SRI SANKARA ARTS AND SCIENCE COLLEGE

(AUTONOMOUS)

ENATHUR, KANCHIPURAM - 631561

M.Sc., BIOTECHNOLOGY

REGULATION & SYLLABUS

(Effective from the academic year 2022 – 2023)

Choice Based Credit System

Preamble

Biotechnology is technology that utilizes biological systems, living organisms or parts of this to develop or create different products. Biotechnology has grown, extensively in last couple of decades. This advanced 'interdisciplinary' life science branch has a tremendous networking potential with modern cutting-edge technology. This has given it a separate status in fundamental research as well as in modern industrial enterprise. Global and local focus has slowly shifted to not only current "Century of Knowledge" but also on to technology development and application in life sciences. In the milieu of research and industrialization for economic development and social change, biotechnology is an ideal platform to work. The interdisciplinary nature of biotechnology flags involves many fundamental research fields from cell biology to molecular biology, from biochemistry to biophysics, from genetic engineering to stem cell research, from bioinformatics to genomics-proteomics, from environmental biology and to biodiversity, from microbiology to bioprocess engineering, from bioremediation to In silco drug discovery and so on. The proposed credit-based curriculum and grading system will even add much more to the existing interdisciplinary nature of biotechnology and will also offer many courses to the other branches of life science. The generative power of biological data is effectively harnessed by biotechnology like no other field. The relevance and application of these studies on living organisms and their bioprocesses is extensively covered in this field with the help of technology. The Choice Based Credit System (CBCS) curriculum for Biotechnology at the postgraduate level has now been developed into a new system called Learning Outcome Curriculum Framework (LOCF) under the recommendations and guidance of University Grants Commission (UGC). The LOCF approach first envisioned the programme learning outcomes of the M.Sc. program in Biotechnology as well as the learning outcomes of the courses being taught under this programme, keeping in view the graduate attributes of the subject. The curriculum was then developed in tune with the learning outcomes. It is envisaged that the students trained under this curriculum will have the required attributes of knowledge, skills, temperament and ethics related to the subject of Biotechnology. Besides the contents of the curriculum, the teaching learning processes have also been designed to achieve these attributes. A variety of learning assessment tasks have been included in the curriculum. Besides assessing the knowledge/skills acquired by the students, these tasks would also help to

supplement the teaching learning processes. The Theory and Practical course in new restructured course will lead to impart skill-set essentials to further Biotechnology Sector. The restructured syllabus combines basic principles of Biological sciences in light of advancements in technology. The curriculum aims to impart basic knowledge with emphasis on its applications to make the students industry ready.

Introduction

A high priority task in the context of future education development agenda in India is fostering quality higher education. Improvement of quality of higher education is considered critical for enabling effective participation of young people in knowledge production, participation in the knowledge economy, improving national competitiveness in a globalized world and for equipping young people with skills relevant for global and national standards and enhancing the opportunities or social mobility. Sustained initiatives are required for institutionalizing an outcome-oriented higher education system and enhancing employability of graduates through curriculum reform based on a learning outcomes-based curriculum framework, improving/upgrading academic resources and learning environment, raising the quality of teaching and research across all higher education institutions; technology use and integration to improve teaching-learning processes and reach a larger body of students through alternative learning modes such as open and distance learning modes and use of MOOCs. Other priority areas of action for fostering quality higher education include translation of academic research into innovations for practical use in society and economy, promoting efficient and transparent governance and management of higher education system, enhancing the capacity of the higher education system to govern itself through coordinated regulatory reform and increasing both public and private sector investment in higher education, with special emphasis on targeted and effective equity-related initiatives.

Learning Outcomes based approach to Curriculum Planning:

Learning Outcome based approach to curriculum planning (LOCF) is almost a paradigm shift in the whole gamut of higher education such that it is based on first and foremost identifying the outcomes of the learning required for a particular subject of study, and then planning all components of higher education so as to achieve these outcomes. The learning

outcomes are the focal point of the reference to which all planning and evaluation of the end learningis compared and further modifications are made to fully optimize the education of the individuals in a particular subject. For the subject of Biotechnology, the outcomes are defined in terms of the understanding and knowledge of the students in Biotechnology and the practical skills the students are required to have to be competitive Biotechnology so that they are able to play their role as biotechnologist wherever required in the society such as the role of biotechnologist in the Biotechnology industry and how they may be able to fit the bill in the industry. The students are also trained in such a way that they develop critical thinking and problem solving as related to the Biotechnology. The curriculum developed and the teaching and the evaluation tasks are such that the students are able to apply their knowledge and training of Biotechnology to solve the problems of Biotechnology as these exist or appear from time to time in the society. The curriculum envisions that the student, once graduate as specialists in a discipline, have an important role to play in the newer developments and innovations in the future in the subject for advancement of the discipline.

Graduate Attributes in Biotechnology:

The students graduating in this degree must have through understanding of basic knowledge or understanding of the fundamentals of Biotechnology as applicable to wide ranging contexts. They should have the appropriate skills of Biotechnology so as to perform their duties as biotechnologists. They must be able to analyze the problems related to biotechnology and come up with most suitable solutions. As biotechnology is an interdisciplinary subject the students might have to take inputs from other areas of expertise. So the students must develop the spirit of team work. Biotechnology is a very dynamic subject and practitioners might have to face several newer problems. To this end, the biotechnologists must be trained to be innovative to solve such newer problems. Several newer developments are taking place in biotechnology. The students are trained to pick up leads and see the possibility of converting these into products through entrepreneurship. To this end, the students are made to interact with industry experts so that they may able to see the possibility of their transition into entrepreneurs. They are also made aware of the requirements of developing a Biotechnology enterprise by having knowledge of patents, copyrights and various regulatory

process to make their efforts a success. Besides attaining the attributes related to the profession of Biotechnology, the graduates in this discipline should also develop ethical awareness which is mandatory for practicing a scientific discipline including ethics of working in a laboratory work and ethics followed for scientific publishing of their research work in future. The students graduating in biotechnology should also develop excellent communication skills both in the written as well as spoken language which are must for them to pursue higher studies from some of the best and internationally acclaimed universities and research institutions spread across the globe. The graduate attributes reflect both disciplinary knowledge and understanding, generic skills, including global competitiveness all students in different academic fields of study should acquire/attain and demonstrate. Some of the characteristic attributes that a graduate should demonstrate are as follows

- ✓ Disciplinary knowledge.
- ✓ Communication Skills.
- ✓ Critical thinking.
- ✓ Problem solving.
- ✓ Research-related skills.
- ✓ Scientific reasoning.
- ✓ Reflective thinking.
- ✓ Self-directed learning.
- ✓ Moral and ethical awareness/reasoning.
- ✓ Lifelong learning.

Qualification Descriptors

Upon successful completion of the course, the students receive a M.Sc. degree in Biotechnology. Biotechnology postgraduates of this department are expected to branch out into different paths of seeking advanced research-based knowledge, professional employment, or entrepreneurship that they find fulfilling. They will be able to demonstrate knowledge as well as skills in diverse fields of Biotechnology. This will provide a foundation, which shall help them to embark on research careers by attaining doctoral positions in coveted institutions, as well as securing employment in research projects in industry or institutes. Besides research,

they can get suitable teaching positions in Colleges and Universities as an Assistant Professor after qualifying National Eligibility Test (NET). It is expected that besides the skills specific to the discipline, the wider life skills of analysis, logical reasoning, scientific aptitude, communication skills, research and life ethics, and moral values will be inculcated in the students. The list below provides a synoptic overview of possible career paths provided by a postgraduate training in Biotechnology:

- ✓ Research
- ✓ Industry
- ✓ Teaching
- ✓ Biotechnology entrepreneurship
- ✓ Administration and Policy Making
- ✓ Scientific Communication
- ✓ Patents and Law
- ✓ Scientific Writing and Editing
- ✓ Document preparation and publication

Programme Specific Outcome

PSO-1 Enriching the Biotechnology knowledge in theoretical aspects at Post graduate level

PSO-2 Enriching the Biotechnology knowledge in practical aspects at Post graduate level

PSO-3 Developing research aptitude among the student community and encouraging them to pursue higher studies in Biotechnology

PSO-4 Designing the syllabus in the manner which enables students to clear competitive exams in the life sciences

PSO-5 Developing the student skills based on current trends in Biotechnology field by offering Job oriented certificate courses and Value added courses.

M.Sc., BIOTECHNOLOGY (2022 – 2023)

REGULATIONS

1. DURATION OF THE PROGRAM

1.1. Two years (four semesters)

1.2. Each academic year shall be divided into two semesters. The odd semesters shall consist of the period from June to November of each year and the even semesters from December to April of each year.

1.3. There shall be not less than 90 working days for each semester.

2. ELIGIBILITY FOR ADMISSION

Pass in B.Sc. degree program with Biology / Botany / Zoology / Biotechnology / Microbiology / Genetics/Chemistry / Bio-chemistry / Physics / Agriculture as Main subject or B.E. / B.Tech Biotech /BVSE /MBBS /BDS

3. CREDIT REQUIREMENTS AND ELIGIBILITY FOR AWARD OF DEGREE

3.1. A Candidate shall be eligible for the award of the Degree only if he/she has undergone the prescribed course of study in a College affiliated to the University for a period of not less than two academic years and passed the examinations of all the four Semesters prescribed earning a minimum of **91 credits as per the distribution given in Regulation 4** and also fulfilled such other conditions as have been prescribed there of.

4. COURSE OF STUDY, CREDITS AND SCHEME OFEXAMINATION

4.1 The Course Components and Credit Distribution shall consist of the following (Minimum Number of Credits to be obtained):

COURSE COMPONENTS /NAME OF THE COURSE	NUMBER OF COURSES	CREDITS	CREDITS ALLOTTED
Core subject Including Project	**14 Courses**	**13 × 4** **1 × 8**	**60**
Elective	**5 Courses**	**3**	**15**
Extra Disciplinary	**2 Courses**	**3**	**6**
Soft Skill	**4 Courses**	**2**	**8**
Internship	**1 Course**	**2**	**2**
Total Credits			**91**

4.2. Scheme of Examination

FIRST SEMESTER

S.No	Course Components	Name of Course	Semester	Inst. Hours	Credits	Exam HRS	Max. Marks	
							CIA	External
1.	Core Paper-1	Biochemistry	I	3	4	3	25	75
2.	Core Paper-2	Cell & Developmental Biology	I	3	4	3	25	75
3.	Core Paper-3	Molecular Genetics	I	3	4	3	25	75
4.	Core Paper-4 Practical-I	Practical – I (A) Biochemistry (B) Cell & Developmental Biology	I	15	4	6	40	60

		(C) Molecular Genetics						
5.	Elective Paper-1*	Environmental Biotechnology	I	2	3	3	25	75
6.	Elective Paper-2 *	Biostatistics	I	2	3	3	25	75
7.	Elective Paper-3 *	Ecology & Evolution	I	2	3	3	25	75
8	Soft Skill - I		I	2	2	3	40	60
24						**Total Credits :**		

SECOND SEMESTER

S. No.	**Course Components**	**Name of Course**	**Semester**	**Inst. Hours**	**Credits**	**Exam HRS**	**Max. Marks**	
							CIA	**External**
9.	Core Paper-5	Microbiology & Bioprocess Technology	II	3	4	3	25	75
10.	Core Paper-6	Immunology	II	3	4	3	25	75
11.	Core Paper-7	Genetic Engineering	II	3	4	3	25	75

12.	Core Paper-8 Practical-II	Practical – II (A)Microbiology & Bioprocess technology, (B) Immunology (C)Genetic Engineering	II	15	4	6	40	60
13.	Elective Paper-4*	Intellectual Property Rights & Biosafety	II	2	3	3	25	75
14.	Elective Paper-5*	Methods in Biology	II	2	3	3	25	75
15.	Extra disciplinary Elective	Plant Physiology	II	2	3	3	25	75
16.	Soft skill – II		II	2	2	3	40	60
Total credits:24								

* **Candidates can opt for any one Elective and one Extra disciplinary elective**

THIRD SEMESTER

S.No.	**Course Components**	**Name of Course**	**Semester**	**Inst. Hours**	**Credits**	**Exam HRS**	**Max. Marks**	
							CIA	**External**
17	Core Paper-9	Plant & Animal Biotechnology	III	3	4	3	25	75
18	Core Paper-10	Bioinformatics	III	3	4	3	25	75

19	Core Paper-11	Molecular Biology	III	3	4	3	25	75
20	Core Paper-12 Practical-III	Practical - III (A) Plant & Animal Biotechnology (B) Bioinformatics (C) Molecular Biology	III	15	4	6	40	60
21	Elective Paper-6 *	Nano Biotechnology	III	2	3	3	25	75
22	Elective Paper-7*	Virology	III	2	3	3	25	75
23	Extra disciplinary elective	Animal physiology	III	2	3	3	25	75
24	Soft skill – III		III	2	2	3	40	60
25	**Internship	Internship in Industries or Research Laboratories related to Biotechnology Field	III		2		-	100
26	Elective offered to other Dept.	Principles of Gene Manipulation Technology	III	2	3	3	25	75
Total credits: 26								

(Practical examination shall be conducted at the end of even semesters.)

*Candidates can opt for any one Elective and one Extra disciplinary elective

****** Internship will be carried out during the summer vacation of the first year and the report will be evaluated by two examiners within the Department of the college. The marks should be included in the Third Semester Marks Statement.

FOURTH SEMESTER

S.No.	Course Components	Name of Course	Semester	Inst. Hours	Credits	Exam HRS	Max. Marks	
							CIA	External
27	Core Paper-13	Stem cell Biology	IV	4	4	3	25	75
28	Elective* Paper -9	Research Methodology	IV	2	3	3	25	75
29	Elective* Paper-10	Marine Biotechnology	IV	2	3	3	25	75
30	Core Paper-14	Dissertation	IV	22	8		60	240 (40-work book, 150-Dissertation + 50-Viva)
31	Soft skill – IV		IV	2	2	3	40	60
Total credits: 17								

* **Candidates can opt for any one Elective**

4.3. Inclusion of the Massive Open Online Courses (MOOCs) available on SWAYAM, NPTEL and other such portals approved by the University Authorities.

4.3.1 The Chairperson, Board of Studies considers the available MOOCs and choose the courses to be included under Core, Elective and SoftSkillcategoryandalsothenumberofcreditsforsuchcoursesbasedonthecontent and duration of course. The credit for such courses shall be included as part of the Core, Elective and Soft Skill to award the Degree. The number of credits will be decided at the University level for such courses which are relevant to more than one department such as soft skills and elective courses.

5.REQUIREMENTS FOR PROCEEDING TO SUBSEQUENT SEMESTERS

5.1. Eligibility: Students shall be eligible to go to subsequent semester only if they earn sufficient attendance as prescribed there for by the Syndicate of the University from time to time.

5.2. Attendance: All Students must earn 75% and above of attendance for appearing for the University Examination. (Theory/Practical)

5.3. Condonation of shortage of attendance: If a student fails to earn the minimum attendance (Percentage stipulated), the Principal shall condone the shortage of attendance up to a maximum limit of 10% (i.e. between 65% and above and less than 75%) after collecting the prescribed fee of Rs. 250/-each for Theory / Practical examination separately, (TheoryRs.250/- Per semester/Per Student: Practical Rs.250/-Per semester/Per Student) towards the Condonation of shortage of attendance. Such fees are collected and should be remitted to the University.

