzzi, G.M. (2009), Wiley Publishing House.
7. Bioinformatics A Practical Guide to the Analysis of Genes and Proteins. 2nd Edition by Baxevanis.
8. Bioinformatics: Sequence, structure and Data Bank: A Practical Approach by higgis.
9. Bioinformatics - from Genomes to drug. 2 volumes by Lenganer.
10. Bioinfòrmatic Methods and Protocols Misener
11. Bioinformatics: Sequence and Genome analysis
12. Introduction to Bioinformatics by Altwood.
13. Proteome Research: New Frontiers in Functional Genomics: Principles and Practices.
14. Genomics: The Science and Technology behind the human project.
15. Protein Biotechnology. Edited by Felix Franks. Humana Press, Totowa, Nevi . J arsey.
16. Practical Statistics for experimental biologist by Wardlaw, A.C. (1985),
17. Statistical Methods in Biology - 2000 by Bailey, N.T. J. English Univ. Press.
18. Biostatistics 7th Edition by Daniel 8. Fundamental of Biostatistics by Khan
19. Statistics for Biologist by Campbell R.C. (1974) Cambridge University Press I 19.Introduction to Biostatistics, Le and Chap (2009), Wilay and Sons.
20. Fundamentals of Biostatistics, B. Rosner Duxbury Press.
21. Medical Statistics from Scratch, Bowers (2008), Wiley and Sons

Exam Duration: 03 hours

Biodiversity, Ecology & Evolution			Theory Paper
Paper Code	Course Discipline	Credits	Max. Marks
IEC 003	**IEC**	**4**	**100 (IA:20 + EA:80)**

Content:

UNIT-I (15 hrs): Introduction to Biodiversity and Microbial Diversity

1. **Biodiversity Concepts:** Definition, types and levels of biodiversity.
2. **Values and Uses of Biodiversity:** Ecological, economic, aesthetic and ethical importance.
3. **Measurement of Biodiversity:** Alpha, beta and gamma diversity indices.
4. **Microbial Diversity and Ecology:** Overview of prokaryotic and eukaryotic microbes; physiological diversity.
5. **Archaea:** Characteristics and ecological significance of extremophiles.

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UNIT-II (15 hrs): Microbial Ecology and Applied Aspects

1. **Microbes in Natural Habitats:** Soil, ocean and human gut microbiota.
2. **Microbe–Eukaryote Associations:** Symbiotic and pathogenic relationships.
3. **Nutrient Cycles:** Role of microbes in carbon, nitrogen and sulfur cycles.
4. **Environmental Applications:** Microbial bioremediation, biodegradation and biomining.
5. **Biodiversity Hotspots in India:** RED Data Book and endangered species.
6. **Role of Biotechnology:** Reintroduction of commercially and economically valuable plants into the wild.

UNIT-III (15 hrs): Conservation and Ecosystem Dynamics

1. **Biodiversity Conservation:** In situ and ex situ methods.
2. **Molecular Markers:** Use in plant conservation and genetic diversity studies.
3. **Ecosystem Concepts:** Structure, dynamics and types of ecosystems.
4. **Ecosystem Components:** Biotic and abiotic components, food chains, food webs and energy flow.
5. **Ecological Structures:** Trophic levels and ecological pyramids.
6. **Biogeochemical Cycles:** Role in ecosystem stability and nutrient recycling.

UNIT-IV (15 hrs): Evolutionary Biology

1. **Theories of Evolution:** Lamarckism, Neo-Lamarckism, Darwinism, Neo-Darwinism and De Vries' Mutation Theory.
2. **Molecular Evolution:** Evolutionary changes at the molecular level.
3. **Natural Selection:** Mechanism and significance in evolution.
4. **Population Genetics:** Gene pool, gene frequency and Hardy-Weinberg equilibrium.
5. **Isolation Mechanisms:** Types and roles in speciation.
6. **Genetic Basis of Evolution:** Mutation, recombination and genetic drift.

Suggested Readings:

1. An advanced Text Book of Biodiversity (2004) K.V. Krishnamoorthy. Oxford &IBH. Delhi.
2. Biodiversity and Conservation (2004). Joshi PC and Namitha Joshi, APH Publishing Company, New Delhi.
3. Biodiversity and Conservation (2001) Melchias Oxford and IBH Publishing Company Pvt Ltd., New Delhi

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4. Fundamentals of Ecology (1971) E P Odom B Saunders &co, Philadelphia, USA
5. Evolution (1975) Savage, Amerind Publishing Company Ltd, New Delhi.
6. The Theory of Evolution (1993) John Marynard Smith, Canto.
7. Evolution (2004) Mark Ridley, Wiley-Blackwell.
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Dr. Arvind Kumar
(Asst. Professor & Coordinator)

Dr. Alok Sharma
(Asst. Professor) MSBU, Bharatpur.

(Prof. Archana Singh)