

***SCHEME OF EXAMINATION
RULES & REGULATIONS
AND
SYLLABUS***
(Applicable for Academic Session 2019-2021)

**Master of Science (M.Sc.)
Biotechnology**

Faculty of Science



UNIVERSITY OF KOTA
MBS Marg, KOTA (Rajasthan)-324 005
INDIA

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University of Kota, Kota

M.Sc. Biotechnology

Semester wise Consolidated Common Scheme of Examinations for the Academic Sessions 2019-2021

Year / Semester	Number, Code or ID and Nomenclature of Paper			Duration of Exam. (in Hrs.)	Teaching Hrs / Week Teaching Th. Pr.		Distribution of Assessment Marks				Total	
	Number of Paper	Code / ID of Paper	Nomenclature of Paper				Continuous or Internal Assessment (30%)		Semester or External Assessment (70%)			
							Max. Marks	Min. Pass Marks	Max. Marks	Min. Pass Marks		
1st Year I Semester	Paper-1.1	BT-511	Cell Biology and Enzyme Technology	3	4	-	30	12	70	28	100	40
	Paper-1.2	BT-512	General Microbiology	3	4	-	30	12	70	28	100	40
	Paper-1.3	BT-513	Bio-Instrumentation	3	4	-	30	12	70	28	100	40
	Paper-1.4	BT-514	Fundamentals of Biochemistry	3	4	-	30	12	70	28	100	40
	Paper-1.5	BT-515	Lab Course-I	6	-	9	--	--	100	50	100	50
	Paper-1.6	BT-516	Lab Course-II	6	-	9	--	--	100	50	100	50
	Total (I Semester)				24	34		120	48	480	212	600
1st Year II Semester	Paper-2.1	BT-521	Fundamentals of Molecular Biology	3	4	-	30	12	70	28	100	40
	Paper-2.2	BT-522	Fermentation Technology, Biosafety and IPR	3	4	-	30	12	70	28	100	40
	Paper-2.3	BT-523	Immunology and Immunotechnology	3	4	-	30	12	70	28	100	40
	Paper-2.4	BT-524	Genetic Engineering and its Applications	3	4	-	30	12	70	28	100	40
	Paper-2.5	BT-525	Lab Course-III	6	-	9	--	--	100	50	100	50
	Paper-2.6	BT-526	Lab Course-IV	6	-	9	--	--	100	50	100	50
	Total (II Semester)				24	34		120	48	480	212	600
2nd Year III Semester	Paper-3.1	BT-631	Basic and Applied Animal Biotechnology	3	4	-	30	12	70	28	100	40
	Paper-3.2	BT-632	Basic and Applied Plant Biotechnology	3	4	-	30	12	70	28	100	40
	Paper-3.3	BT-633	Environmental Biotechnology	3	4	-	30	12	70	28	100	40
	Paper-3.4	BT-634	Medical Biotechnology	3	4	-	30	12	70	28	100	40
	Paper-3.5	BT-635	Lab Course-V	6	-	9	--	--	100	50	100	50
	Paper-3.6	BT-636	Lab Course-VI	6	-	9	--	--	100	50	100	50
	Total (III Semester)				24	34		120	48	480	212	600
2nd Year IV Semester	Paper-4.1	BT-641	Industrial BioProcess Technology	3	4	-	30	12	70	28	100	40
	Paper-4.2	BT-642	Biostatistics, Bioinformatics and Research Methodology	3	4	-	30	12	70	28	100	40
	Paper-4.3	BT-643	Dissertation	3	-	-	-	-	200	100	200	100
	Paper-4.4	BT-644	Lab Course-VII	6	-	9	-	-	100	50	100	50
	Paper-4.5	BT-645	Comprehensive Viva Voce	8	-	-	--	--	100	50	100	50
	Total (IV Semester)				16	17		60	24	540	256	600
Grand Total (I + II + III + IV Semester)				88	119		420	168	1980	892	2400	1060

Objectives of the Course:

Biotechnology is the broad area of biology involving living systems and organisms to develop or make products, or "any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use". M.Sc. Biotechnology programme is to promote education and research in biotechnology and provide academic and professional excellence for immediate productivity in industrial, governmental, or clinical settings for an ultimate benefit of society and environment.

Duration of the Course:

The course for the degree of Master of Science in Biotechnology shall consist of two academic years / sessions divided in to four equal semesters. The first academic year / session will comprise first and second semesters. The second academic year / session will comprise of the third and fourth semesters. Each semester shall comprise normally 90 working days. The course shall run on the regular basis.

Eligibility for Admission in M.Sc. First Semester:

- ❖ A candidate who has passed any one of the following examination from any University recognized by the UGC shall be permitted to take admission in M.Sc. First Semester to award M.Sc. degree in Biotechnology from this University after completion of a course of study of two academic years divided in the four semester scheme of examination:
 - ❖ B.Sc. (Pass / Hons) under biological science stream with subjects: Biotechnology, Microbiology, Biochemistry, Biology, Chemistry, Botany, Zoology, Genetics, Environmental Sciences, Bioinformatics, Pharmaceutical Science, etc. or
 - ❖ Bachelor of Science and Education (B.Sc.-B.Ed.) with subject biology, chemistry, botany, zoology.
 - ❖ B.Tech. Biotechnology
- ❖ Foreign students who are residing in India and are studying in Indian universities are also eligible to seek admission in this course after due screening.
- ❖ An applicant for the M.Sc. Biotechnology examination, prosecuting a regular course of study leading to the Master of Science in Biotechnology, shall not be permitted for doing any service or for giving any other regular examination simultaneously to earn a degree.
- ❖ No person shall be admitted to M.Sc. Biotechnology if he/she has already passed M.Sc. Biotechnology or equivalent examination of any University or statutory body. However, this restriction shall not be applicable to diploma / certificate holders.
- ❖ The candidate who has passed any part of M.Sc. Biotechnology programme of any University or statutory body will not be admitted to M.Sc. Biotechnology programme of this University on migration basis.

Minimum Marks required in Qualifying Examination:

- ❖ Qualifying examination passed from any recognised University which is situated in Rajasthan State:
 - General Category = 55%.
 - SC / ST / OBC / SBC or MBC = Min. Pass Marks
- ❖ Qualifying examination passed from any recognised University which is situated at outside the Rajasthan State:
 - All Categories = 60%.