5.4. Non-eligibility for Condonation of shortage of attendance:

5.5. Students who have secured less than 65% but more than 50 %of attendance are NOT ELIGIBLE for Condonation of shortage of attendance and such Students will not be permitted to appear for the regular examination, but will be allowed to proceed to the next year/next semester of the program and they may be permitted to take

next University examination by paying the prescribed Condonation fee of Rs.250/-each for Theory/Practical separately. Such fees shall be remitted to the University. Name of such Students should be forwarded to the University along with their attendance details in the prescribed format.

Mentioning the category (3 copies). Year wise/ Branch wise /Semester wise together with the fees collected from them, so as to enable them to get permission from the University and to attend the Theory/Practical examination subsequently without any difficulty.

5.6. Detained students for want of attendance: Students who have earned less than 50% of attendance shall be permitted to proceed to then extsemester and to complete the Program of study. Such Students shall have to repeat the semester, which they have missed by re-joining after completion of final semester of the course, by paying the fee for the break of study as prescribed by the University from time to time.

5.7. Condonation of shortage of attendance for married women students: In respect of married women students undergoing PG programs, the minimum attendance for Condonation (Theory/Practical) shall be relaxed and prescribed as 55% instead of 65% if they conceive during their academic career**.** Medical certificate from the Doctor (D.G.O) attached to the Government Hospital and the prescribed fee of Rs. 250/- there for together with the attendance details shall be forwarded to the university to consider the Condonation of attendance mentioning the category.

5.8. Zero Percentage (0%) Attendance: The Students, who have earned 0% of attendance, have to repeat the program (by rejoining) without proceeding to succeeding semester and they have obtained prior permission from the University immediately to rejoin the program.

5.9. Transfer of Students and Credits: The strength of thecreditssystemisthatitpermitsinterInstitutionaltransferofstudents.Byprov

idingmobility, it enables individual students to develop their capabilities fully by permitting them to move from one Institution to another in accordance with their aptitude and abilities.

5.9.1. Transfer of Students is permitted from one Institution to another Institution for the same program with same nomenclature.
Provided the reisavacancyin the respective program of Study in the Institution where the transfer is requested.
Provided the Student should have passed all the courses in the Institution from where the transfer is requested.

5.9.2. The marks obtained in the courses will be converted and grades will be assigned as per the University norms.

5.9.3. The transfer students are eligible for classification.

5.9.4. The transfer students are not eligible for Ranking, Prizes and Medals.

5.9.5. Students who want to go to foreign Universities upto two semesters or Project Work with the prior approval of the Departmental/College Committee are allowed to get transfer of credits and marks which will be converted into Grades as per the University norms and are eligible to get CGPA and Classification; they are not eligible for Ranking, Prizes and Medals.

5.9.6. Students are exempted from attendance requirements for online courses of the University and MOOCs.

6. EXAMINATIONANDEVALUATION

6.1. Students shall register their names for the First Semester Examination after the admission in PG programs.

6.2. Students shall be permitted to proceed from the First Semester upto Final Semester irrespective of their failure in any of the Semester Examination and they should register for all the arrear courses of earlier semesters along with the current (subsequent) Semester courses.

6.3. Marks for Internal and End semester Examinations

Category	Theory	Practical
Internal Assessment	25	40
End semester (University) Examination	75	60

6.4 Procedure for Awarding Internal Marks

Course	Particulars	Marks
Theory Papers	Tests (2 out of 3)	10
	Attendance	05
	Seminars	05
	Assignments	05
	TOTAL	**25**
Practical Papers	Attendance	05
	Test best 2out of 3	30
	Record	05
	TOTAL	**40**
Project	Internal Marks (best 2outof3presentations)	60
	Viva-Voce	60
	Project Report	180
	TOTAL	**300**

6.5 : (i) Awarding Marks for Attendance (out of 5)Attendance

below60%=0marks,

61%to75%=3marks,

7 6 %to90%=4marksand

above91%=5marks

Conducting Practical and Project Viva –Voce Examination: By Internal and External Examiners.

Improvement of Internal Assessment Marks.

(a) Should have cleared end - semester University examination with more than 50% Marks in PG.

(b) Should have obtained less than 30% marks the Internal Assessment

(c) Should be permitted to improve internal assessment within N + 2 years where Nis denoted for number of years of the programme.

(d) Chances for reassessment will be open only for25% of all core courses in Colleges and only one chance per course will be given.

(e) The Principal will decide based on the request for reassessment and designate faculty member of the department to conduct the examination and evaluation.

(f) The reassessment may be based on a written test / assignment or any other for the entire internal assessment marks.

(g) The candidate must register for examination in the on-line system along with prescribed examination fee for that course.

6.6. Question Paper Pattern for End Semester (University Examination).

PART A

(50words): Answer10 questions out of 12 Questions:

10x1Marks= 10 marks

PARTB

(200words):Answer 5questions out of 7 Questions:

5 x5Marks =25marks

PARTC

(500words):Answer 4 questions out of 6 Questions:

4x10Marks= 40 marks

Total=75 Marks

6.7. PASSING MINIMUM:

6.7.1. There shall be no Passing Minimum for Internal.

6.7.2. A Student who secures not less than 50 percent marks in the External Written Examination and the aggregate (i.e. Written Examination Marks and the Internal

Assessment Marks put together) respectively of each paper shall be declared to have passed the examination in that subject.

6.7.3. AStudentshallbedeclaredtohavepassedProjectWorkandViva-Voce respectively, if he/ she secures maminimum 50 percent marks in the Project Work Evaluation and the Viva Voce each.

6.7.4. A Student failing in any subject will be permitted to appear for the examinations again on a subsequent occasion without putting in any additional attendance.

6.7.5. A Student who fails in either Project Work or Viva- Voce shall be permitted to redo the Project Work for evaluation and reappear for the Viva-Voce on a subsequent occasion, if sore commended by the Examiners.

6.7.6. A Student who successfully completes the Programme and passes the examinations of all the FOUR Semesters prescribed as per the Scheme of Examinations earning 91 CREDITS shall be declared to have qualified for the Degree.

6.8. INSTANT EXAMINATION:

6.8.1. Instant Examinations is conducted for the students who appeared in the final semester examinations of the PG degree courses. Eligible criteria for appearing in the Instant Examinations are as follows:

6.8.2. Eligibility: A Student who is having arrear only in one theory paper in the final semester examination of the PG Degree program is eligible to appear for the Instant Examinations.

6.8.3. Non eligibility for one Arrear Paper: A Student who is having more than one arrear paper in the current appearance of Fourth Semester for PG Examinations is not eligible for appearing for the Instant Examinations.

6.8.4. Non eligibility for Arrear in other semester: Student having arrear in any other semester is not eligible and a candidate who is absent in the current appearance is also not eligible for appearing in the Instant Examinations and those Students who have arrear in Practical/Project are not eligible for the Instant Examinations.

6.8.5. Non eligibility for those completed the program: Students who have completed their Program duration but having arrears are not eligible to appear for Instant

Examinations.

6.9. RE TOTALLING, REVALUATION AND PHOTOCOPY OF THE ANSWER SCRIPT

6.9.1. Re totalling: PG Students not eligible for applying re totalling of their answer script.

6.9.2. Revaluation: All current batch students who have appeared for their Semester Examinations are alone eligible for Revaluation of their answer scripts; Passed out students are not eligible for Revaluation.

6.9.3. Photocopy of the answer scripts: Students who have applied for revaluation can download their answer scripts from the University Website after fifteen days from the date of publication of the results.

6.9.4. The examination and evaluation for MOOCs will be as per the requirements of the Courses and will be specified at the beginning of the Semester in which such courses are offered and will be notified by the University.

7. CLASSIFICATION OF SUCCESSFUL STUDENTS

7.1 Students who secured not less than 60 % of aggregate marks (Internal + External) in the whole examination shall be declared to have passed the examination in the **First Class.** All other successful Students shall be declared to have passed in **Second Class** .Candidates who obtain 75% of the marks in the aggregate (Internal + External) shall be deemed to have passed the examination in **First Class with Distinction**, provided they pass all the examinations (theory papers, practical, project and viva-voce) prescribed for the course in the First appearance.

8. GRADING SYSTEM

8.1. Minimum Credits to be earned: For TWO year Program: **Best 91Credits**:75 Credits (Core and Elective, 16 Credits (Soft skills and Internship, Non-major Electives and Extra Disciplinary).

8.2. Marks and Grades

8.2.1. The following table shows the marks, grade points, letter grades and classification to indicate the performance of the student:

RANGE OF MARKS	**GRADE POINTS**	**LETTER GRADE**	**DESCRIPTION**
90-100	9.0-10.0	O	Outstanding
80-89	8.0-8.9	D+	Excellent
75-79	7.5-7.9	D	Distinction
70-74	7.0-7.4	A+	Very Good
60-69	6.0-6.9	A	Good
50-59	5.0-5.9	B	Average
00-49	4.0-4.9	U	Re-appear
ABSENT	0.0	AAA	ABSENT

8.2.2. GPA (Grade Point Average) for a Semester:=

∑iCiGi÷ ∑iCi

Sum of the multiplication of grade points by the credits of the courses ÷Sum of the credits of the courses in a semester.

8.2.3. CGPA (Cumulative Grade Point Average) For the entire program: = ∑n∑iCniGni ÷ ∑n∑iCni

CGPA =Sum of the multiplication of grade points by the credits of the entire programme ÷ Sum of the credits of the courses of the entire programme

Where,

Ci = Credits earned for course **i**n any semester Gi = Grade Point obtained for course in any semester
n=Semester in which such courses were credited

8.3. Letter Grade and Class

CGPA	GRADE	CLASSIFICATION OF FINAL RESULT
9.5-10.0	O+	First Class-Exemplary*
9.0 and abovebutbelow9.5	O	
8.5 and abovebutbelow9.0	D++	First Class with Distinction*
8.0 and abovebutbelow8.5	D+	
7.5 and abovebutbelow8.0	D	
7.0 and abovebutbelow7.5	A++	First Class
6.5 and abovebutbelow7.0	A+	
6.0 and abovebutbelow6.5	A	
5.5 and abovebutbelow6.0	B+	Second Class
5.0 and abovebutbelow5.5	B	
0.0 and abovebutbelow5.0	C+	Re-appear

*** The candidates who have passed in the first appearance and within the prescribed semester of the PG Programme (Major, Allied and Elective courses alone) are eligible.**

9. RANKING

9.1. Students who pass all the examinations prescribed for the program in the first appearance itself are alone eligible for Ranking / Distinction, Provided in the case of candidates who pass all the examinations prescribed for the program with a break in the First Appearance due to the reasons as furnished in the Regulation sunder **5** are only eligible for Classification.

10. CONCESSIONS FOR DIFFERENTLY-ABLED STUDENTS

10.1. Dyslexia students: For students who are mentally disabled, having disability and mental retardation, who are slow learners, who are mentally impaired having learning disorder and seizure disorder and students who are spastic and cerebral Palsy, the following concessions shall be granted, Provided the request is duly certified by the Medical Board of the Government Hospital / General Hospital / District head quarters Hospitals.:

a. One-third of the time of paper as extra time in the examination

b. Leniency in overlooking spelling

c. Amanuensis for all PG programme provided the request is duly certified by the Medical Board of the Government Hospital / General Hospital / District headquarters Hospitals and they shall be declared qualified for the degree if they pass the other examinations prescribed for the degree.

10.2. Visually Challenged Students

a. Exempted from paying examination fees.

b. A scribe shall be arranged by the college and the scribe be paid as per the college decision.

11. MAXIMUM PERIOD FOR COMPLETION OF THE PROGRAMS TO QUALIFY FOR A DEGREE

11.1.A Student who for whatever reasons is not able to complete the programme within the normal period(N) or the Minimum duration prescribed for the programme, may be allowed two years period beyond the normal period to clear the backlog to be qualified for the degree. (Time Span = N + 2 years for the completion of programme.)

11.2. In exceptional cases like major accidents and childbirth, an extension of one year be considered by on maximum span of time (Time Span = N+2+1 years for the completion of programme).

11.3. Students qualifying during the extended period shall not be eligible for **RANKING.**

UNIVERSITY OF MADRAS
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M.Sc., BIOTECHNOLOGY
(Effective from the academic year 2022 – 2023)

Title of the paper	**Core Paper Theory 1- Biochemistry**		
Category of the course	Year	Semester	Credits
	I	I	4
Objectives of the course	To introduce the students to basics of Biochemistry		
QUALIFICATION PACK	**NATIONAL OCCUPATIONAL STANDARDS**		
LFS/Q0311 Quality Management System In charge LFS/Q0308 Quality Control Chemist - Microbiology LFS/Q2201 Production / Manufacturing Biologist	LFS/N0327 LFS/N0322 LFS/N0701	Involved In the Performing of Various quantification techniques	
Course focusing on: Skill development			

	Course Outcome
CO-1	A student will gain knowledge about the molecule and its bond.
CO-2	Will have basic knowledge about structure and function of biomolecules.
CO-3	Student will get appropriate knowledge about biological pathways and metabolisms.
CO-4	Student will learn about enzymes and its metabolisms.
CO-5	This unit clearly give the knowledge about the proteins and nucleic acids.

UNIT	**CONTENT**	**HOURS**	**COs**	**COGNITIVE LEVEL**
I	Structure of atoms, molecules and chemical bonds. Structure and catalysis – Water - Vander Waals, electrostatic, hydrogen bonding, hydrophobic interaction. Principles of biophysical chemistry - pH, buffer, reaction kinetics, thermodynamics, colligative properties.	**12**	**CO-1**	**K1, K2, K3, K4, K5**

II	Composition, structure and function of biomolecule – carbohydrates (Monosaccharide, Disaccharides and Polysaccharides), lipids (Storage Lipids, Structural Lipids in Membranes, Lipids as Signals, Cofactors, and Pigments), vitamins- Classification and derivatives. Secondary metabolites from plants.	**12**	**CO-2**	**K1, K2**
III	Principles of Bioenergetics - Glycolysis, Gluconeogenesis, Pentose Phosphate pathway, Oxidative phosphorylation, Electron Transport Chain, Citric acid cycle, Urea cycle, Metabolism of lipids – fatty acid oxidation, Ketone bodies, Biosynthesis of fatty acids, Metabolism of phospholipids, Metabolism of glycolipids, Metabolism of cholesterol, Lipoproteins. Biological energy transducers, Coupled Reaction, Metabolism of Amino acid, Importance of acetyl coA.	**12**	**CO-2 CO-3**	**K1, K2, K3, K4, K5**
IV	Enzymes – Nomenclature, Classification, Enzyme Active Site, Enzyme specificity. Mechanism of enzyme action, Properties of enzymes – Reaction Kinetics, Enzyme inhibition, Control of enzyme activity. Enzyme Kinetics – Effect of substrate concentration, Effect of pH, Effect of temperature. Enzyme Regulation - Feedback Regulation, Allosteric enzymes. Isoenzymes.	**12**	**CO-4**	**K1, K2, K3, K4, K5**
V	Proteins (amino acids, peptides), nucleic acids Composition, strucuture and function, Conformation of proteins and Nucleic acids: Protein - Ramachandra plot, secondary structure, domains, motif and folds. Nucleic acid - t-RNA, micro-RNA. Nucleic acid metabolism – Nucleotide synthesis and degradation, DNA structure (helix (A, B, Z)), DNA synthesis and Repair, RNA metabolism, The genetic code and Translation, Gene expression in Prokaryotes and Eukaryotes.	**12**	**CO-5**	**K1, K2, K3, K4, K5**

Text Books:

1. David L. Nelson, Michael M. Cox. 2017. Lehninger Principles of Biochemistry, 7th Edition. W. H. Freeman. New York, United States.
2. Nagini S. 2015. Textbook of Biochemistry. 2nd Edition. Scitech Publications Pvt Ltd. India.
3. Donald Voet, Judith G. Voet and Charlotte W. Pratt. 2012. Principles of Biochemistry. 3rd Edition. Wiley Press. New York, United States.
4. Sathyanarayana.U. 2011. Biochemistry. 1stEdition. Books and Allied private limited, Kolkata, India.