❖ **Eligibility for Admission in M.Sc. Third Semester:**

A candidate may be promoted in the next academic session (in odd semester *i.e.* III semester) if he/she has cleared collectively at least 50% of the papers of both semesters (*i.e.* semester I & II) of previous academic session with 50% of the aggregate marks. The candidate who does not fulfill the above condition will remain as an ex-student and will re-appear in the due papers examinations along with next odd/even semester examinations.

A candidate who has passed B.Ed. examination as a regular course of study after completing first and second semester examinations from this University shall also be eligible to take admission in third semester examination as a regular candidate.

Course Structure:

The Master of Science in Biotechnology programme will consist of core and advanced courses of theory as well as practical which are compulsory for the students. Each semester consist of four theory papers, one practical paper and one seminar / personality development / skill development activity. Dissertation(s), project work(s), training(s), field work(s), industrial visit(s), *etc.* (which is/are approved by the concerned Department) may be performed / executed by the students in the government / public / private organization(s), institution(s), industry(ies), firm(s), enterprise(s), *etc.* for advanced learning and more practical exposures.

Course Number, Course Code or ID and Nomenclature:

Number of the course has been given in the Arabic number as Paper-1.1, Paper-1.2, and Paper-1.3 and so on. In the Paper-1.2, 1 represents the semester number and 2 represent the paper number. To give a code to a particular course, following sequence has been adopted:

“Abbreviation of the programme in upper case + nth number of year of study + nth number of semester of the programme + course number in Arabic number”

According to the above sequence, code of paper-IV of the first semester of postgraduate Microbiology programme shall be as “BT-514”. It is noted that the 5 represents here the fifth year of study because it is considered that the student has completed four years of study during his / her undergraduate programme *e.g.* B.Sc. pass course with three or B.Sc. Hons course with three / four years or B.Sc.-B.Ed. / B.Sc.-Tech. / B.Tech. *etc.* with four years. Therefore, the figure 5 represents the fifth year of study.

Nomenclature of the particular course has been given according to the nature or type of contents included in the Unit-I to Unit-V of course of study.

Maximum Marks and Credit Points:

Maximum marks of a theory and practical paper will be decided on the basis of their contact hours per week and subsequently their credit points. One teaching or tutorial hour per week will be equal to 01 credit point and will carry 25 maximum marks. Therefore, 4 teaching hours per week will be equal to 4 credit points and will carry 100 maximum marks for each theory paper / course. For calculating of credit points for practical papers, two contact hours per week for laboratory or practical work will be equal to one contact hour per week of theory paper and will carry 01 credit point. Therefore, 18 contact hours per week for practical work or laboratory work will be equal to 9 contact hours per week of theory paper and will carry 9 credit points. Therefore, 9 credit points per week for practical / laboratory work will carry 225 maximum marks.

Attendance:

Every teaching faculty, handling a course, shall be responsible for the maintenance of Attendance Register for candidates who have registered for the course. The teacher of the course must intimate the Head of the Department at least seven calendar days before the last instruction day in the semester about the attendance particulars of all students. Each student should earn 75% attendance in the courses of the particular semester failing which he or she will not be permitted to sit in the end semester examinations. However, it shall be open to the authorities to grant exemption to a candidate who has failed to obtain the prescribed 75% attendance for valid reasons and such exemptions should not under any circumstance be granted for attendance below 65%.

Teaching Methodologies:

The classroom teaching would be through conventional lectures or use of OHP or power point presentations (PPT). The lecture would be such that the student should participate actively in the discussion. Student seminars would be conducted and scientific discussions would be arranged to improve their communicative skill. In the laboratory, instruction would be given for the experiments followed by demonstration and finally the students have to do the experiments individually. For the students of slow learners, special attention would be given.

Assessment Pattern:

The assessment of the students shall be divided into two parts in which first part is continuous assessment or internal assessment or mid-term assessment (30% weightage of the maximum marks) and second part is semester assessment or external assessment or end-term assessment (70% weightage of the maximum marks). Assessment pattern and distribution of maximum marks is summarized as given below:

(i) Continuous or Internal or Mid Term Assessment:

- (a) The continuous or internal or mid-term assessment (30% weightage of the maximum marks) for each theory paper shall be taken by the faculty members of the respective Departments during each semester. There will be three internal assessment tests (*i.e.* first internal assessment test or first mid-term test and second internal assessment test or second mid-term test and third internal assessment test) each of 10% weightage of maximum marks of each theory paper. Each internal assessment shall be of one hour duration for theory paper and shall be taken according to academic calendar which will be notified by the Department / University.
- (b) For practical papers, there will be no continuous or internal or mid-term assessment. There will be only one external or semester or end-term assessment (100% weightage of maximum marks).
- (c) A student who remains absent (defaulter) or fails or wants to improve the marks in the internal assessment may be permitted to appear in the desired paper(s) (only one time) in the same semester with the permission of the concern Head of the Department. A defaulter / improvement fee of Rupees 250/- per paper shall be taken from such candidates. Duly forwarded application of such candidates by the teacher concerned shall be submitted to Head of the Department who may permit the candidate to appear in the internal assessment after production of satisfactory evidence about the reason of his/her absence in the test(s) and

deposition of the defaulter / improvement fee. A record of such candidates shall be kept in the Department.

- (d) Regular attendance of the student shall be considered in the internal assessment. Some marks for regularity shall be given to the student(s) who is/are taken classes regularly from the 5% weightage of the maximum marks. The 5% weightage of the maximum marks of regularity shall be taken from the weightage given for second internal assessment (10% weightage of maximum marks). After excluding the 5% weightage of regularity, the second internal assessment shall be of 10% weightage of maximum marks. If the attendance / regularity factor is similar for all the students, then it may be merged with the weightage of second internal assessment test (class test, home assignment, quiz, seminar, *etc.*) and then second internal assessment test shall be of 15% weightage of maximum marks.
- (e) Paper wise consolidated marks for each theory paper and dissertation / seminar (*i.e.* total marks obtained during various modes of internal assessment) obtained by the students (out of the 30% weightage of the maximum marks of the each paper) shall be forwarded (in two copies) by the Head of the Department to the Controller of Examinations of the University within a week from the date of last internal assessment test for incorporation in the tabulation register.
- (f) The consolidated marks obtained by the students be also made known to them before being communicated by the concerned Head of the Department to the University for final incorporation in the tabulation register. If any discrepancies are discovered or pointed out by the students, the same shall be looked into by the concerned faculty member and corrections made wherever necessary. The decision of the Head of the Department before the communication of marks to the University shall be final. No corrections shall be made in the internal assessment marks after the declaration of the result by the University.
- (g) Consolidated marks of internal assessment obtained out of the 30% weightage of maximum marks of each theory paper which will be communicated to the University shall be in whole number and not in fraction. Marks awarded for the various internal assessments in each paper shall be added up and then round off to the next whole number to avoid any fraction.
- (h) All test copies and other material related to the internal assessment shall also be sent to the Controller of Examinations of the University to keep in record as per the University guidelines.
- (i) The concerned Head of the Department shall be responsible for proper conduct of internal assessment tests and for communication of the consolidated marks to the University within the prescribed time.
- (j) The Head of the Department shall keep a record of the marks and also notify the same to the candidates immediately so that if any candidate is not satisfied with the award in any test or seasonal work, he / she should represent the matter to the higher authority.

(ii) Semester or External or End Term Assessment:

- (a) The semester or external or end-term assessment (70% weightage of the maximum marks) shall be three hours duration to each theory paper and twelve

hours duration (spread over two days with 6 hours per day) for each practical paper and shall be taken by the University at the end of each semester.

(b) The syllabus for each theory paper is divided into five independent units and question paper for each theory will be divided into three sections as mentioned below:

- **Section-A** will carry 10 marks with one compulsory question comprising ten short answer type questions (maximum 20 words answer) taking two questions from each unit. Each question shall be of one mark.
- **Section-B** will carry 30 marks with equally divided into five long answer type questions (answer about in 250 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.
- **Section-C** will carry 30 marks with equally divided into three long answer type questions (answer about in 500 words). Paper setter shall be advised to design total five questions by setting one question from each unit. Students are instructed to attempt any three questions.

(c) The syllabus of practical paper is divided according to main streams of Microbiology. Marks shall be awarded on the basis of major & minor experiments, spotting, viva-voce, practical record, regularity factor, lab skills, maintain cleanness of workplace, etc.

Question Paper Pattern:

(A) Continuous or Internal or Mid Term Assessment:

30% weightage of Maximum Marks (30 Marks out of 100 Maximum Marks).

(i) First Continuous or Internal or Mid Term Assessment:

Format

Department of
College / University
Address.....

First Internal Assessment Test 20... - 20....

Class	:	Max. Marks	:	10 Marks
Semester	:	Duration of Exam.	:	
Subject	:	Date of Examination	:	
Paper	:	Name of Teacher	:	

Note: All questions are compulsory and marks are given at the end of the each question. Two or three sub-divisions may be given in the question.

Q. No. 1.
or
.....
4 Marks

Q. No. 2.
or
.....

3 Marks

Q. No. 3.

or

.....

3 Marks

(ii) Second Continuous or Internal or Mid Term Assessment:

(a) Attendance:

Marks shall be given by the faculty member in each paper according to its weightage.

5% weightage of Maximum Marks

Note:

If the attendance / regularity factor is similar for all the students, then it may be merged with the weightage of second internal assessment test (class test, assignment, quiz, etc.).

(b) Seminar / Presentation

5% or 10% weightage of Maximum Marks

Format

Department of

College / University

Address.....

Second Internal Assessment Test 20... - 20....

Class	:	Max. Marks	: 10 Marks
Semester	:	Duration of Exam.	:
Subject	:	Date of Examination	:
Topic/Paper	:	Name of Teacher	:

Seminar / Presentation
(Based on Curriculum)

Format

Department of

College / University

Address.....

Third Internal Assessment Test 20... - 20....

Class	:	Max. Marks	: 10 Marks
Semester	:	Duration of Exam.	:
Subject	:	Date of Examination	:
Topic/Paper	:	Name of Teacher	:

(a) Assignment:

(May be divided in parts or questions or may not be. It will be depending on the nature of assignment).

10% weightage of Maximum Marks

or

(b) Quiz:

(May be divided in parts or questions or may not be. It will be depending on the nature of quiz).

10% weightage of Maximum Marks

Or

(c) Excursion or Industrial visit or Any other tool may be adopted for internal Assessment

10% weightage of Maximum Marks

(B) Semester or External or End Term Assessment:

70% weightage of Max Marks (*i.e.* 70 Marks out of 100 Max Marks).

Duration of Examination: 3 Hours

Max. Marks: 70

Note: The syllabus is divided into five independent units and question paper will be divided into three sections.

- **Section-A** will carry 10 marks with one compulsory question comprising ten short answer type questions (maximum 20 words answer) taking two questions from each unit. Each question shall be of one mark.
- **Section-B** will carry 30 marks with equally divided into five long answer type questions (answer about in 250 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.
- **Section-C** will carry 30 marks with equally divided into three long answer type questions (answer about in 500 words). Paper setter shall be advised to design total five questions by setting one question from each unit. Students are instructed to attempt any three questions.

SECTION-A

Q. 1.

Unit-I

- (i) **1 Mark**
(ii) **1 Mark**

Unit-II

- (iii) **1 Mark**
(iv) **1 Mark**

Unit-III

- (v) **1 Mark**
(vi) **1 Mark**

Unit-IV

- (vii) **1 Mark**
(viii) **1 Mark**

Unit-V

- (ix) **1 Mark**
(x) **1 Mark**

SECTION-B

Unit-I

Q. 2. **6 Marks**
or

..... **6 Marks**

Unit-II

Q. 3. **6 Marks**
or

..... **6 Marks**

Unit-III

Q. 4. **6 Marks**
or

..... **6 Marks**

Unit-IV

Q. 5. **6 Marks**
or

..... **6 Marks**

Unit-V

Q. 6. **6 Marks**
or

..... **6 Marks**

SECTION-C

Unit-I

Q. 7. **10 Marks**

Unit-II

Q. 8. **10 Marks**

Unit-III

Q. 9. **10 Marks**

Unit-IV

Q. 10. **10 Marks**

Unit-V

Q. 11. **10 Marks**

Practical Examinations: For All Lab Courses

Continuous or Internal or Mid Term Assessment: *Not applicable in practical.*

External or Semester or End Term Assessment:

Duration of Exam : 6 Hours

Maximum Marks : 100 Marks*

Distribution of Maximum Marks:

S. No.	Name of Exercise	Marks
1.	Exercise No. 1 : Major Experiment	20
2.	Exercise No. 2 : Major Experiment	20
3.	Exercise No. 3 : Minor Experiment	10
4.	Exercise No. 4 : Minor Experiment	10
5.	Exercise No. 5 : Spotting Experiment(5 spots)	15

6.	Laboratory Skills, Regularity, etc.	10
7.	Practical Record	5
8.	Viva-voce	10
Total Marks		100

Seminar :

The students shall compulsorily have to deliver an oral presentation on for continuous or internal or mid-term assessment in each semester. There will not be semester or external or end-term assessment for seminar.