Reference Books:

1. Schaum. S Philip Kuchel, Simon Easterbrook-Smith, Vanessa Gysbers, Jacqui M. Matthews. 2011. Outline of Biochemistry. 3rd Edition. McGraw-Hill. Europe.

2. Jeremy M. Berg, John L. Tymoczko, Lubert Stryer. 2019. Biochemistry. 9th Edition W.H.Freeman publishers. New York, United States.

Title of the paper	**Core Paper Theory– 2 Cell & Developmental Biology**		
Category of the course	Year	Semester	Credits
	I	I	4
Objectives of the course	To introduce the students to basics of Developmental Biology		
QUALIFICATION PACK	**NATIONAL OCCUPATIONAL STANDARDS**		
AGR/Q4804 Animal Health Worker	AGR/N4821	Gain knowledge about the infertility problems and handling Practice to Understand the common animal birth related problems.	
Course focusing on: Skill development			

	Course Outcome
CO-1	A student will develop understanding for the fundamental concepts of structural organization and function of intracellular organelles blood circulation and its system with comparative anatomy.
CO-2	Will have theoretical knowledge on cell signaling pathways and its regulatory mechanisms
CO-3	Familiarize students with cancer biology and its therapeutic interventions
CO-4	Students can develop basic understanding of stem cells and gametogenesis
CO-5	This course give an idea about morphogenesis and organogenesis in plants and animals

UNIT	**CONTENT**	**HOURS**	**COs**	**COGNITIVE LEVEL**
I	Membrane structure and function: Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, membrane pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes). Structural organization and function of intracellular organelles: Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure & function of cytoskeleton and its role in motility. Organization of genes and chromosomes: Operon, unique and	**12**	**CO 1 CO 2 CO 3 CO 4**	**K1, K2, K3, K6**

	repetitive DNA, interrupted genes, gene families, structure of chromatin and chromosomes, heterochromatin, euchromatin, transposons. Cell division and cell cycle: Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle.			
II	Cell signalling: Hormones and their receptors, cell surface receptor, signalling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signalling pathways, bacterial and plant two-component systems, light signalling in plants, bacterial chemo taxis and quorum sensing. Cellular communication: Regulation of Hematopoiesis, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation	**12**	**CO-2**	**K1, K2**
III	Cancer: Genetic rearrangements in progenitor cells, oncogenes, tumour suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, apoptosis, therapeutic interventions of uncontrolled cell growth. Programmed cell death, aging and senescence.	**12**	**CO 1**	**K2, K3, K4, K5, K6**
IV	Basic concepts of development: Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the Cytoplasmic determinants; imprinting; mutants and transgenic in analysis of development. Gametogenesis, fertilization and early development: Production of gametes, cell surface molecules in sperm-egg recognition in animals; embryo sac development and double fertilization in plants; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis, establishment of symmetry in plants; seed formation and germination.	**12**	**CO1 CO4 CO5**	**K1, K2, K3, K6**
V	Morphogenesis and organogenesis in animals : Cell aggregation and differentiation in Dictyostelium; axes and pattern formation in Drosophila, amphibian and chick; organogenesis – vulva formation in *Caenorhabditis elegans*, eye lens induction, limb development and regeneration in	**12**	**CO 1 CO 4**	**K2, K3, K6**

	vertebrates; differentiation of neurons, post embryonic development- larval formation, metamorphosis; environmental regulation of normal development; sex determination. Morphogenesis and organogenesis in plants: Organization of shoot and root apical meristem; shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristem and floral development in *Arabidopsis* and *Antirrhinum*.			

Text Books:

1. Harvey Lodish , A. Berk , Chris A. Kaiser , M. Krieger , A. Bretscher , H. Ploegh, A. Amon Kelsey C. Martin. 2016. Molecular Cell Biology, 8 th Edition, W. H. Freeman and Company
2. Scott F. Gilbert, Michael J. F. Barresi 2016. Developmental Biology. Oxford University Press.
3. Paul, A. 2011. Text Book of Cell and Molecular Biology, Second edition, 2001. Niyogi Books.
4. David E. Sadva. 2009. Cell biology organelles structure and function, CBS publishers and distributors, New Delhi.
5. Prakash S. Lohar, 2009. Cell and Molecular Biology. John Wiley & Sons, New York.

Reference Books:

1. J. Iwasa and W. Marshall. 2016. Karp. Cell and Molecular Biology, 8th Edition, John Wiley & Sons, New York.
2. J. M. W. Slack. 2012. Essential Developmental Biology, 3 rd Edition, Wiley-Blackwell.
3. Richard M.Twynman, 2001 Developmental Biology. (2nd edition), Viva Publications, New Delhi.

Title of the paper	**Core Paper Theory–3 Molecular Genetics**		
Category of the course	Year	Semester	Credits
	I	I	4
Objectives of the course	To introduce the students to basics of Molecular Genetics		
QUALIFICATION PACK	**NATIONAL OCCUPATIONAL STANDARDS**		
LFS/Q0507 Scientist Clinical Research and Development	LFS/N0516	knowledge of concepts and purification techniques	
LFS/Q3905 Bioinformatics Scientist	LFS/N03912	Apply the coding and non-coding in gene regulatory pathways as appropriate for delivering project outcome Explain the concepts of human genetics, disease and human genomics.use the concepts of molecular genomics and its fundamentals	

LFS/Q0511 Research Associate-Technology Transfer/ Process Development	LFS/N0517	Devise ways to produce the new product on a large scale with standardized protocols and support in technology transfer

Course focusing on: Skill development

	Course Outcome
CO-1	A student will gain knowledge in detail about the mendelian principles and laws
CO-2	Will come to study about the gene mapping methods
CO-3	Students study about the detail procedure about microbial genetics
CO-4	Students will know about the quantitative genetics
CO-5	Students will study about the details on gene regulation

UNIT	CONTENT	HOURS	COs	COGNITIVE LEVEL
I	Mendelian principles: Dominance, segregation, independent assortment. Concept of gene: Allele, multiple alleles, pseudo allele, complementation tests Extensions of Mendelian principles: Co dominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters.	**12**	**CO 1**	**K1, K2, K4, K5**
II	Gene mapping methods: Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants. Extra chromosomal inheritance: Inheritance of Mitochondrial and chloroplast genes, maternal inheritance.	**12**	**CO 2**	**K1, K2, K4, K6**
III	Microbial genetics: Methods of genetic transfers – transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes. Human genetics: Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.	**12**	**CO 3**	**K2, K3, K4, K6**
IV	Quantitative genetics: Polygenic inheritance, heritability and its measurements, QTL mapping. Mutation: Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis. Structural and numerical alterations of chromosomes: Deletion, duplication, inversion, translocation, ploidy and	**12**	**CO 3 CO 4**	**K2, K4, K6**

	their genetic implications. Recombination: Homologous and non-homologous recombination including transposition.			
V	Gene Regulatory network - Principles of gene regulation- - Transcriptional and post transcriptional gene regulation-activators, co-activators, suppressors, co-suppressors, moderators, silencers, insulators, enhancers. Operon - Lac Operon, Trp Operon, Ara Operon and Gal Operon.	**12**	**CO 3 CO 5**	**K1, K2, K3, K4, K6**

Text Books:

1. Daniel L. Hartl, Elizabeth W. Jones, 2013.Genetics: Analysis of Genes and Genomes, Jones & Bartlett Learning.
2. Karvita B. Ahluwalia., 2010. Genetics. New Age International Pvt Ltd and Publishers, New Delhi.
3. Robert brooker, 2011. Genetics: Analysis and principles. 4th Edition. McGraw-Hill.
4. Gardner, M. J. Simmons, D. P. Snustad, 2006. Principles of Genetics, 8th Ed, John Wiley & Sons.
5. Iba, Hitoshi, Noman, Nasimul, Akutsu, Tatsuya, 2016. Evolutionary computation in gene regulatory network research. Hoboken, New Jersey : Wiley.

Reference Books:

1. Anthony J F Griffiths, Susan R. Wessler , Sean B. Carroll , John Doebley, An Introduction to Genetic Analysis Solutions Manual, 2015.
2. Leland Hartwell, Leroy Hood, Michael Goldberg, Ann Reynolds, Lee Silver, 2010. Genetics: From Genes to Genomes. 4th edition, McGraw-Hill.
3. Monroe W. Strickberger, 2008. Genetics, PHI Learning.

Core Paper –4 Practical – I				
Title of the paper		**Biochemistry, Cell & Developmental Biology, Molecular Genetics**		
Category of the course		Year	Semester	Credits
Core		I	I	4
LFS/Q0308 Quality Control Chemist – Microbiology	LFS/N0322	Involved In the Performing of Various quantification techniques		
LFS/Q0511	LFS/N0517	Devise ways to produce the new product on a large scale with standardized protocols and support in technology transfer		

Research Associate-Technology Transfer/ Process Development		

Course focusing on: Employability

CO-1. A student will study about in practical on estimation, separation and chromatographic techniques

CO-2. Will come to know practically about the cell counting, suspension and viability

CO-3. Students study in detail about the isolation of DNA, RNA from various sources

Biochemistry

1. Extraction of Proteins from biological materials
2. Protein separation methods-Ammonium sulphate Precipitation
3. Membrane Dialysis
4. SDS PAGE
5. Estimation of Proteins by Lowry's method
6. Estimation of Proteins by Biuret method
7. Estimation of Proteins by Bradford method
8. Estimation of RNA by orcinol method
9. Estimation of DNA by diphenylamine method
10. Estimation of Carbohydrate by Anthrone method
11. Estimation of Cholesterol
12. Estimation of vitamins
13. Purity check of DNA & RNA by UV Spectrophotometry - A260/280
14. Separation of amino acids by Paper Chromatography
15. Separation of sugars by Paper Chromatography
16. Separation of amino acids by Thin layer chromatography
17. Separation of sugars by Thin layer chromatography

Demo Experiments

1. High Performance Liquid Chromatography
2. Gel permeation chromatography
3. Affinity chromatography
4. Ion exchange chromatography
5. Western blotting

Cell & Developmental Biology

1.Observation of prokaryotic and eukaryotic cells and cell types
2. Living Cells/Temporary/Permanent Preparations.
3. Squash preparation of giant chromosome of salivary gland of Chironomous larva.
4. Squash preparation of onion root tip, testis and anther lobes.

5. Preparation of buccal smear. 6. Red blood cell as osmometer. 7. Subcellular fractionation and biochemical/enzymological analysis. 8. Cytochemical study of cells/cell types using specific dyes/reagents. 9. Immunocytochemical analysis for specific cellular constituents. 10. Meiotic study in flower buds and cockroach or grasshopper. 11 . Preparation of tissue culture medium and membrane filtration; 12. preparation of single cell suspension from spleen and thymus; 13. Cell counting and cell viability; 14. Macrophage monolayer from PEC and measurement of phagocytic activity; 15. Trypsinization of monolayer and subculturing; Cryopreservation and thawing; 16. MTT assay for cell viability and growth 17. Demo experiment - Embryonic development and stem cells (Serpulid polychaete Hydroides elegans/ chick/ frog)
Molecular Genetics 1. Isolation of DNA from bacteria 2. Isolation of DNA from plants 3. Isolation of DNA from animal tissue 4. Isolation of DNA from blood 5. Plasmid DNA isolation. 7. Transfer of DNA from gel. Southern Blotting 8. Isolation and Purification of RNA 9. Glyoxal denatured Agarose gel electrophoresis of RNA 10. Formaldehyde denatured Agarose gel electrophoresis of RNA 11. Urea denatured Agarose gel electrophoresis of RNA 12. Transfer of RNA from gel. Northern Blotting 13. Restriction digestion of DNA 14. Blue white screening of recombinants 15. Amplification of DNA using PCR

Title of the paper	**Elective Paper – 1 Environmental Biotechnology**		
Category of the course	Year	Semester	Credits
	I	I	3
Objectives of the course	To introduce the students to basics of Environmental Biotechnology		
QUALIFICATION PACK	**NATIONAL OCCUPATIONAL STANDARDS**		
LFS/Q0214 Environment, Health and Safety Manager	LFS/N0230	Develop pollution control, pollution prevention and recycling programs and supervise Effluent Treatment Plant (ETP) operations. Co-ordinate all aspects of resource use, pollution reduction, waste management, environmental health, risk assessment and employee involvement.	

LFS/Q0220	SGJ/N6601	Classification of different types of filters, and how they are cleaned or replaced
LFS/Q2201 Production / Manufacturing Biologist	LFS/N0701	Undertake line monitoring of environment conditions in the process area

Course focusing on: Employability

	Course Outcome
CO-1	A student Acquire knowledge about impact of microbial metabolism on environment.
CO-2	Will have knowledge about Different types of pollution and pollution control methods and strategies.
CO-3	Student will get appropriate knowledge about Bioremediation.
CO-4	Student will learn about types of effluents and different types of treatment methods.
CO-5	This unit clearly gives the knowledge about Involvement of Biotechnology on waste treatment.