Dissertation :

A dissertation shall be initiated at the end of the Semester III and continued during Semester IV. A dissertation may be undertaken in any research laboratories/industries/university department. The students shall compulsorily submit the certificate of completion and report to the Department during the practical examination. The marks will be awarded by the external examiner on the day of the practical examination on the basis of the experimental, presentation and viva-voce.

Minimum Pass Marks and Rules regarding Determination of Results:

Each semester shall be regarded as a unit for working out the result of the candidates. The result of each semester examination shall be worked out separately (even if the candidate has appeared at the paper(s) of the lower semester examination along with the papers of higher semester examination) in accordance with the following conditions:

- (i) A candidate, for a semester examination, shall be offered all the papers prescribed for that semester examination and besides he/she also shall be offered paper(s) not cleared by him/her at any of the lower semester examination subject to the limitation that the number of un-cleared papers of the lower semester examinations shall not exceed the total number of the papers prescribed for any one semester.
- (ii) The candidate shall be declared to have passed the examination, if the candidate secures at least 40% marks in each theory paper separately in continuous or internal or mid-term examination & semester or external or end-term examination and also separately 50% marks in each practical / project / dissertation / seminar with 50% aggregate marks of the maximum marks prescribed for each semester examination. There is no minimum pass marks for the practical record / notebook. However, submission of a practical record / notebook is a mandatory during the practical examination. The candidate should compulsorily attend viva-voce / presentation examination to secure pass in practical / project / dissertation / seminar.
- (iii) A candidate, who has been declared as failed/absent in one or more theory paper(s) at any odd semester examination shall be permitted to join the courses of study for the next higher semester *i.e.* permitted to join the course of second semester after first semester examination, permitted to join the course of fourth semester after third semester examination, permitted to join the course of sixth semester after fifth semester examination and so on and eligible to re-appear in that paper(s) as due paper(s) along with next higher semester (next year) examination provided that he/she must have cleared at least 50% of the papers (including practical / project / dissertation / seminar as one paper) collectively prescribed for the first and second semester examinations taken together for promotion to the third semester examination.

- (iv) A candidate may be promoted in the next semester (odd semester) if he/she has cleared collectively at least 50% of the papers of both semesters of previous academic session with 50% of the aggregate marks. The candidate who does not fulfill the this condition will remain in the same semester as an ex-student and will re-appear in the due papers examination along with next odd/even semester examinations.
- (v) If any student who is provisionally admitted in higher odd semester but could not secure prescribed minimum marks in previous semesters will be treated as ex-student and his/her admission fee will be carry forwarded to the next odd semester of forthcoming academic session.
- (vi) A candidate declared as failed in that particular paper he/she can re-appear for that paper in the next year examination as a due paper. However, the internal marks shall be carried forward for the total marks of the due examination. A candidate will not be allowed to re-appear in the practical examination.
- (vii) A candidate may be given only two additional chances for passing the semester thus maximum tenure for completing the two years' postgraduate course will be limited to four years, for three years postgraduate programme up to five years and so on.
- (viii) If the number of papers prescribed at the first and second or third and fourth semester examination is an odd number, it shall be increased by one for the purpose of reckoning 50% of the papers.
- (ix) A candidate who passes in 50% or more papers of the first and second semester examination, and thereby becomes eligible for admission to the third semester examination, but chooses not to do so and desires to appear in the remaining papers of first and second semester examination only or to re-appear in all the prescribed papers and practical/dissertation/seminar of the M.Sc. first and second semester examination will be permitted to do so on the condition that in the latter case his previous performance will be treated as cancelled.
- (x) If a candidate, who has been promoted to the next semester and wishes to improve his / her performance in the theory paper(s) of previous semester, can be permitted to do so in case of the theory papers only, not in practical / project / dissertation / seminar, belonging to the immediately preceding semester only for one time in these papers in next odd/even semester examinations. In such a case, he/she shall have to appear in these papers along with the papers of his/her own semester.
- (xi) A candidate shall be declared as passed after the result of the fourth semester examination, if he/she cleared all papers of the all the four semesters and secure minimum 40% of the aggregate marks of the maximum marks in theory papers and 50% of the aggregate marks of the maximum marks for practical / dissertation / presentation / seminar prescribed for four semesters Master's programme.
- (xii) In the case of an ex-student, the marks secured by him/her at his/her last examination as a regular candidate shall be taken into account except in cases where a candidate is re-appearing at the examination as a regular student and in that event he/she shall have to repeat the internal assessment test which will be finally accounted for working out his result.
- (xiii) A candidate who has failed at the M.Sc. third and fourth semester examination but has passed in at least 50% of the papers prescribed for the examination shall be exempted from re-appearing in a subsequent year in the papers in which he/she has passed.

- (xiv) If a candidate clears any paper(s) prescribed at the first and second semester (previous) and/or third and fourth semester (final) examination after a continuous period of three years, then for the purpose of working out his/her division, only the minimum pass marks shall be taken into account in respect of such paper(s) as are cleared after the aforesaid period provided that in case where a candidate requires more than 40% marks in order to reach the requisite minimum aggregate, as many marks out of those secured by him/her will be taken in to account as would enable him/her to make up the deficiency in the requisite minimum aggregate.
- (xv) In case the candidate is not able to clear his/her due paper(s) in the stipulated period as mentioned above (continuous period of three years), he/she may be given last one mercy attempt to clear due paper(s) subjected to approval of the Vice Chancellor or Board of Management.
- (xvi) The grace marks scheme shall be applicable as per University norms.