UNIT	**CONTENT**	**HOURS**	**Cos**	**COGNITIVE LEVEL**
I	Introduction to Biotechnology: The Role of Environmental Biotechnology, The Scope for Use, The Market for Environmental Biotechnology, Integrated Approach, Microbes and Metabolism: The Immobilisation, Degradation or Monitoring of Pollutants from a Biological Origin, Microbes, Plants, Metabolism, Microbial diversity, Metabolic Pathways of Particular Relevance to Environmental Biotechnology (Glycolysis, TCA cycle), Production of cellular energy.	**12**	**CO 1**	**K1, K2, K3, K4, K5**
II	Fundamentals of Biological Intervention: Using Biological Systems- Extremophiles, thermophiles, Diverse degradative abilities, Pollution and Pollution Control: Classification of Pollution- toxicity, persistence and mobility, Ease of control, Pollution Control Strategies- Dilution and dispersal, Concentration and containment, Practical Applications to Pollution Control- Biofilters, biotrecking filters, Bioscrubbers, Biological control- Whole-organism approaches, Semiochemical agents, Biosubstitutions.	**12**	**CO 2 CO 4**	**K1, K2, K4, K5**
III	Bioremediation: Methods in bioremediation, *In Situ* and *Ex Situ* Techniques, Intensive and	**12**	**CO 2 CO 3**	**K1, K2, K3, K4, K6**

	Extensive Technologies, Process Integration, The Suitability of Bioremediation, Factors Affecting the use of Bioremediation and use of bio diversity.			
IV	Aerobes and Effluents: Sewage Treatment, Nitrogenous Wastes, Aeration, Diffused air systems, Mechanical aeration systems, Trickling systems, Activated Sludge Systems, Process disruption, Organic loadings, Deep Shaft Process, Pure Oxygen Systems, The Oxidation Ditch, The Rotating Biological Contactor, Membrane Bioreactors, Sludge Disposal. Phytoremediation and photosynthesis: Terrestrial Phyto-Systems (TPS), Metal Phytoremediation, Phytoextraction, Hyper accumulation, Rhizofiltration, Phytostabilisation, Organic Phytoremediation-Phytodegradation, Rhizodegradation, Phytovolatilisation, Hydraulic Containment	**12**	**CO 4**	**K2, K3, K4, K6**
V	Biotechnology and Waste: The Nature of Biowaste, Composition of Biowaste, Biological Waste Treatment, Composting, The composting process, Applying Composting to Waste Management- Home composting, Centralised composting, Process parameters, Anaerobic Digestion process, Applying AD to Waste Management, Genetic Manipulation-Manipulation of Bacteria Without Genetic Engineering, Manipulation of Bacteria by Genetic Engineering, Basic Principles of Genetic Engineering, Analysis of Recombinants, Examples of developments in plant GE, Integrated Environmental Biotechnology: Bioenergy, Derived Biofuel, Ethanol fermentation, Biodiesel, Integrated Agricultural Applications, Plant disease suppression, Microbial pesticides, Plant/microbe interactions.	**12**	**CO 2 CO 5**	**K1, K2, K3, K4, K5, K6**

Text Books:

1. Viswanath Buddolla, 2016. Environmental Biotechnology: Basic Concepts and Applications, Alpha Science International Ltd.
2. BhattacharyyaandRintu Banerjee, 2011. Environmental Biotechnology, 2nd Revised edition, I K International Publishing House Pvt. Ltd.

Reference Books:

1. Allen K., 2016. Environmental Biotechnology, CBS; 1st Edition.

2. Moo-Young, M., Anderson, W.A., Chakrabarty, A.M., 2010. Environmental Biotechnology: Principles and applications. 1st Edition, Springer.

3. Gareth M. Evans, Judith C. Furlong, 2010. Environmental Biotechnology: Theory and Application. 2ndEdition.Wiley Blackwell Publisher.

4. Viswanath Buddolla, 2016. Environmental Biotechnology.1st Edition. Alpha Science International Publisher.

Title of the paper	**Elective Paper 2 - Biostatistics**		
Category of the course	Year	Semester	Credits
	I	I	3
QUALIFICATION PACK	**NATIONAL OCCUPATIONAL STANDARDS**		
LFS/Q0501	LFS/N0503	Application of statistics to analyse trends and data	
Course focusing on: Skill Development			

	Course Outcome
CO-1	A student Acquire knowledge about collection of data
CO-2	Able to learn hypothesis testing
CO-3	Student will get appropriate knowledge Correlation
CO-4	Student will learn about t test
CO-5	This unit clearly gives the knowledge about ANOVA.

UNIT	**CONTENT**	**HOURS**	**COs**	**COGNITIVE LEVEL**
I	Collection of data- census method, sampling method; Classification and tabulation of data – Class intervals, Tally marks, Frequency distribution; Presentation of biometric data- Line diagrams, frequency polygon, scatter or dot diagrams, bar diagrams, pareto charts, map diagrams; Types of graphs-histogram, frequency curve, pie chart, pictograms	**12**	**CO1**	**K1, K2,K3,K4,K6**

II	Measures of central tendency (mean, median, mode) and dispersal; probability distributions (Binomial, Poisson and normal); Sampling distribution; Difference between parametric and non-parametric statistics; Confidence Interval; Errors; Hypothesis testing, Levels of significance.	**12**	**CO2**	**K1, K2,K3,K4,K6**
III	Correlation- Types of correlations, Linear and non-linear correlations, measures of correlations, Bivariate and Multivariate distributions, positive and negative correlation. Regression- Regression coefficient, objectives of regression analysis, differences between regression analysis and correlation analysis.	**12**	**CO3**	**K1, K2,K3,K4,K6**
IV	t-test- degrees of freedom.t-test for single mean, t test for group data, parametric and non parametric tests, assumptions for t test, types of t tests,t test for two sample means. Chi-Square Test- Pearson's chi-squared test, Yates's correction for continuity, Tukey's test of additivity.	**12**	**CO4**	**K1, K2,K3,K4,K6**
V	Analysis of variance- test of ANOVA, summary of steps for calculating ANOVA, F test, assumptions of ANOVA, computation analysis of ANOVA, assumptions in F-test, Basic introduction to Muetrovariate statistics. Application of Biostatistics in life science research. Software packages used in Biostatistics.	**12**	**CO5**	**K1, K2,K3,K4,K6**

Text Books:

1. S.Rao, 2012. Introduction to Biostatistics and Research Methods. 5th Edition. Prentice Hall India Learning Pvt Ltd.
2. Veer Bala Rastogi. 2011. Fundamentals of Biostatistics. Ane books Pvt Ltd, Chennai.
3. Banerjee Pranab Kumar, 2007. Introduction to Biostatistics. S Chand Publishing Company.
4. Rosner B. 2005. Fundamentals of Biostatistics, Duxbury Press.

Reference Books:

1. Wayne W.Daniel. 2014. Biostatistics: Basic concepts and Methodology for the Health Sciences. Wiley
2. Warren J, Gregory E, Grant R. 2004. Statistical Methods in Bioinformatics. 1st Edition, Springer.

Title of the paper	Elective Paper 3- Ecology and Evolution		
Category of the course	Year	Semester	Credits
	I	I	3
QUALIFICATION PACK	**NATIONAL OCCUPATIONAL STANDARDS**		
LFS/Q0214 Environment, Health and Safety Manager	LFS/N0230	Relevant Environmental Health and Safety standards pollution control, pollution prevention and recycling programs	
	LFS/N0232	Local/ state/national environmental health and safety standards and regulations	
Course focusing on: Employability			

	Course Outcome
CO-1	The students would be able to get knowledge about various types of environments, habitant, feeding type and species interactions.
CO-2	Will be able to acquire knowledge about community, energy flow, mineral cycle and biodiversity management.
CO-3	The students are able to understand the evolutionary concept and experiments from noted scientist.
CO-4	The students are acquiring knowledge about molecular concept behind the evolution
CO-5	The students are learning the brain activity and behavior about various activities.

UNIT	**CONTENT**	**HOURS**	**COs**	**COGNITIVE LEVEL**
I	The Environment- Physical environment; biotic environment; biotic and abiotic interactions. Habitat and Niche- Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement. Population Ecology- Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations. Species Interactions- Types of	**12**	**CO1**	**K1, K2**

	interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.			
II	Community Ecology-Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones. Ecological Succession- Types; mechanisms; changes involved in succession; concept of climax. Ecosystem Ecology- Ecosystem structure; ecosystem function; energy flow and mineral cycling (C, N, P); primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine). Biogeography: Major terrestrial biomes; theory of island biogeography; biogeographical zones of India. Applied Ecology- Environmental pollution; global environmental change; biodiversity: status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches. Conservation Biology- Principles of conservation, major approaches to management, Indian case studies on conservation/management strategy (Project Tiger, Biosphere reserves).	**12**	**CO2**	**K1, K2**
III	Emergence of evolutionary thoughts -Lamarck; Darwin– concepts of variation, adaptation, struggle, fitness and natural selection; Mendelism; Spontaneity of mutations; The evolutionary synthesis. Origin of cells and unicellular evolution. Origin of basic biological molecules; Abiotic synthesis of organic monomers and polymers; Concept of Oparin and Haldane; Experiment of Miller (1953); The first cell; Evolution of prokaryotes; Origin of eukaryotic cells; Evolution of unicellular eukaryotes; Anaerobic metabolism, photosynthesis and aerobic metabolism. Paleontology and Evolutionary History-The evolutionary time scale; Eras, periods and epoch; Major events in the evolutionary time scale; Origins of unicellular and multi cellular organisms; Major groups of plants and animals; Stages in primate evolution including Homo.	**12**	**CO3**	**K2, K3**
IV	Molecular Evolution-Concepts of neutral evolution, molecular divergence and molecular clocks; Molecular tools in phylogeny, classification and identification; Protein and nucleotide sequence analysis; origin of new	**12**	**CO4**	**K4, K5**

	genes and proteins; Gene duplication and divergence. The Mechanisms-Population genetics – Populations, Gene pool, Gene frequency; Hardy Weinberg Law; concepts and rate of change in gene frequency through natural selection, migration and random genetic drift; Adaptive radiation; Isolating mechanisms; Speciation; Allopatricity and Sympatricity; Convergent evolution; Sexual selection; Co-evolution.			
V	Brain, Behaviour and Evolution-Approaches and methods in study of behaviour; Proximate and ultimate causation; Altruism and evolution-Group selection, Kin selection, Reciprocal altruism; Neural basis of learning, memory, cognition, sleep and arousal; Biological clocks; Development of behavior; Social communication; Social dominance; Use of space and territoriality; Mating systems, Parental investment and Reproductive success; Parental care; Aggressive behaviour; Habitat selection and optimality in foraging; Migration, orientation and navigation; Domestication and behavioural changes.	**12**	**CO5**	**K2, K5**

Text Books:

1. P.D.Sharma, 2017. Ecology and Environment. 13th Edition, Rastogi Publications.
2. R. Rajagopalan. 2016. Environment & Ecology. Lexis Nexis.
3. V.B. Rastogi, 2014. Organic Evolution. Med Tech Publication, New Delhi.
4. P.S. Verma and V.K. Agarwal, 2010. Environmental Ecology, S. Chand Publishing.
5. V.K. Agarwal. 2010. Animal Behaviour (Ethology), S. Chand Publishing.
6. E. Odum, Gary W. Barrets, 2005. Fundamentals of Ecology, 5th Edition. Cengage Learning.

Reference Books:

1. A. Manning and M.S. Dawkins, 2016. An Introduction to Animal Behavior, Sixth Edition, Cambridge University Press, India.
2. Jones & Bartlett, 2013. Strickberger‟s Evolution. Jones & Bartlett Learning.
3. Carl T. Berstrom and Lee Alan Dugatkin, 2012. Evolution. International Student Edition, W.W. Norton & Company.
4. Peter Stilling, 2011. Ecology – Global Insights & Investigations, Ecology. McGraw-Hill Education.

SECOND SEMESTER

Title of the paper	**Core Paper 5- Microbiology & Bioprocess Technology**		
Category of the course	Year	Semester	Credits
	I	II	4
QUALIFICATION PACK	**NATIONAL OCCUPATIONAL STANDARDS**		
LFS/Q0308 Quality Control Chemist – Microbiology	LFS/N0322	Grow strains of bacteria in various conditions to understand their reaction Methods of using laboratory equipment like autoclave, laminar airflow, etc. importance of the safe handling of microorganisms	
LFS/Q2301 Quality Control Biologist	LFS/N0338	Explain different types of medias for bioanalytical quality test Describe culture and sub-cultures, its handling and maintenance Describe bacterial cell structure and cytoplasmic organelle and their functions Perform biochemical characterization of microbes by Gram stain and biochemical cards	
LFS/Q0305 Validation Supervisor/ In charge - Life Sciences	LFS/N0312	Basics of chemistry, principles of the process, measuring units and method of performing simple chemical calculation High level concepts of microbiology, analytical chemistry and biotechnology	
LFS/Q0308 Quality Control Chemist - Microbiology Quality Control Chemist - Microbiology	LFS/N0321	Identify and classify microorganisms found in specimens collected from humans, plants, animals, or the environment	
LFS/Q1201 Production/ Manufacturing Chemist	LFS/N0203	Follow-up on Reaction set up/ Distillation/ Separation/ Dispensing/ Mixing /Granulation/ Compression/ Coating/ Filling/ Encapsulation/ Visual Inspection/any other production activity as per Good Manufacturing Practices (GMP)	
LFS/Q0308 Quality Control Chemist – Microbiology	LFS/N0322	Grow strains of bacteria in various conditions to understand their reaction Methods of using laboratory equipment like autoclave, laminar airflow, etc. importance of the safe handling of microorganisms	
LFS/Q0219 Bio Process Engineer	LFS/N0247	Provide day-to-day bioprocess engineering support to upstream / downstream manufacturing operations	

		Operate fermenters, centrifuges, other harvest systems and protein purifications units
	LFS/N0248	Optimize growth and productivity parameters of suspension cell lines and assist, as needed, in the hands-on experiments to define these variables

Course focusing on: Employability and skill development

	Course Outcome
CO-1	A student will gain knowledge in detail about the classification of microorganisms
CO-2	Will come to study about the microbial pathogenicity of microbes
CO-3	Students study about the detail procedure about role of microbes in food
CO-4	Students will know about the principles and advantages of bioprocess technology
CO-5	Students will study about the details on fermentation

UNIT	**CONTENT**	**HOURS**	**COs**	**COGNITIVE LEVEL**
I	Important criteria used for classification in each taxon: Classification microorganisms - Evolutionary relationships among taxa - Host parasite interaction - Recognition and entry processes of different pathogens like bacteria, viruses into host cells - Alteration of host cell behavior by pathogens, virus-induced cell transformation, pathogen-induced diseases in animals and plants, cell-cell fusion in both normal and abnormal cells - Microbial Physiology (Growth yield and characteristics, strategies of cell division, stress response).	**12**	**CO 1**	**K1, K2, K3, K4**
II	Morphology, culture, biochemical, pathogenicity, laboratory diagnosis and prevention of bacterial diseases - Salmonella typhi, Vibrio cholerae, Escherichia coli, Pseudomonas aeruginosa, Yersinia pestis and Borrelia type – Common parasites and pathogens of humans. Antimicrobial activity - antimicrobial resistance-tests for sensitivity to antimicrobial agents - antibiotics and its mode of actions.	**12**	**CO 2**	**K1, K2, K3, K4, K5**

III	Role of microorganisms in food production (SCP) dairy and non-dairy products - Fuel (ethanol), pharmaceuticals (antibiotics), biofertilizers (BGA), biopesticides (*Bacillus thuringenesis*), biopolymers (CBB), Biosurfactants (BS), vitamin B12, protease, glutamic acid. Secondary metabolites, Biogas production, Biocomposting and Biotransformation.	**12**	**CO 3**	**K2, K3, K5, K6**
IV	Basic principles and Advantages of bioprocess technology. Isolation and screening of industrially important microbes- Primary screening and Secondary. Detection and assay of fermentation products. Improvement of the strains for increased yield and other desirable characteristics. Design and construction of Fermentor -Types of fermentor: CSTR, bubble column, airlift, fluidized bed, packed bed bioreactors. Media formulation-substrates for industrial fermentation. Media sterilization and contamination. Principles of microbial growth in batch and continuous fermentation. Scale up.	**12**	**CO 3** **CO 4**	**K1, K2, K3, K4, K6**
V	Fermentations – Submerged, solid state, anaerobic fermentation processes and their applications. Production of beer, wine, vinegar, citric acid, enzymes, penicillin and insulin. Primary recovery process: Cell disruption - physical, chemical, enzymatic methods. Solid liquid separation – floatation, flocculation, filtration, centrifugation. Product formulation-Drying, freeze drying and crystallization.	**12**	**CO 3** **CO 4** **CO 5**	**K2, K3, K5, K6**

Text Books:

1. Puvana Krishnan, R, Sivasubramanian, S and Hemalatha. T. 2015. Microbes and enzymes basics and applied, 1st edition MJP Publishers, India.
2. Patel, A.H. 2015. Industrial Microbiology, 2nd edition, Mac Millan India Ltd New Delhi.
3. Trivedi, P.C., Pandey, S and Bhadauria, S. 2010. Text Book of Microbiology, Pointer Publishers, Jaipur, India.
4. Abhilasha, M.S.2009. Industrial Biotechnology. ANE books publisher.