Classification of Successful Candidates:

The classification of successful candidates after last semester examination shall be as:

Description of Marks Obtained	Division / Result
• 80% and above marks in a paper.	Distinction in that paper.
• A candidate who has secured aggregate 60% and above marks	First Division
• A candidate who has secured aggregate 50% and above but less than 60% marks	Second Division
• A candidate who has secured aggregate 40% and above but less than 50% marks	Pass

Candidates who pass all the examinations prescribed for the course in the first instance and within a period two academic years in four semesters from the year / semester of admission to the course only are eligible for University Ranking. A candidate is deemed to have secured first rank provided he/she

- (i) Should have passed all the papers in first attempt itself.
- (ii) Should have secured the highest marks in the whole examination of the programme / course, or should have secured the highest cumulative grade point average (CGPA).

..... X X X

M.Sc. Biotechnology

First Semester Examination

Paper 1.1: BT-511 Cell Biology and Enzyme Technology

Contact Hours / Week : 4 Hours Maximum Marks : 100
Marks

Duration of Examination : 3 Hours Continuous/Internal/Assessment : 30 Marks
Semester Assessment : 70 Marks

Note: The syllabus is divided into five independent units and question paper will be divided into three sections.

- **Section-A** will carry 10 marks with 01 compulsory question comprising 10 short answer type questions(maximum 20 words answer) taking two questions from each unit. Each question shall be of one mark.
- **Section-B** will carry 25 marks with equally divided into five long answer type questions (answer about in 250 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.
- **Section-C** will carry 35 marks with five long answer type questions comprising one compulsory question of 15 marks and four questions of 10 marks each. Students are instructed to attempt total three questions with one compulsory question (answer about in 500 words) and any two more questions (answer about in 400 words) out of remaining four questions. Paper setter shall be advised to design question paper covering from all five units..

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

UNIT-I **15-18L**

The cell theory, Modern concepts of cell, pre-cellular evolution, Endosymbiont theory, overview of prokaryotic and eukaryotic cell types.

Plasma Membrane: various models of biological membrane, Membrane structure and composition: lipid bilayer, membrane carbohydrates, membrane proteins, channel proteins, carrier proteins and pumps. Study of the GERL Complex: Golgi complex, Endoplasmic reticulum and Lysosomes. Peroxisomes and Ribosome.

UNIT-II **15-18L**

Structure of Nucleus and Chromosome. Transport across membrane as active facilitated and passive transport.

Mitochondrial and chloroplast energy transformation: ultra structure of mitochondria and chloroplasts, structure and role of ATP synthetase, oxidative and photophosphorylation. Proton gradient and chemiosmotic coupling.

UNIT-III **15-18L**

Cell cycle, Cell Cycle Regulators- Cyclin and CDKs, Mechanism of cell division: Mitosis and Meiosis. Programmed Cell Death: intrinsic and extrinsic pathways.

Overview of extracellular signaling, modes of signaling, ligands and receptor molecules. G-protein coupled receptors, Secondary messengers (cAMP), Tyrosine kinase linked receptors.

UNIT-IV **15-18L**

Introduction to enzyme and enzyme technology: Enzymes:- General properties, Classification and Nomenclature. Mechanism of enzyme action and regulation.

Steady state kinetics: Methods of estimation of rate of enzyme catalyzed reaction with special reference to Michaelis-menton kinetics. Feedback inhibition. Isozymes, ribozymes, abzymes, zymogens, multi-enzymes complexes and multifunctional enzymes.

UNIT- V

15-18L

Enzyme isolation, purification and large scale Production.

Enzyme immobilization: methods and applications. Enzymes biosensor:

Principle, components and applications.

Advancement in enzyme technology.

Reference Books:

1. The World of the Cell: Becker, Kleinsmith and Hardin.
2. Cell and molecular biology: Gerald Karp.
3. Cell and molecular biology: P.K. Gupta.
4. Molecular cell biology: By Lodish et al.
5. The Cell: Cooper.
6. Molecular biology of the cell: Bruce Alberts et al.
7. Enzymology and Enzyme Technology: S M Bhatt.
8. Enzyme Technology- M F Chaplin and D C Bucks
9. Industrial Enzymology- Godfrey and West
10. Enzyme – Copeland
11. Enzyme in Industry – W. Gerhartz
12. Principles of Biochemistry. Ed Lehninger, Nelson and Cox. CBS publishers and distributors.
13. Biochemistry. Ed Donald Voet and Judith G. Voet. John Wiley & sons, Inc

Microbial metabolism : Phototrophy, chemolithotrophy, anaerobic respiration, fermentation, methanogens, biological nitrogen fixation.

Bacterial Growth: Growth curve and its kinetics and growth yield, growth synchronization. Determination of biomass, Environmental factors affecting growth.

UNIT V

15-18L

Microbiol diseases: Food and water borne disease, Anthrax, Tuberculosis, AIDS, Influenza, cutaneous and systemic mycoses, Malaria.

Antimicrobial drugs : General Characteristics, Antibacterial (Classification and mode of action), antifungal and antiviral.

Text/Reference books:

1. Prescott, L.M., J.P Harley and D.A Klein, 2007. Microbiology VII Ed. Mc Grow Hill,
2. Davis R.Y. E.A. Adeberg and J.L. Ingram, 1991 General Microbiology
3. Stainer .General Microbiology, V Ed., Printice Hall of India Pvt,Ltd. New Delhi
4. Ronald M. Atlas 1997. Principles of Microbiology. II Ed. Mc Graw Hill Pub.
5. Salle A.J., Fundamental Principles of Bacteriology.
6. Microbiology vol.I & II. Power and Daginawala
7. Microbiology. P.D.Sharma
8. Microbiology: An Introduction. Tortora GJ, Funke BR, and Case CL.
9. Bergey`s manual of systematic bacteriology. George M.Garrity, David R. Boone, Richard W.Castenholz.
10. Brock Biology of Microorganisms, 14th Edition. Michael T. Madigan, John M. Martinko, Paul V. Dunlap and David P. Clark

M.Sc. Biotechnology
First Semester Examination
Paper-1.3 BT-513 Bio-Instrumentation

Contact Hours / Week : 4 Hours

Maximum Marks : 100 Marks

Duration of Examination : 3 Hours

Continuous/Internal/Assessment : 30 Marks

Semester Assessment : 70 Marks

Note: The syllabus is divided into five independent units and question paper will be divided into three sections.