Reference Books:

1. Stanbury, P.F and Whitaker, A. 2016. Principles of Fermentation technology, 3rd edition, Butterworth-Heinemann.
2. Clarke, W. 2016.Biotechnology: Industrial Microbiology A text book. CBS Publisher.
3. Prescott, Harley and Klein, 2011, Microbiology, 8th edition, McGraw Hill, Newyork.
4. Joanne Willey. 2010. Prescott's Microbiology, eighth edition, McGraw Hill, Newyork.

Title of the paper	Core Paper-6 Immunology		
Category of the course	Year	Semester	Credits
	I	II	4
Objectives of the course	To introduce the student to understandings of our immune system.		
QUALIFICATION PACK	**NATIONAL OCCUPATIONAL STANDARDS**		
HSS/Q0301 Medical Laboratory Technician LFS/Q0308 Quality Control Chemist - Microbiology	HSS/ N0301 LFS/N0322	Immunological techniques	
Course focusing on: Employability			

	Course Outcome
CO-1	The students would be able to develop immune system and Lymphatic Systems.
CO-2	Will have complete knowledge about Humoral Immune Response, CMI and MAbs.
CO-3	The students are able to understand the Antigen and antibody reactions
CO-4	Also comprehension about Antigen processing and presentation, Host Parasite Relationship and Infectious disease
CO-5	Students are learning the Immuno-techniques like ELISA, Western Blotting and RIA, also enables students to apply nanotechnology methods to animal biotechnology

UNIT	**CONTENT**	**HOURS**	**COs**	**COGNITIVE LEVEL**
I	History and scope of immunology- Innate and adaptive immune system - Cells and molecules involved in Innate and Adaptive immunity – Mechanism of phagocytosis process – Hematopoiesis – Programmed cell death (PCD) – Cells and Organs of the immune system, myeloid stem cells and Lymphatic system, Maturation of B cell and CALT.	**12**	**CO-1**	**K1, K2, K4**
II	Immune Responses- Humoral Immune Response (HMI), CMI and Antigen Dependent Cell Mediated Cytotixicity (ADDC); Antigens – antigenicity, immunogenicity and biological classes of antigen (Haptens, Mitogens and Adjuvant), B and T cell epitopes, activation and	**12**	**CO-2**	**K1, K2, K3, K5**

	differentiation of B and T cells, B and T cell receptors; Immunoglobulins – Structure and classes of Immunoglobulins, structure and function of antibody molecules, generation of antibody diversity, Monoclonal antibodies, production and applications of Mabs and Enzymes.			
III	Antigen – Antibody interactions, opsonization and western blotting; Primary and Secondary immune modulation -complement system- Lectin pathway, classical pathway and alternative pathway; Cytokines- properties and functions of cytokines, cytokines receptors; MHC molecules; Toll-like receptors, cell-mediated effectors functions, inflammation.	**12**	**CO-3**	**K1, K2, K3, K4, K5**
IV	Antigen processing and presentation- Immunological Tolerance-Transplantation, classification, Graft rejection and tissue typing MLR, Immune Transfusion reactions; hypersensitivity and autoimmunity, immune response during bacterial (tuberculosis), parasitic (malaria) and viral (HIV) infections, congenital and acquired immunodeficiency's – Application of immunological principles – vaccines, diagnostics. Tumor Immunology; Host parasite relationship.	**12**	**CO-3 CO-4**	**K1, K2, K4, K5**
V	Immunotechnology- Purification of Immunoglobins - Ion Exchange Chromatography, Gel filtration Chromatography; Nephelometry; FACS; Immunological screening of Recombinant Library; ELISA; Western Blotting; RIA; *In vitro* and *In vivo* Immuno histochemical Techniques; Laboratory animals.	**12**	**CO-5**	**K1, K2, K3, K4, K5**

Text Books:

1. Abul K. Abbas & Andrew H. H. Lichtman & Shiv Pillai. 2019. Basic Immunology, 6th Edition, Elsevier Publications
2. Owen, J.A., Punt, J. and Stranford, S.A., 2019. Kuby immunology (p. 574). New York, NY, USA: WH Freeman.

Reference Books:

1. Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt. 2011. Roitt's Essential Immunology, 12th edition, Wiley-Blackwell. USA.
2. Abbas, A.K., A.H.L. Lichtman and S. Pillai. 2010. Cellular and Molecular Immunology, 6th Edition. Saunders Elsevier Publications, Philadelphia.

Title of the paper	**Core Paper-7 Genetic Engineering**		
Category of the course	Year	Semester	Credits
Core	I	II	4
Pre- requisites	Knowledge of biology at Research level		
Objectives of the course	To introduce the student to basics of genetic engineering		
LFS/Q0507 Scientist Clinical Research and Development	LFS/N0516	knowledge of concepts and purification techniques	
LFS/Q2301 Quality Control Biologist	LFS/N0338	Prepare the required buffer, solvent solutions and bio-analytical quality tests Perform all the test activities, including procedures, protein purifications etc	
LFS/Q3905 Bioinformatics Scientist	LFS/N3912	Apply the coding and non-coding in gene regulatory pathways as appropriate for delivering project outcome Explain the concepts of human genetics, disease and human genomics	
	LFS/N3912	Make use of the concepts of genetic studies / lab diagnostics	
LFS/Q3904 Bioinformatics Associate/ Analyst	LFS/N3909	Principles of microarray, basic molecular techniques (PCR, extractions etc)	
LFS/Q0308 Quality Control Chemist - Microbiology	LFS/N0501	Recombinant and DNA Vaccine	
LFS/Q0507 Scientist Clinical Research and Development	LFS/N0522	Types and uses of vaccines in the prevention of infection	
LFS/Q2301 Quality Control Biologist	LFS/N0338	Biological assays reporter	
LFS/Q0308 Quality Control Chemist - Microbiology	LFS/N0321	Fluorescence in situ hybridization (FISH) is a molecular technique	
LFS/Q3905 Bioinformatics Scientist	LFS/N3912	use molecular markers and transcriptions	
Course focusing on: Skill development			
CO-1	A student will study about isolation and purification of DNA and RNA		

CO-2	Will come to know about the Recombinant protein using bacterial, animal and plant vectors
CO-3	Students study in detail about the sequencing methods
CO-4	Students will know about the labeling methods and probes
CO-5	Students will study on the molecular cloning and Recombinant technology

UNIT	**CONTENT**	**HOURS**	**COs**	**COGNITIVE LEVEL**
I	Isolation and purification of RNA, DNA (genomic and plasmid) and proteins, different separation methods. Analysis of RNA, DNA and proteins by one and two dimensional gel electrophoresis, Isoelectric focusing gels.	**12**	**CO-1**	**K1, K2, K3**
II	Expression of recombinant proteins using bacterial, animal and plant vectors. Isolation of specific nucleic acid sequences Generation of genomic and cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors. . In vitro mutagenesis and deletion techniques, gene knock out in bacterial and eukaryotic organisms.	**12**	**CO-2**	**K3,K4, K5**
III	Protein sequencing methods, detection of post translation modification of proteins. DNA sequencing methods, strategies for genome sequencing. Luciferase Reporter Gene Assay. Transcriptomics, methods for analysis of gene expression at RNA and protein level, large scale expression, such as micro array based techniques Isolation, separation and analysis of carbohydrate and lipid molecules. RFLP, RAPD and AFLP techniques.Principles of microarray.	**12**	**CO-3**	**K1, K2, K3, K4**
IV	Probes, Heterologous probes, Homologous probes, Fluorescence in situ hybridization. Complementary DNA (cDNA) synthesis. Polymerase chain reaction (PCR). Radioactive and nonradioactive labeling methods. Nucleic acid labeling, Electrophoresis, Southern blot. Antisence RNA Technology and Ribozyme	**12**	**CO-4**	**K2, K3, K5**
V	Molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems. DNA in disease diagnosis and medical forensics. ,Pharmaceutical products of DNA technology. Recombinant and DNA Vaccine, types and prevention of infection. Gene therapy	**12**	**CO-2, CO-5**	**K, K5, K6**

Text Books:

1. Somnath De. 2016. Basic concepts of Recombinant DNA Technology, 1st edition, DuPedia Publiations (P) Ltd. Delhi.
2. T.A.Brown, 2010. Gene cloning and DNA analysis: An introduction, 6th edition, Wiley-Blackwell.
3. Sardul Singh Sandhu, 2010. Recombinant DNA Technology, IK International House Pvt. Ltd.
4. Sandy B.Primrose and Richard Twyman, 2006. Principles of Gene Manipulation and genomics, 7th edition, Wiley-Blackwell.
5. Bernard R. Glick and Jack J. 2003. Molecular Biotechnology, American Society for Microbiology.
6. Verma P.S. & Agarwal V.K.2009.Genetics,9th edition,S. Chand Publishing,Delhi.

Reference Books:

1. Bernard J. Click *et al*. 2010. Molecular Biotechnology: Principles and Applications of recombinant DNA, 4th Edition
2. Lewin, 2009. Genes X, 10th edition, Jones & Barlett Publishers
3. Thiel, 2002. Biotechnology DNA to Protein: A laboratory Project, 1st Edition, and Tata McGraw-Hill.
4. Smita Rastogi, Neelam Pathak, 2009.Genetic Engineering, Oxford University Press.

<table>
<tr><th colspan="5">Core Paper - 8 Practical -II</th></tr>
<tr><td colspan="2">Title of the paper</td><td colspan="3">Microbiology & Bioprocess Technology, Immunology and Genetic Engineering</td></tr>
<tr><td colspan="2">Category of the course</td><td>Year</td><td>Semester</td><td>Credits</td></tr>
<tr><td colspan="2">Core</td><td>I</td><td>II</td><td>4</td></tr>
<tr><td rowspan="2">LFS/Q0308

Quality Control Chemist - Microbiology</td><td>LFS/N0321</td><td colspan="3">Identify and classify microorganisms found in specimens collected from humans, plants, animals, or the environment

Undertake culture/media preparation to conduct quality analysis on the samples and maintain standard cultures

Fulfil requirements of sterility testing like aseptic conditions</td></tr>
<tr><td>LFS/N0322</td><td colspan="3">Grow strains of bacteria in various conditions to understand their reaction

Methods of using laboratory equipment like autoclave, laminar airflow, etc.</td></tr>
<tr><td>HSS/Q0301 Medical Laboratory Technician</td><td>HSS/ N 0301
LFS/N0322</td><td colspan="3">Immunological techniques</td></tr>
</table>

LFS/Q0308 Quality Control Chemist - Microbiology		
LFS/Q0507 Scientist Clinical Research and Development	LFS/N0516	knowledge of concepts and purification techniques
LFS/Q2301 Quality Control Biologist	LFS/N0338	Prepare the required buffer, solvent solutions and bio-analytical quality tests Perform all the test activities, including procedures, protein purifications etc

Course focusing on: Employability

CO-1. A student will study about isolation of microbes and production, estimation of enzyme products

CO-2. Will come to know practically about the immunodiagnostic techniques

CO-3. Students study in detail about the preparation, staining, transformation, amplification and determination of DNA

Microbiology & Bioprocess Technology

1. Sterilization of glassware using dry heat- hot air oven
2. Preparation of Liquid and Solid media
3. Preparation of Agar slants, Plating methods, Serial dilution
4. Isolation of microbes from soil, water, air
5. Gram staining and morphological characterization of microbes.
6. Preparation of bacterial smear and fixation
7. Parts and design of fermenter
8. Media preparation and sterilization
9. Isolation of industrially important microorganisms for microbial processes.
10. Conservation of Bacteria by Lyophilization.
11. Production and estimation of protease
12. Production and estimation of amylase.
13. Production of wine using grapes
14. Production of penicillin and its activity.
15. Citric acid production and estimation
16. Immobilization of whole cells / enzymes.
17. Media standardization (C:N ratio) for maximum biomass production of an industrially important microorganism.
18. Aqueous Two Phase Extraction of enzyme

Immunology

1. Identification of various immune cells from human peripheral blood.
2. Lymphocyte separation and identification
3. Determination of lymphocyte viability by trypan blue method
4. WBC counting
5. Preparation of serum and plasma
6. Preparation of cellular antigen – human RBC
7. Isolation of IgG molecule from serum
8. Immunodiagnostics: CRP
9. Immunodiagnostics: ASO
10. Immunodiagnostics: Widal
11. Immunodiagnostics: RF
12. Immunodiagnostics: Blood grouping and typing
13. Immunodiagnostics: hCG
14. Radial Immunodiffusion
15. Ouchterlony Immunodiffusion
16. Immuno electrophoresis
17. Rocket electrophoresis
18. Counter current immuno electrophoresis.

Demonstration:

1. Electrophoretic profile of human serum in native PAGE
2. Preparation of antigen-adjuvent mixture for production of polyclonal antibody
3. ELISA

Genetic Engineering

1. Preparation of plasmid DNA by alkaline lysis method.
2. Isolation and Purification of Genomic DNA
3. Agarose gel electrophoresis
4. Silver staining of gels
5. Methylene blue DNA staining
6. Elution of DNA from agarose gel.
7. Restriction enzyme digestion.
8. Restriction mapping of plasmid DNA.

9. Ligation.
10. Transformation and selection of recombinants (Blue white screening).
11. RAPD
12. RFLP
13. Amplification of DNA - PCR
14. Determination of molecular weight of DNA.

Title of the paper		**Elective Paper 4 - Intellectual Property Rights & Biosafety**		
Category of the course		Year	Semester	Credits
		I	II	3
QUALIFICATION PACK		**NATIONAL OCCUPATIONAL STANDARDS**		
LFS/Q0219 Bio Process Engineer	LFS/N0247	Comply with safety requirements, GMP, SOP and manufacturing guidelines		
	LFS /N0101	Report any identified breaches in health, safety, and security policies and procedures to the designated person		
LFS/Q0308 Quality Control Chemist - Microbiology	LFS/N0322	Methods of using laboratory equipment like autoclave, laminar airflow, etc.		
HSS/Q6106 Healthcare Quality Assurance Manager	HSS/N9618	Explain standards for biomedical waste disposal		
AGR/Q7901 Agri Research Analyst	AGR/N9911	Adhere to garbage and trash disposal guidelines		
Course focusing on: Employability				

	Course Outcome
CO-1	The students would be able to get Intellectual Property Types of IP.
CO-2	Will be able to acquire knowledge about Patent databases and Patent search.
CO-3	The students are able to understand the Filing of a patent application.
CO-4	The students get knowledge of comprehension about Patent application-forms and Guidelines, fee structure and PCT.
CO-5	Students are learning the Biosafety, GMOs and Risk assessment.