- **Section-A** will carry 10 marks with 01 compulsory question comprising 10 short answer type questions(maximum 20 words answer) taking two questions from each unit. Each question shall be of one mark.
- **Section-B** will carry 25 marks with equally divided into five long answer type questions (answer about in 250 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.
- **Section-C** will carry 35 marks with five long answer type questions comprising one compulsory question of 15 marks and four questions of 10 marks each. Students are instructed to attempt total three questions with one compulsory question (answer about in 500 words) and any two more questions (answer about in 400 words) out of remaining four questions. Paper setter shall be advised to design question paper covering from all five units..

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

UNIT- I

15-18L

Microscopy: Microscopes types, use of techniques of preparing specimens, resolving power, optical microscope-Basic idea of light microscopy, Types-bright field, dark field, ultra-violet, fluorescence and phase-contrast microscopes, confocal microscopy Electron microscope: TEM, SEM.
Microtomy and sample preparation for microscopy.

UNIT – II

15-8L

Centrifugation techniques: - Differential, gradient, zonal or band and isopycnic density gradient centrifugation.
Chromatography: principle and procedure of absorption, column, thin layer (TLC), partition, and gas-liquid, ion-exchange chromatography.

UNIT – III

15-18L

Electrophoresis: Principle, equipment and procedure of various types (vertical & horizontal) electrophoresis, SDS-PAGE electrophoresis.
Nucleic acid hybridizations Technique: colony, plaque, dot blot, southern, northern and western blotting.

UNIT- IV

15-18L

DNA sequencing techniques: Sanger-Coulson method, Maxam Gilbert method and next generation sequencing.
Polymerized Chain Reaction: PCR -steps, Types of PCR and its applications. Radio autography (autoradiography): principles and procedure of radio autography.

UNIT- V

15-18L

Mass Spectroscopy (LC-MS, GC-MS). Fluorescent spectroscopy.
Applications of different spectroscopic techniques in Biology.

GM counter, Scintillation counter, Flow cytometry, RIA, ELISA, DNA
Fingerprinting.

Biosensors: concept, principle, types and applications.

Text/Reference books:

1. Wilson K. and Walker J. (2008). Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press
2. A Biologist Guide to Principle and Techniques: Willson K. and Gounding K.H.
3. Biochemical Techniques theory and practice : White R
4. Molecular biotechnology- Glick
5. An Introduction to Practical Biochemistry: Plummer D. T.
6. Life Science in tools and Techniques: P. S. Bisen and Shruti Mathur.

M.Sc. Biotechnology
First Semester Examination
Paper-1.4 BT-514 Fundamentals of Biochemistry

Contact Hours / Week : 4 Hours Maximum Marks : 100 Marks

Duration of Examination : 3 Hours Continuous/Internal/Assessment : 30 Marks
Semester Assessment : 70 Marks

Note: The syllabus is divided into five independent units and question paper will be divided into three sections.

- **Section-A** will carry 10 marks with 01 compulsory question comprising 10 short answer type questions(maximum 20 words answer) taking two questions from each unit. Each question shall be of one mark.
- **Section-B** will carry 25 marks with equally divided into five long answer type questions (answer about in 250 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.
- **Section-C** will carry 35 marks with five long answer type questions comprising one compulsory question of 15 marks and four questions of 10 marks each. Students are instructed to attempt total three questions with one compulsory question (answer about in 500 words) and any two more questions (answer about in 400 words) out of remaining four questions. Paper setter shall be advised to design question paper covering from all five units..

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

UNIT- I

15-18L

Covalent, Non Covalent, hydrophilic and hydrophobic interaction and their influence on structure of biomoleculars. Acid, bases, pH, p_k, and ionization of water. Buffers.

High energy phosphate compounds: Introduction, Phosphate group transfer free energy of hydrolysis of ATP and sugar phosphate. Henderson Hasselbalch equation, concepts of bioenergetics. First and second law of thermodynamics. Gibb's free energy.

UNIT-II

15-18L

Carbohydrates: Classification, characteristics and functions. Reactions of carbohydrates, Isomerism of carbohydrates, Fischer projections, Haworth structures. Structure and functions of homo and heteropolysaccharides, glycoconjugates,

Carbohydrate Metabolism: Introduction, Aerobic and anaerobic pathways:, Glycogenolysis, Gluconeogenesis, Glycolysis.TCA cycle, Electron Transport chain, Oxidative phosphorylation, Chemiosmotic theory of ATP Synthesis Reductive TCA cycle, Glyoxylate cycle, amphibolic & anaplerotic reactions. Pentose phosphate pathway (HMP Shunt), Glycogen metabolism.

UNIT-III

15-18L

Lipids-Introduction, Sources, Nomenclature,Classification. Properties and Functions. Steroids: Structure of steroid nucleus, biological role of cholesterol. Lipid Metabolism- Biodegradation of fatty acids, beta – oxidations of fatty acids. Ketone bodies production during starving and diabetes.

Biosynthesis of fatty acids – Acetyl-CoA carboxylase reaction, Fatty acid synthase complex, biosynthesis of palmitate. Biosynthesis of triacylglycerols, Biosynthesis of cholesterol, Prostaglandins .

UNIT- IV

15-18L

Amino Acid Metabolism- Overview of amino acid metabolism, Biodegradation of amino acids – deamination, transamination, decarboxylation, glutamine and glutamic acid pathway, urea cycle, uric acid biosynthesis. Protein structure (primary, secondary, tertiary and quaternary). Ramachandran plot. Protein degradation and Targeting.

UNIT- V

15-18L

Nucleic Acid: Biosynthesis and degradation of Purines and Pyrimidines. Coenzymes and cofactors: Role and mechanisms of action of NAD⁺/NADP⁺, FAD, lipoic acid, thiamine, Pyrophosphate, Biotin, Pyridoxal Phosphate, B₁₂ co-enzymes and Metal ions with specific examples. Water and Fat soluble vitamins; Structure, distribution, interaction and functions.

Text/Reference books:

1. Wilson K. and Walker J. (2008). Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press.
2. Nelson D and Cox MM. (2009). Principles of Biochemistry. W.H. Freeman and Company, New York.
3. Voet D and Voet JG. (2003). Biochemistry. John Wiley and Sons New York.
4. Zubay G (2000). Biochemistry. W. C. Brown, New York.
5. Berg J, Tymoczko J, Stryer L (2001). Biochemistry. W. H. Freeman, New York.
6. Robert K., Murray M.D., Granner D.K., Mayes P.A. and Rodwell V.I. Harper's Biochemistry. McGraw-Hill/Appleton and Lange.
7. Biochemistry: U, SatyaNarayan.
8. Biochemistry: Lehninger
9. Fundamental of Biochemistry: A.C.Dev.
10. Biochemistry: J.L. Jain.
11. Elements of Biochemistry : H.R. Shrivastava.

M.Sc. Biotechnology

First Semester Examination

Paper 1.5 BT 515 Lab Course-I

Practical Exercises

1. Mitosis in onion root tip cells.
2. Meiosis in anther.
3. Study of mitosis and meiosis from permanent slides.
4. Study of cell biology techniques.
5. Urease estimation by titrimetric method.
6. Urease estimation by colorimetric method.
7. Acid Phosphatase estimation.
8. Alkaline Phosphatase estimation.
9. Estimation of amylase.
10. Study of enzyme kinetics – calculation of V_{max} , K_m , K_{cat} values.
11. Applications of enzymes.
12. Immobilization of *Saccharomyces cerevisiae*.
13. Microscopy: simple, compound, Dark Field, phase contrast.
14. Micrometry: Calibration of stage and Occular micrometer and measurement of the given biological sample
15. Cleanliness, media preparation, sterilization, culture methods, dilution techniques in microbiology.
16. Staining techniques in microbiology i) Flagella staining ii) Negative staining iii) Spore staining iv) Capsule staining. (v) Lactophenol blue.
17. Isolation of pure culture- Serial Dilution, Pour, Spread, Streak.
18. To learn culture preservation techniques (Agar slants, stabs and glycerol stocks).
19. Identification of unknown bacteria by biochemical tests.-IMVIC, Catalase test, starch hydrolysis.
20. Bacterial growth curve-serial dilution, plating and turbidity measurement.
21. Antibiotics Sensitivity test.
22. Standard qualitative analysis of water (microorganisms).

M.Sc. Biotechnology

First Semester Examination

Paper 1.6 BT 516 Lab Course-II

Practical Exercises

1. Ion exchange and gel filtration chromatography.
2. Separation of subcellular organelles by differential centrifugation.
3. Separation of blood cells by density gradient centrifugation.
4. Polyacrylamide gel electrophoresis of proteins.
5. To perform PCR for amplification of target DNA segment (or gene).
6. Electrophoretic separation of DNA in agarose gel.
7. SDS PAGE for protein separation.
8. Southern Blotting Techniques.
9. Restriction Digestion.
10. Demonstration of DNA fingerprinting.
11. Preparation of reagents, buffers and solutions
12. pH meter: Buffering capacity of a buffer, indicators. To determine the pKa value and hence the dissociation constant of a given acid by using pH meter.
13. Estimation of protein: Lowry, Biuret and Bradford methods, standard curves, linear regression and assessment of ranges and reliability.
14. Estimation of reducing sugar by DNS method.
15. Protein purification: Ammonium sulphate, acetone, TCA pptn. dialysis, concentration.
16. Thin layer chromatography: amino acids, lipids, mixture of dyes.
17. Chlorophyll-a concentration measurement with acetone method using spectrophotometer.
18. Spectrophotometry: To find out absorption spectrum of given chromophore and /or oxidised and reduced forms (NAD and NADH).
19. Colorimetry: To determine the association constant of given indicator colorimetrically and to prepare the buffer solutions in pH range of 2.2 to 8.0.
20. To estimate total hardness of water
21. To estimate Calcium hardness of water
22. To estimate the total solids (Ts), total dissolved solids (TDS) and suspended solids (SS) in the given water sample

UNIT- V

15-18L

Gene Regulation: Prokaryotic Gene Regulatory Mechanism; Operon concept: Lac and Trp operons. Gene Regulation in Eukaryotes – Attenuation control, Regulation by DNA Methylation, Transcription Factors, Enhancer Element.

Genetic Code – Salient Features and Wobble Hypothesis, Initiation and Termination Codon.

Text/Reference books:

1. Molecular Biology of the Gene :Watson-Baker-Bell-Gann- Levine-Losick, Pearson Education
2. Molecular Biology: D. Freifelder, Narosa Publishing House, New Delhi
3. Genome: T.A. Brown, John Wiley & Sons
4. Microbial Genetics:. Freifelder, Narosa Publishing House, New Delhi
5. Gene VII: Lewin Benjamin (Oxford)
6. Molecular Cell Biology: J.Darnell, H.Lodhis & D.Baltimore (W.H.Freeman & Co.)
7. DNA Repair and Mutagenesis: E.C.Friedberg, G.C.Walker and W. Seide (ASM Publisher)
8. Molecular Biotechnology: S.B. Primrose
9. Molecular Biotechnology: Glick

methods. Concentration by precipitation, ultra-filtration, reverse osmosis. Drying and crystallization.

UNIT-IV

15-18L

Introduction to biosafety: Biosafety issues in biotechnology – risk assessment and risk management – safety protocols: risk groups – biosafety levels – biosafety guidelines and regulations (National and International), types of biosafety containment. The Cartagena protocol on biosafety. Benefits and risks of genetic engineering, ethical aspects of genetic testing, ethical aspects relating to use of genetic information, genetic engineering and bio warfare. GM crops and GMO's and biopiracy

UNIT-V

15-18L

Introduction to intellectual property and intellectual property rights: Types, patents, copy rights, trade secrets and trade marks, design rights, geographical indications, Importance of IPR. Patent claims, the legal decision-making process. Basic requirement of patentability, Special issues in Biotechnology Patent: Disclosure Requirement, Ethical issues, Plant Biotechnology-UPOV and Plant breeder's rights, case studies/experiences from developing and developed countries, IPR issues in the Indian context.