UNIT	CONTENT	HOURS	COs	COGNITIVE LEVEL
I	Introduction to Intellectual Property Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of New GMOs; International framework for the protection of IP, IP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies; Introduction to History of GATT, WTO, WIPO and TRIPS.	**12**	**CO1**	**K1, K2**
II	Concept of 'prior art' Invention in context of "prior art"; Patent databases; Searching International Databases; Country-wise patent searches (USPTO, EPO, India etc.); Analysis and report formation.	**12**	**CO2 CO3**	**K3, K4**
III	Basics of Patents Types of patents; Indian Patent Act 1970; Recent Amendments; Filing of a patent application; Precautions before patenting-disclosure/non-disclosure; WIPO Treaties; Budapest Treaty; PCT and Implications; Role of a Country Patent Office; Procedure for filing a PCT application.	**12**	**CO2 CO3**	**K2, K3, K4**
IV	Patent filing and Infringement Patent application- forms and guidelines, fee structure, time frames; Types of patent applications: provisional and complete specifications; PCT and convention patent applications; International patenting-requirement, procedures and costs; Financial assistance for patenting-introduction to existing schemes; Publication of patents-gazette of India, status in Europe and US Patenting by research students, lecturers and scientists-	**12**	**CO4**	**K3, K4**

	University/organizational rules in India and abroad, credit sharing by workers, financial incentives Patent infringement- meaning, scope, litigation, case studies and examples.			
V	Biosafety Introduction; Historical Background; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety guidelines - Government of India; Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements including Cartagena Protocol.	**12**	**CO5**	**K1, K2, K3, K4**

Text Books:

1. Deepa Goel and Shomini Parashar, 2013. IPR, Biosafety and Bioethics, Pearson Education India.
2. Sree Krishna, V., 2007. Bioethics and Biosafety in Biotechnology, 1st Ed. New Age International Publishers, New Delhi.
3. Trayror, P.C., Frederic. R. and Koch, M. 2002. Biosafety. Board of Trustees, Michigan State University, USA.

Benjamin Lewin, 2000, Genes VII, First edition, Oxford, New York.

Reference Books:

1. XyeDayuan, 2015. Biosafety and Regulation for genetically modified organisms. Alpha Science International Limited.
2. William, S Klug and Michel, R Cummings, 2003. Concepts of Genetics, Seventh edition, Pearson Education, Singapore.
3. Beauchamp, T.L. and Leroy, W. 1999. Contemporary issues in bioethics. Wards worth publishing Co. Belmont, California.

Title of the paper	**Elective Paper 5 - Methods in Biology**		
Category of the course	Year	Semester	Credits
	I	II	3
Pre- requisites	Knowledge of biology at Higher Secondary level		
Objectives of the course	To introduce the student to basic methods applied in the field of biology		
QUALIFICATION PACK	**NATIONAL OCCUPATIONAL STANDARDS**		
LFS/Q0203 Production Supervisor/In Charge	LFS/N010	Handling and working on the instruments in the industry and research fields	
LFS/Q0509 Lab Technician/ Assistant	LFS/N0560		
LFS/Q0216 Manufacturing Assistant/ Helper	LFS/N0239		

Course focusing on: Employability

CO-1	Student acquire knowledge of methods of estimating population density and Remote sensing methods.
CO-2	Students will well verse in important molecular biology techniques.
CO-3	Student will gain knowledge about laboratory instruments.
CO-4	Student will get basic concepts and immense knowledge about medical Instruments.
CO-5	This unit clearly gives the knowledge about microscopic techniques.

UNIT	**CONTENT**	**HOURS**	**COs**	**COGNITIVE LEVEL**
I	Methods of estimating population density of animals and plants, ranging patterns through direct, indirect and remote observations, sampling methods in the study of behavior, habitat characterization: ground and remote sensing methods.	**12**	**CO1**	**K1, K2, K3**
II	Antibody generation, Detection of molecules using ELISA, RIA, western blot, immunoprecipitation, Flowcytometry and	**12**	**CO2**	**K2, K3, K4, K5**

	Immunofluorescence microscopy, detection of molecules in living cells, in situ localization by techniques such as FISH and GISH.			
III	Molecular analysis using UV/visible, fluorescence, circular Dichroism, NMR and ESR spectroscopy, Chromatography techniques, Molecular structure determination using X-ray diffraction and NMR, Molecular analysis using light scattering, different types of mass spectrometry and surface plasma resonance method.	**12**	**CO3**	**K2, K3, K4**
IV	Detection and measurement of different types of radioisotopes normally used in biology, incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, safety guidelines. Single neuron recording, patch-clamp recording, ECG, Brain activity recording, lesion and stimulation of brain, pharmacological testing, PET, MRI, fMRI, CAT.	**12**	**CO4**	**K2, K3, K4**
V	Visualization of cells and subcellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells, scanning and transmission microscopes, different fixation and staining techniques for EM, freeze-etch and freeze fracture methods for EM, image processing methods in microscopy.	**12**	**CO5**	**K3, K4, K5**

Text Books:

1. Khandpur, R.S. 2014. Handbook of Biomedical instrumentation, 3rd Edition. McGraw Hill Education.
2. Dinesh Kumar Chatanta, Prahlad Singh Mehra. 2012. Instrumental Methods of Analysis in Biotechnology. First Edition. I K International Publishing House Pvt. Ltd.
3. Ghatak K. L. 2011. Techniques and Methods in Biology. Prentice Hall India Learning Private Limited.
4. Keith Wilson, John Walker. 2018. Principles and Techniques of Biochemistry and Molecular Biology (8th Edition) Cambridge University Press.

Reference Books:

1. David L. Nelson, Michael M. Cox. Lehninger. 2008. Principles of Biochemistry, Fifth edition and W. H. Freeman, New York.

2. Shawn O. Farrell, Ryan T. Ranallo. 2007. Experiments in Biochemistry: A Hands-On Approach. Brooks Cole Publisher

Title of the paper	**Extra disciplinary Elective - Plant Physiology**		
Category of the course	Year	Semester	Credits
	I	II	3
Pre- requisites	Knowledge of biology at Higher Secondary level		
Objectives of the course	This course is designed to survey contemporary aspects of plant physiology with emphasis on recent research progress in related fields.Topics covered plant water relations, water transport, mineral nutrition, carbon and nitrogen metabolism (photosynthesis, respiration, and N assimilation), plant growth and development.		

Course focusing on: Employability

	Course Outcome
CO-1	A student will acquire the knowledge about photosynthesis and its molecular level pathway
CO-2	Will have deep knowledge about the plant's respiration and photorespiration
CO-3	Student will get appropriate knowledge about plant hormones and its mode of action
CO-4	Student will learn the basics about the photo assimilation of plants
CO-5	This unit clearly give the knowledge about the stresses that will affect the plants

UNIT	**CONTENT**	**HOURS**	**COs**	**COGNITIVE LEVEL**
I	Plant Physiology- Photosynthesis - Light harvesting complexes; mechanisms of electron transport; photoprotective mechanisms; CO2 fixation-C3, C4 and CAM pathways.	**12**	**CO 1 CO 3 CO 4 CO 5**	**K1, K2, K5**
II	Respiration and photorespiration – Citric acid cycle; plant mitochondrial electron transport and ATP synthesis; alternate oxidase; photorespiratory pathway. Nitrogen metabolism - Nitrate and	**12**	**CO 1 CO 2 CO 3**	**K1, K2, K5**

	ammonium assimilation; amino acid biosynthesis.		**CO 4** **CO 5**	
III	Plant hormones – Biosynthesis, storage, breakdown and transport; physiological effects and mechanisms of action. Sensory photobiology - Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins	**12**	**CO 1** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5**
IV	Stomatal movement; photoperiodism and biological clocks. Solute transport and photoassimilate translocation – uptake, transport and translocation of water, ions, solutes and macromolecules from soil, through cells, across membranes, through xylem and phloem; transpiration; mechanisms of loading and unloading of photo assimilates	**12**	**CO 1** **CO 3** **CO 4** **CO 5**	**K2, K4, K5**
V	Secondary metabolites - Biosynthesis of terpenes, phenols and nitrogenous compounds and their roles. Stress physiology – Responses of plants to biotic (pathogen and insects) and abiotic (water, temperature and salt) stresses. Common parasites and pathogens of crops.	**12**	**CO 1** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K5**

Text Books:

1. V. K. Jain. 2015. Fundamentals of Plant physiology 8th edition S Chand Publisher.
2. S. N. Pandey, B. K. Sinha, 2009.Plant Physiology, 4th Edition, Vikas publishing company, Noida.

Reference Books:

1. Lincoln Taiz, Eduardo Zeiger. 2015. Plant Physiology and Development. Sinauer Associates Inc.,U.S.
2. Philip Stewart, Sabine Globig. 2011. Plant Physiology. CRC publication. Apple Academic Press
3. Lincoln Taiz, Eduardo Zeiger. 2010. Plant Physiology: International Edition. Sinauer Associates Inc., U.S.

THIRD SEMESTER

Title of the paper		**Core Paper-9 Plant and Animal Biotechnology**		
Category of the course		Year	Semester	Credits
		II	III	4
QUALIFICATION PACK		**NATIONAL OCCUPATIONAL STANDARDS**		
AGR/Q8101 Plant Tissue Culture Technician	AGR/N8102	Preparation of culture Medium, types of medium and role of different phytohormones		
	AGR/N8103	*In vitro* organogenesis		
AGR/Q4804 Animal Health Worker	AGR/N4821	Gain knowledge about techniques of artificial insemination and infertility problems.		
LFS/Q0219 Bio Process Engineer	LFS/NO249	Contribution of technical support to develop and execute technical transfer plans Technical guidance to R&D cell-line development and media optimization functions Designing and execution of protocols		
Course focusing on: Entrepreneurship				

	Course Outcome
CO-1	This course enables the student to understand various types of culture techniques in plant tissue culture
CO-2	Will have complete knowledge about transgenic plants and its creation
CO-3	This course enables the student to understand various types of culture techniques in Animal tissue culture
CO-4	Students can learn cell lines, detection of cell viability and Cytotixicity
CO-5	Will have complete knowledge about transgenic animals and its creation.

UNIT	**CONTENT**	**HOURS**	**COs**	**COGNITIVE LEVEL**
I	Introduction of plant tissue culture, Composition of media, tissue and cell culture methods for plants, micro propagation, organogenesis, somatic embryogenesis, haploid and triploid production, protoplast isolation and fusion,	**12**	**CO-1**	**K1, K2, K4**

	hybrid and hybrid, Artificial seeds , production of secondary metabolites - Biosynthesis of terpenes, phenols and nitrogenous compounds and their roles. Organisms of conservation concern: Rare, endangered species. Conservation strategies.			
II	Plant Transformation- Methods of gene transformation in plants - Agro bacterium and crown gall tumour-mechanism of t-DNA transfer to plants. Breeding in plants, Marker – assisted selection, Transgenic plants-transgenic Responses of plants and conferring resistance to biotic (pathogen and insects) and abiotic (water, temperature and salt) stresses.	**12**	**CO-2**	**K1, K2**
III	Introduction to animal cell culture - Laboratory establishment- Culture medium: natural media, synthetic media, sera, balanced salt solutions and simple growth medium. Role of carbon dioxide. Behavior of cells in culture, properties, utility. Disaggregation of tissue and primary culture; cell separation, Slide and cover slip cultures, flask culture, test tube culture techniques	**12**	**CO-3**	**K1, K2, K4, K5**
IV	Definition of cell lines, maintenance and management; cell adaptation. Measurement of viability and Cytotixicity. Cell cloning, cell synchronization and cell manipulation. Various methods of separation of cell types, advantages and limitations; flow cytometry. Use of cryoprotectants, Methods of cryopreservation of cells and retrieval.	**12**	**CO-4**	**K1, K2, K3, K6**
V	Ovary stimulation. Oocytes recovery and uptake. Sperm preparation IVF and embryo transfer, Assisted Reproduction technology (ART). Transgenic animals in livestock improvement, transgenic animals as model for human diseases. Molecular approaches to diagnosis and strains identification. Breeding in animals, including marker-assisted selection. Common parasites and pathogens of animals.	**12**	**CO-5**	**K1, K2, K3, K4, K5**

Text Books:

1. Vinay Sharma and AfrozAlam.2015. Plant tissue culture. IK International publishing house Pvt limited.
2. C.B. Nirmala, G. Rajalakshmi and Chandra Karthick. 2009. Plant Biotechnology, 1st Edition, MJP Publishers.

3. H. S. Chawla 2009. Introduction to Plant Biotechnology.3rd edition. Oxford &IBH Publishers, New Delhi.
4. M.K.Razdan.2008.Introduction to Plant tissue culture, 2nd Edition Oxford and IBH publisher.
5. Ralf Portner. 2007. Animal cell biotechnology: Methods and protocols. 2nd Edition, Humana Press, New Jersey
6. K. Dass. 2005. Text book of Biotechnology, Second Edition, Wiley Dreamtech, India (P) Ltd.

Reference Books:

1. Sant Saran Bhojwani, Prem Kumar Dantu. 2013. Plant Tissue Culture: An Introductory Text. Springer Publication.
2. Adrian Slater. 2012. Plant Biotechnology: The Genetic Manipulation of Plants, 2ndEdition, Oxford University Press.
3. Ian Freshney. 2010. Culture of animal cells. 6th Edition, Wiley-Blackwell publishers.
J.D.Watson, M. Gillman, J. Witknowski and M. Zoller, 2006. Recombinant DNA. 3rd Edition, W.H.Freeman.

Title of the paper		**Core Paper-10 Bioinformatics**		
Category of the course		Year	Semester	Credits
		II	III	4
QUALIFICATION PACK		**NATIONAL OCCUPATIONAL STANDARDS**		
LFS/Q3904 Bioinformatics Associate/ Analyst	LFS/N3909	Basics of object-oriented programming languages including C++ and PERL for bioinformatics and Linux operating system		
	LFS/N3910	Analyze data from databases or datasets using computational tools to drive biological or medical knowledge and insight from them Implement bioinformatics tools to predict the structure and function of genes, proteins, drug ingredients and metabolic pathways		
LFS/Q3905 Bioinformatics Scientist	LFS/N3912	Explain the various applications of biology concepts of evaluation of data Recall drug discovery and development process and Quantitative Structure Activity Relationship (QSAR) to deliver the project outcomes Demonstrate the use of sequence analysis tools		

		Explain the outcomes of visualization and evaluation by applying concepts of cheminformatics, molecular docking and molecular dynamics
LFS/Q0605 Coordination Manager - Life Sciences	LFS/N0607	Maintain proper and concise records as per given format Exhibit good report writing skills Ability to communicate, solve conflicts, negotiate on behalf of the team and company Maintain confidentiality of information and data

Course focusing on: Employability

	Course Outcome
CO-1	A student will be able to use biological database and extract biological data
CO-2	Will have complete knowledge about sequence alignments and tools used.
CO-3	Student can access specialized secondary databases and can infer on phylogenetics
CO-4	Students can appreciate structural biology and biological pathway prediction
CO-5	This course enables students to apply bioinformatics in important clinical areas like Drug Designing and Discovery

UNIT	**CONTENT**	**HOURS**	**COs**	**COGNITIVE LEVEL**
I	Introduction to Bioinformatics –Historical overview and definitions-Bioinformatics databases – definitions-types of databases-nucleic acids and protein databases-considerations for biological databases-information search and data retrieval-electronic libraries-data retrieval tools-downloadable and web-based tools-tools for sequence searches, motif analysis and presentation-data mining of biological databases-data mining for sequence analysis	**12**	**CO-1**	**K1, K2, K4**
II	Sequence alignment-basics of sequence alignment-alignment of pairs of sequences-methods of sequence alignments–global and local alignment algorithms using scoring matrices-Multiple sequence alignment-methods of multiple sequence alignment-progressive alignment and Iterative	**12**	**CO-2**	**K1, K2**

	alignment algorithms-applications of multiple sequence alignments. Tools for similarity search and sequence alignment-Pairwise alignment based rigorous algorithm (Smith and Waterman) and Heuristic algorithms (FASTA and Blast).Markov models and Hidden Markov Models (HMM's).			
III	Bioinformatics for genome analysis and mapping-linkage analysis-physical and genetic maps- genome cloning-sequence assembly tools-contigs-human genome project(HGP)-basics of gene prediction-pattern recognition-gene prediction methods and tools- Protein structure prediction and classification-Motifs, patterns, profiles and fingerprints-Tools and databases for proteomics- -DNA microarrays-applications of Microarray technology-Bioinformatics for phylogenetic analysis-distance-based and character-based methods-phylogenetic tree evaluation-tools for phylogenetic evaluation. Genomics and its application in health and agriculture including gene therapy	**12**	**CO-3**	**K1, K2, K4, K5**
IV	Molecular visualization tools– Structure analysis tools – VAST and DALI-Basics of programming languages-C and PERL for bioinformatics-basics of Linux operating system-analysis of metabolic pathways-KEGG Database-basics of technical writing and report writing –communicative skills for reports according to SOPs and regulations-Structural biology - Homology modeling-prediction of functionally important features of proteins and biomolecules-biosensors.	**12**	**CO-4**	**K1, K2, K3, K6**
V	Medical application of Bioinformatics – disease genes, Drug Discovery – Introduction– Pharmacogenetics-Pharmacogenomics-Single Nucleotide Polymorphisms(SNPs)-Steps in drug discovery – Target Identification-G-protein coupled receptors-Ion channels: drug discovery and techniques-voltage-gated and non-voltage gated ion channels-Aquaporins-Biomarkers in drug development- Target Validation and	**12**	**CO-5**	**K1, K2, K3, K4, K5**

	druggability–cell cycle in drug discovery–cell cycle regulatory mechanisms and cancer. Lead Identification –computer-aided drug design-Preclinical pharmacology and toxicology – ADME-Tox–Rational drug design – Computer aided drug design – Ligand based approach – Target based approach.			

Text Books:

1. Rastogi, S.C., Mendiratta, N., and Rastogi, P. 2013. Bioinformatics Methods and Applications-Genomics, Proteomics and Drug Discovery. Fourth edition. Prentice-Hall of India Private Limited, New Delhi.
2. Thiagarajan, B. and Rajalakshmi, P.A. 2009. Computational Biology, MJP publishers, Chennai.
3. Bosu, O and Thukral, S.K. 2007. Bioinformatics Databases, Tools and Algorithms.Oxford University Press, New Delhi.
4. Lohar, S. P. 2009. Bioinformatics, MJP Publishers, Chennai.

Reference Books:

1. Lesk, Arthur, M.2014.Introduction to bioinformatics, Fourth edition. Oxford University Press, Oxford.
2. Singh, R. and Sharma, R.2010. Bioinformatics basics, algorithms and applications. Universities Press
3. Atwood, T.2007.Introduction to Bioinformatics. Oxford University Press, Oxford.
4. Lakshminarayanan, R. 2010.English for technical communication. Scitech Publications, India.

Title of the paper	**Core Paper 11 - Molecular Biology**		
Category of the course	Year	Semester	Credits
	II	III	4
QUALIFICATION PACK	**NATIONAL OCCUPATIONAL STANDARDS**		
LFS/Q3905 Bioinformatics Scientist	LFS/N3912	Explain the basic and fundamental concepts of human genetics, disease, and human genomics, Deliver genome projects and genetic studies or lab diagnostics by using the concepts of molecular genomics, Deliver project outcome by using appropriate coding and non-coding gene regulatory pathways	
Course focusing on: Employability			

	Course Outcome
CO-1	The students would learn central dogma.
CO-2	The students will be able to acquire knowledge about DNA replication and Recombination.
CO-3	The students are able to understand the RNA synthesis and Transport.
CO-4	The students get knowledge of comprehension about Protein synthesis and processing
CO-5	The students understand the gene expression studies.

UNIT	**CONTENT**	**HOURS**	**COs**	**COGNITIVE LEVEL**
I	Basic mechanisms in the living cell-role of biomolecule in the cell-cell division-mitosis-meiosis-proteins-nucleic acids-DNA-RNA-types and functions-Genetic code-chromosome structure-DNA organization-central dogma-signal transduction-C-value paradox.	**12**	**CO1**	**K1, K2, K3**
II	DNA replication, repair and recombination-Unit of replication, enzymes involved replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms, homologous and site-specific recombination.	**12**	**CO2**	**K2, K3**
III	RNA synthesis and processing -transcription factors and machinery, formation of initiation complex, transcription activator and repressor, RNA polymerases, capping, elongation, and termination, RNA processing, RNA editing, splicing, and polyadenylation, structure and function of different types of RNA, RNA transport.	**12**	**CO2** **CO3**	**K2, K3, K4**
IV	Protein synthesis and processing -Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, and translational proof-reading, translational inhibitors, post-translational modification of proteins.	**12**	**CO2** **CO3** **CO4**	**K3, K4, K5**
V	Control of gene expression at transcription and translation level -regulating the expression of phages, viruses, prokaryotic and eukaryotic genes, role of chromatin in gene expression and gene silencing.	**12**	**CO5**	**K5, K6**

Text books:

1. George M Malacinski. 2015. Freifelder'S Essentials of Molecular Biology. Jones & Bartlett Publishing Ltd.
2. Veer Bala Rastogi, 2015. Principles of Molecular Biology, 2nd Edition, Medtech Publisher, New Delhi.
3. Burton E. Tropp. 2012. Molecular Biology: Genes to Proteins: 4th Edition, Laxmi Publications.

Reference Books:

1. 1.James D. Watson and A. Baker Tania. 2017. Molecular Biology of the Gene, 7th Edition. earson Learning.
2. Lodish, Arnold Berk and Chris A. Kaiser. 2016. Molecular Cell Biology. 8th Edition, WH Freeman Company.
3. Bruce Alberts, Alexander Johnson, Julian Lewis. 2014. Molecular Biology of the Cell, 6th Edition, Garland Science.

Core Paper 12 - Practical – III				
Title of the paper		**Plant & Animal Biotechnology, Bioinformatics, Molecular Biology**		
Category of the course		Year	Semester	Credits
Core		II	III	4
AGR/Q8101 Plant Tissue Culture Technician	AGR/N8102	Preparation of culture Medium, types of medium and role of different phytohormones		
	AGR/N8103	*In vitro* organogenesis		
LFS/Q3905 Bioinformatics Scientist	LFS/N3912	Explain the basic and fundamental concepts of human genetics, disease, and human genomics Deliver genome projects and genetic studies or lab diagnostics by using the concepts of molecular genomics, Deliver project outcome by using appropriate coding and non-coding gene regulatory pathways		
LFS/Q3904 Bioinformatics Associate/ Analyst	LFS/N3910	Analyze data from databases or datasets using computational tools to drive biological or medical knowledge and insight from them, Implement bioinformatics tools to predict the structure and function of genes, proteins, drug ingredients and metabolic pathways		
Course focusing on: Employability				
CO-1. A student will study about culturing of plant and animal cells CO-2. Will come to know practically about various tools in Bioinformatics CO-3. Students study in detail about isolation and analysis of DNA.				
Plant & Animal Biotechnology 1. Sterilization Techniques. 2. Preparation of MS medium.				

3. Micro propagation.
4. Callus induction.
5. Induction of Suspension culture.
6. Production of secondary metabolites from callus
7. Preparation of synthetic seeds
8. Regeneration of Shoots callus culture
9. Regeneration of roots from shoots.
10. Protoplast Isolation
11. Protoplast viability
12. Protoplast fusion.
13. Induction of tumors by Agrobacterium.
14. Isolation of Ti plasmid.
15. Meristem culture.
16. Introduction to Animal Cell culture: Procedure for handling cells and medium.
17. Cleaning and sterilization of glassware and plastic tissue culture flasks
18. Preparation of animal cell culture media
19. Preparation of sera for animal cell culture
20. Preparation of single cell suspension from chicken liver (Primary cell culture).
21. Trypsinization of established cell culture.
22. Cell counting and viability - staining of cells a) Vital Staining (Trypan blue, Erythrosin b) Giemsa staining.
23. MTT Assay

Bioinformatics

1. Sequence retrieval from Genbank
2. Sequence retrieval from Uniprot.
3. Sequence identity search- Sequence similarity search using BLAST
4. Sequence similarity search using FASTA
5. Sequence similarity search using PSI BLAST
6. Sequence similarity search using PHI- BLAST.
7. Prediction of signal sequence using SignalP online tool
8. Pattern Search (Domains & Motifs) using Pfam
9. ORF gene Search - Genscan
10. Sequence translation using ExPASy translate tool
11. Characterization of retrieved protein sequence by ProtParam tool.
12. Pair-wise global sequence alignment using EBI-EMBOSS Needleman-Wunsch tool
13. Pair-wise local sequence alignment using EBI-EMBOSS Smith-Waterman tool
14. Multiple sequence alignment using EBI-CLUSTALW2.
15. PHYLOGENY- Phylogenetic tree using PHYLIP.
16. Prediction of secondary protein structure using GOR (Garnier-Osguthorpe-Robson) server.
17. Prediction of tertiary protein structure using SWISS-MODEL Server
18. Validation of the predicted structure using PROCHECK server
19. Molecular visualization of proteins using RASMOL.

20. Docking of small molecule with protein structure using Hex software.
21. Docking of two proteins using PatchDock (Protein-Protein docking) tool.
22. Retrieval of *E.Coli* glycolytic pathway from KEGG.

Molecular Biology

1. Preparation of buffer stocks (TE, TBE, TAE)
2. Isolation of genomic DNA from plant and animal tissues
3. Isolation of genomic DNA from *E. coli*
4. Isolation of plasmid DNA from *E. coli* / *Agrobacterium*
5. Agarose gel electrophoresis
6. Molecular weight determination of isolated DNA using agarose gel electrophoresis
7. Extraction and Isolation of histone proteins from plant, animal tissues and *E. coli.*
8. Molecular weight determination of isolated protein using SDS-PAGE
9. Estimation of proteins by Lowry and Bradford method
10. Western blotting
11. Southern blotting
12. PCR

Title of the paper	**Elective Paper 6 - Nanobiotechnology**		
Category of the course	Year	Semester	Credits
	II	III	3
Pre- requisites	Knowledge of biology at Research level		
Objectives of the course	To introduce the student to basics of Nanobiotechnology		
QUALIFICATION PACK	**NATIONAL OCCUPATIONAL STANDARDS**		
LFS/Q1301 Quality Control Chemist	LFS/N0314		Photoflourometer
LFS/Q0504 Regulatory Medical Writer	LFS/N0512		Preparation of dossiers that includes sections on the protocol for each planned study, toxicology information
LFS/Q0505 Research Associate/ Associate Scientist Technical/ Process Development	LFS/N0516		Concepts and technologies, various synthesis technologies, and analytical

LFS/Q0509 Lab Technician/ Assistant	LFS/N0530	Operational knowledge of laboratory equipment and instruments such as spectrometer, colorimeter, and other equipment
LFS/Q1301 Quality Control Chemist	LFS/N0301	Handling, use and interpretation of data generated on the analytical instruments used in the Quality Control Laboratory
LFS/Q1201 Production/ Manufacturing Chemist	LFS/N0203	Follow-up on Reaction set up/ Mixing / Granulation/ Coating/ Filling/ Encapsulation/ any other production activity as per Good Manufacturing Practice

Course focusing on: Employability

	Course Outcome
CO-1	Students would be learning basics and scale of nanotechnology
CO-2	Will be able to acquire classes of nanomaterials and Nanocomposites.
CO-3	The students are able to understand the synthesis of nanomaterials
CO-4	Comprehension about Nanoparticle characterization
CO-5	Students understand the application of nanomaterials

UNIT	**CONTENT**	**HOURS**	**COs**	**COGNITIVE LEVEL**
I	Introduction – Scientific revolutions – Definition of a Nanosystem – Basic concepts of Nanoscience and Nanotechnology- Definition of nanoparticle and its types.	**12**	**CO-1**	**K1, K2**
II	Classification based on dimensionality - Quantum Dots, Wells and Wires –Carbon - based nano materials (buckyballs, Nanotubes, grapheme) – Metal based nanomaterials (Nanogold, nanosilver and metal oxides) - Nanocomposites – Nanopolymers – Nanoglasses – Nano ceramics - Biological nanomaterials.	**12**	**CO-2**	**K1, K2**

III	Chemical Methods: Metal Nanocrystal by Reduction - Solvothermal Synthesis - Photochemical Synthesis - Sonochemical Routes - Chemical Vapor Deposition (CVD) – Metal Oxide - Chemical Vapor Deposition (MOCVD). Physical Methods**:** Ball Milling – Electrodeposition - Spray Pyrolysis - Flame Pyrolysis - DC/RF Magnetron Sputtering - Molecular Beam Epitaxy (MBE).	**12**	**CO-3**	**K1, K2, K3, K6**
IV	Introduction to Nanoparticle characterization: Methods and Instruments- X- ray diffraction, Neutron diffraction and Electron diffraction – different types of mass spectrometry surface plasma resonance methods. X - Ray fluorescence spectroscopy – Fourier transform Infrared spectroscopy (FTIR) – Ultraviolet and visible spectroscopy (UV - Vis) – Differential Scanning Calorimetry (DSC). Field Emission Scanning Electron Microscopy (FESEM) – Environmental Scanning Electron Microscopy (ESEM) High Resolution Transmission Electron Microscope (HRTEM), Photo flourometer, Atomic Absorption Spectrophotometer, Spectrometer, colorimeter	**12**	**CO-4**	**K1, K2, K3, K4, K5**
V	Potential application of nanomaterials in electronics, Nanorobots, sensors - Applications of nanomaterials in medicine and biotechnology – Nanotoxicology challenges.	**12**	**CO-5**	**K1, K2, K3, K5, K6**

Text Books:

1. Thiruvadigal, J.D., Ponnusamy, S. Sudha and Krishnamohan M., 2013. Materials Sciences, Vibrant Publication, Chennai.
2. Singh, Shubra, M.S., and Rao, Ramachandra.2013. Nanoscience and Nanotechnology: Fundamentals to Frontiers. Wiley Publishers, India.
3. Murthy, B.S., Shankar, P., Baldev, R., Rath, B.B., and Murday, J. 2012.Textbook of Nanoscience and Nanotechnology. Universities Press, IIM, India.
4. Pradeep T, 2012. A Textbook of Nanoscience and Nanotechnology, Tata McGraw-Hill Education Pvt. Ltd.
5. Shanmugam, S. 2010.Nanotechnology.MJP Publishers, Chennai, India.
6. Subbiah Balaji, 2010. Nanobiotechnology.MJP Publishers, Chennai, India.