Reference Books

1. Sullia S. B & Shantharam S: (1998) General Microbiology, Oxford & IBH Publishing Co. Pvt.Ltd.
2. Glaser A.N & Nilaido.H (1995) Microbial Biotechnology, W.H Freeman & Co.
3. Prescott & Dunn (1987) Industrial Microbiology 4th Edition, CBS Publishers & Distributors. .
4. Crueger W. & Crueger A. (2000) A text of Industrial Microbiology, 2nd Edition, Panima Publishing Corp.
5. Stanbury P.F, Ehitaker H, Hall S.J (1997) Principles of Fermentation Technology., Aditya Books (P) Ltd.
6. S.N.Jogdan (2006) Industrial Biotechnology, Himalaya Publishing House .
7. Intellectual Property Right in the Global Economy. Maskus, K.E. (2000), Peterson Institute, ISBN 0881322822, pp. 1-266.
8. Intellectual Property: Patent, copyright, trade mark and allied rights, Cornish, W.R. (2003). Universal Law Publishing, New Delhi. ISBN-10: 0421781203, pp. 1-895
9. Intellectual Property Rights: Infringement and Remedies, Padmanabha A. (2012). Publisher: Lexis Butterworth Wadhwa Inc. ISBN: 9788180387937.pp. 1-638.
10. Assess to Knowledge in the, Age of Intellectual Property. Krikorian G,

UNIT-V

15-18L

Antigen- Antibody interaction -Precipitation, agglutination ,complement fixation, Radial Immunodiffusion, Enzyme Linked absorbent assay, Western blotting, ELISPOT assay, immunofluorescence, flow cytometry and immunoelectrophoresis, Mixed lymphocyte reaction, Apoptosis, Microarrays, Cell cytotoxic assay.

Autoimmune diseases- Addison's disease, Grave's disease, Hashimoto's thyroidites, goodpasture's disease, rheumatoid arthristis.

Immune deficiencies- B cell deficiencies.

Text/Reference books:

- 1.Essentials of Immunology, Author- Roitt, I.M., ELBS. Blackwell Scientific Publishers, London.
- 2.Immunology II Edition, Author- Kuby, J. WH., Freemanand Company, New York.
- 3.Immunology. Author- Klaus D. Elgert ,Wiley-Liss. NY.
- 4.Text Book on Principles of Bacteriology, Virology and Immunology, IX Edition (5 volumes). Authors- Topley and Wilson's, Edward Arnold, London.
- 5.The Experimental Foundations of Modern Immunology. Authors- Clark, V.R., John Willey and Sons, Incl.
- 6.Fundamental Immunology. Author – W.E. Paul, Raven Press, New York.
- 7.Fundamentals of Immunology. Authors – R.M. Coleman, M.F. Lombord and R.E. Sicard 2nded. C. Brown publishers.
- 8.Immunology. Authors – D.M. Weir and J. Steward 7thEd. (1993).
- 9.Immunology : Shailendra Sharma.
10. Immunology: C.V.Rao.

UNIT- V

15-18L

Genome analysis: Introduction, DNA typing, human genome project.
Genetically modified organisms: Introduction, Transgenic animals, Transgenic Plants. Transgenic Technology. Antisense technology.
Nanotechnology: Introduction and Biological materials. DNA nanotechnology.
Stem cell technology.

Text/Reference books:

1. Molecular Biology of the Gene: Watson-Baker-Bell-Gann-
Levine-Losick, 5 th Edn., Pearson education
2. Molecular Biology: D. Freifelder, Narosa Publishing House, New Delhi
3. Genome: T.A. Brown, John Wiley & Sons
4. Microbial Genetics: D. Freifelder, Narosa Publishing House, New Delhi
5. Gene VII: Lewin Benjamin (Oxford)
6. Molecular Cell Biology: J.Darnell, H.Lodhis & D.Baltimore (W.H.Freeman &
Co.)
7. DNA Repair & Mutagenesis: E.C.Friedberg, G.C.Walker and W. Seide (ASM
Publisher)

M.Sc. Biotechnology
Second Semester Examination
Paper 2.5 BT 525 Lab Course-III

Practical Exercises

1. Isolation of total DNA.
2. Isolation of plasmid and its quantification.
3. Preparation of competent cells
4. To induce mutation by UV radiations and to exhibit DNA repair by photo reactivation.
5. To isolate and produce UV induced auxotrophic mutants by replica plating method.
6. To perform Ames test for detecting carcinogen or mutagen.
7. Quantification of DNA by DPA method.
8. Quantification of RNA by Orsinol method
9. To check purity and quantity of DNA by Spectrophotometric method.
10. Preparation of competent cells.
11. Instrumentation of fermentor: Design of various types of fermentors & bioreactors.
12. Operation of fermentor.
13. Batch fermentation in conical flask
14. Solid state fermentation
15. Screening of microbes for production of industrially important enzymes.
16. Optimization of conditions for optimal production: - Media composition, Incubation temperature, Aeration, Incubation time.
17. Determination of TDP of an organism.
18. Determination of TDT of an organism.
19. To demonstrate DSP.
20. Searching of India Patent databases
21. Drafting and filing of Indian Patent databases
22. Searching of International Patent application
23. Drafting and filing of International Patent application

M.Sc. Biotechnology
Second Semester Examination
Paper 2.6 BT 526 Lab Course-IV

Practical Exercises

1. Antibody titre by ELISA method.
2. Double diffusion, Immuno-electrophoresis and Radial Immuno diffusion.
3. Immunoblotting, Dot Elisa assays
4. Blood smear identification of leucocytes by Giemsa stain .
5. Separation of leucocytes.
6. Blood group typing.
7. Blood film preparation and identification of cells.
8. MIC assay – Kirby Bauer method.
9. Isolation of serum from whole blood.
10. Bacterial culture and antibiotic selection media.
11. Isolation of plasmid DNA.
12. Isolation of phage DNA.
13. Restriction mapping of Plasmid DNA.
14. Cloning in Vectors.
15. PCR.
16. To study the production of transgenic crops for disease resistance.
17. To study the genetically modified crop plants production & their usefulness.
18. Restriction endonuclease digestions and separation of fragments .
19. RFLP analysis
20. Biosynthesis of nanoparticles.
21. Use to nanobiotechnology in various fields.