Reference Books:
1. Laurencin, Lakshmi S. Nair, 2012. Nanotechnology and tissue engineering. CRC press.
2. M.A.Shah and Tokeer Ahmad 2010 Principles of Nanoscience and Nanotechnology Alpha Science International Ltd.
3. Kurt E. Geckeler, Hiroyuki Nishide, 2010. Nanotechnology- Advanced Nanomaterials, Wiley VHC.
4. Chad A. Mirkin and Christof M. Niemeyer. 2007. Nanobiotechnology II: More Concepts and Applications, Wiley-VCH.
5. Poole, F.O.C.2007. Introduction to Nanotechnology. Wiley Publishers, USA.
7. Vollath, D. 2013. Nanomaterials an introduction to synthesis, properties, and applications.2nd ed. Weinheim Ander Bergstrasse, Publishers, Germany
8. Houdy, Philippe. Lahmani, Marcel. Marano, Francelyne.2011.Nanoethics and Nanotoxicology.1st ed. Berlin, Heidelberg: Springer Berlin Heidelberg: Imprint: Springer

<table>
<tr><td>Title of the paper</td><td colspan="3">Elective Paper 7- Virology</td></tr>
<tr><td rowspan="2">Category of the course</td><td>Year</td><td>Semester</td><td>Credits</td></tr>
<tr><td>II</td><td>III</td><td>3</td></tr>
<tr><td>QUALIFICATION PACK</td><td colspan="3">NATIONAL OCCUPATIONAL STANDARDS</td></tr>
<tr><td>HSS/Q0301 Medical Laboratory Technician</td><td>HSS/N9610</td><td colspan="2">Describe the Classification and general properties of viruses
Describe the Morphology, pathogenicity and laboratory diagnosis of human viruses.</td></tr>
<tr><td>LFS/Q0507 Scientist Clinical Research and Development</td><td>LFS/N0522</td><td colspan="2">Examine and analyze at microscopic, chemical and molecular level the body fluids and cells to look for bacteria, parasites, and other microorganisms.
Identify types and uses of vaccines in the prevention of infection</td></tr>
<tr><td>HSS/Q0301 Medical Laboratory Technician</td><td>HSS/N9610</td><td colspan="2">Describe the Classification and general properties of viruses
Describe the Morphology, pathogenicity and laboratory diagnosis of human viruses.</td></tr>
<tr><td colspan="4">Course focusing on: Employability</td></tr>
<tr><td></td><td colspan="3">Course Outcome</td></tr>
<tr><td>CO-1</td><td colspan="3">The students will gain knowledge in detail about the structure of animal viruses and plant viruses</td></tr>
<tr><td>CO-2</td><td colspan="3">The students will come to study about the genome organization of animal viruses</td></tr>
</table>

CO-3	The students will study in detail about the detail genome organization of plant viruses
CO-4	The students will know about the methods to diagnose animal virus infection
CO-5	The students will study about the methods to diagnose plant virus infection

UNIT	CONTENT	HOURS	COs	COGNITIVE LEVEL
I	Structure of animal viruses and plant viruses; Classification of animal and plant viruses; Satellite viruses; Viroids; Virusoids etc.; Diseases causes by animal viruses and plant viruses; Economic loss due to important viruses.	**12**	**CO1**	**K1,K2,K3**
II	Genome organization of animal viruses; Replication of RNA viruses; Replication of DNA viruses	**12**	**CO2**	**K3,K4**
III	Genome organization of plant viruses; Replication of RNA viruses; Replication of DNA viruses	**12**	**CO3**	**K2, K3, K4**
IV	Methods to diagnose animal virus infections: Electron microscopy, Tissue culture growth of viruses, Virus quantitation assays, Viral serology: ELISA, neutralization assays; Molecular methods: hybridization, PCR, real time PCR, sequencing, microarray, gene silencing and antiviral assays.	**12**	**CO2 CO4**	**K4, K5, K6**
V	Methods to study plant viruses; Infectivity assays – Sap transmission, insect vector transmission, agroinfection (using Agrobacterium); Ultracentrifugation, electron microscopy, serological methods, immuno electrophoretic in gels, direct double-antibody sandwich method, Dot ELISA, Immunosorbent electron microscopy (ISEM), Decoration technique, Polymerase chain reaction; DNA and oligonucleotide microarray; Gene silencing, PTGS & TGS, viral suppressors of gene silencing.	**12**	**CO3 CO5**	**K3, K4, K5, K6**

Text Books:

1. James D. Watson, 2017. Molecular Biology of the Gene. 7th Edition, Pearson Education.
2. Apurba Sankar Sastry and Sandhya Bhat, 2016. Essentials of Medical Microbiology, Jaypee Brothers Medical Publishers.
3. Peter Paolella, 2010. Introduction to Molecular Biology, McGraw Hill Education.
4. Vinod Singh, 2010. Virology. Ibdc Publishers

Reference Books:

1. Alan J. Cann, 2015. Principles of Molecular Virology. Academic Press.

2. Bruce Alberts et al. 2014. Molecular Biology of the Cell, Sixth Edition, Garland Science.

Title of the paper	**Extra Disciplinary Elective - Animal Physiology**		
Category of the course	Year	Semester	Credits
	II	III	3
Pre- requisites	Knowledge of biology at Higher Secondary level		
Objectives of the course	To provide students with a comprehensive overview of animal physiology from molecular, cellular and whole animal systems approaches.		
QUALIFICATION PACK	**NATIONAL OCCUPATIONAL STANDARDS**		
LFS/Q0401 Medical Sales Representative	LFS/N0401 LFS/N0401	Use the basics of general anatomy, physiology, and various systems of the human body while performing the product presentation to healthcare professionals	
HSS/Q2301 Emergency Medical Technician - Basic	HSS / N 2306 HSS/N 2312 - 2319	Vital assessing equipments such as BP apparatus Identify and locate on the body the following topographic terms: medial, lateral, proximal, distal, superior, inferior, anterior, posterior, midline, right and left, mid-clavicular, bilateral, and mid-axillary. Describe anatomy and functions of the following major body systems: respiratory, circulatory, musculoskeletal, nervous, and endocrine.	
Course focusing on: Employability			
	Course Outcome		
CO-1	A student will develop understanding for the fundamental concepts of blood circulation and its system with comparative anatomy		
CO-2	Will have theoretical knowledge on respiratory system in different species with its anatomical and physiological effects		
CO-3	Familiarize students with nervous system physiology and sensory organs		
CO-4	Students can develop basic understanding of endocrine system and hormones		

CO-5	The course aims to develop critical thinking skills, to apply physiological concepts and principles at the basic and applied levels, to develop a working knowledge of the major physiological systems, and to associate anatomical areas with their specific function

UNIT	CONTENT	HOURS	COs	COGNITIVE LEVEL
I	Animal Physiology- Blood and circulation - Blood corpuscles, haemopoiesis and formed elements, plasma function, blood groups, hemoglobin, immunity, haemostasis. Cardiovascular System: Comparative anatomy of heart structure, myogenic heart, specialized tissue, ECG – its principle and significance, cardiac cycle, heart as a pump, blood pressure, neural and chemical regulation of all above.	12	CO 1 CO 5	K1, K2, K4, K5, K6
II	Genome organization of animal viruses; Replication of RNA viruses; Replication of DNA viruses	12	CO2	K3 K4
II	Respiratory system - Comparison of respiration in different species, anatomical considerations, transport of gases, exchange of gases, waste elimination, neural and chemical regulation of respiration.	12	CO 2 CO 5	K1, K2, K4
III	Nervous system - Neurons, action potential, gross neuroanatomy of the brain and spinal cord, central and peripheral nervous system, neural control of muscle tone and posture. Sense organs - Vision, hearing and tactile response	12	CO 3 CO 5	K1, K2, K3, K4
IV	Digestive system - Digestion, absorption, energy balance, BMR. Endocrinology and reproduction - Endocrine glands, basic mechanism of hormone action, hormones and diseases; reproductive processes, gametogenesis, ovulation, neuroendocrine regulation	12	CO 4 CO 5	K1, K2, K3, K4
V	Excretory system - Comparative physiology of excretion, kidney, urine formation, urine concentration, waste elimination, maturation, regulation of water balance, electrolyte balance, acid-base balance. Thermoregulation - Comfort zone, body temperature – physical, chemical, neural regulation, acclimatization. Stress and adaptation.	12	CO 5	K1, K2, K4, K5

Text Books:

1. S. C. Rastogi, 2015. Essentials of Animal Physiology, 3rd Edition, New Age International Pvt Ltd, New Delhi

2. Surendra Nath Paipuru, 2013. Essentials of Animal Physiology. Lap Lambert Academic Publishing GmbH KG.

Reference Books:

1. C.D. Moyes and P.M. Schulte. 2016. Principles of Animal physiology. Second Edition. Pearson Education.

2. Richard Hill, Gordon A. Wyse & Margaret Anderson, 2016. Animal Physiology. Sinauer Associates Inc Publisher.

Title of the paper	**Elective offered to other departments - Principles of Gene Manipulation Technology**		
Category of the course	Year	Semester	Credits
	II	III	3
QUALIFICATION PACK	**NATIONAL OCCUPATIONAL STANDARDS**		
LFS/Q3905 Bioinformatics Scientist	**LFS/N3912**	**Make use of the concepts of genetic studies / lab diagnostics**	
Course focusing on: Employability			

	Course Outcome
CO-1	Students can learn about tools in gene manipulation
CO-2	This course enables students to know about genetic engineering techniques
CO-3	Will able to gain complete knowledge gene transfer technique
CO-4	Students can understand transgenic animals
CO-5	This course gives an idea about GMOs and ethics

UNIT	**CONTENT**	**HOURS**	**COs**	**COGNITIVE LEVEL**
I	Restriction enzymes, DNA modifying enzymes, cloning vectors, prokaryotic hosts-Creating Recombinant DNA molecules-Isolation and Cloning of genes	**12**	**CO-1**	**K1, K2, K4**

II	Construction of representative cDNA and genomic libraries-Polymerase Chain Reaction (PCR) and applications-Innovations in PCR - Real-time PCR-Taqman fluorescent probes-Pfu and Tth polymerases in PCR-Southern/Northern Blotting analysis-RFLP-RAPD analysis-Applications of cloning and DNA analysis-Gene expression studies-PCR-Production of protein-Applications in Medicine and Agriculture-Protein for non-invasive imaging-near-infra-red Fluorescent Protein (iRFP)	**12**	**CO-2**	**K1, K2, K3, K5**
III	Gene transfers-Introduction of foreign genes into cells:electroporation-biolistic transfer-transfection-Selectable markers-Microinjection-Embryonic stem cells-Reporter transgenes-Homologous recombination-"knock in/knock out"-Recombinant cellulose binding domains (CBD) in affinity chromatography	**12**	**CO-3**	**K1, K2, K3, K4, K5**
IV	Transgenics-approaches to transgenesis: Microinjection-Embryonic stem cells-Sperm mediated transfer-Mammalian cloning by nuclear transfer-"Dolly" the cloned sheep-"Noori"-Cloned Indian goat-Genetic mosaics-Chimeric organisms- Tender Coconut Water (TCW) as animal cell growth media	**12**	**CO-3 CO-4**	**K1, K2, K4, K5**
V	Edible Vaccines-Disease Resistance in transgenic organisms-Pest and herbicide resistant plants. The Mx gene system or anti-viral disease resistance in animals -Biosafety and Food safety of GMOs-Regulatory organizations in India for biologic drugs-Department of biotechnology (DBT)-Review Committee on genetic manipulation (RCGM)-Central Drugs Standard Control Organization (CDSCO).	**12**	**CO-5**	**K1, K2, K3, K4, K5**

Text Books:

1. Brown, T.A. 2014, Gene cloning and DNA analysis: An Introduction. 6th Edition, Wiley-Blackwell.
2. Strachan, T. and Read, A.P. 2010, Human Molecular Genetics 4. 4th Edition, Garland Science.
3. Sandy B. Primrose and Richard Twyman, 2006, Principles of Gene manipulation and genomics. 7th Edition, Wiley-Blackwell.

Reference Books:

1. Dubey R.C., 2014. A Textbook of Biotechnology. 5th Edition, S.Chand Publications.
2. Dabhole M.P. 2014. Recent Innovations in Therapeutic Recombinant Protein**.** Pharma Bio World.
3. Dubey, R.C. and Maheshwari D.K., 2013. A Textbook of Microbiology. 3rd Edition, S. Chand Publications.
4. Gupta, P.K., 2012. Biotechnology and Genomics. 1st Edition, Rastogi Publications.

5. Michael Zachariou, 2008. Affinity Chromatography: Methods and Protocols. 1st Edition, Humana Press.

FOURTH SEMESTER

Title of the paper	**Core Paper 13 - Stem Cell Biology**		
Category of the course	Year	Semester	Credits
	II	IV	4
Pre- requisites	Knowledge of biology at Research level		
Objectives of the course	To introduce the student to basics of Stem Cell Biology		
QUALIFICATION PACK	**NATIONAL OCCUPATIONAL STANDARDS**		
LFS/Q0308 Quality Control Chemist - Microbiology	LFS/N0321	Applications of flow cytometry	
LFS/Q2301 Quality Control Biologist	LFS/N0338	Perform all the test activities and validations satisfactorily, including procedures such as cell culture	
Course focusing on: Employability			

	Course Outcome
CO-1	Students can learn a topic on introduction of stem cell and its classification, Embryonic, hematopoietic and neural stem cells and its sources.
CO-2	This course enables students to know about embryonic Stem Cells, organogenesis and Stem cells cryopreservation
CO-3	Will able to gain complete knowledge on characteristics of stem cell, cell cycle pathways and its applications of flow cytometry
CO-4	Students can understand chromatin modification and transcriptional regulation, chromatin modifying factors and human embryonic stem cell ethical issues
CO-5	This course gives an idea about therapeutic applications of embryonic stem cells, bone marrow stem cells, adipose derived stem cells and hematopoietic stem cells in Heart regeneration and neural defects.

UNIT	**CONTENT**	**HOURS**	**COs**	**COGNITIVE LEVEL**
I	Introduction to stem cells, classification, Potency, commitment, specification, induction, competence, Sources, programming and reprogramming, tissue specific stem cells	**12**	**CO-1**	**K1, K2**

	Embryonic hematopoietic, Basic pluripotent stem cell culture and neural stem cells, Classification and Sources			
II	Embryonic Stem Cells Blastocyst and inner cell mass cells; Organogenesis; Cellular communication Regulation of hematopoietic, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation. Mammalian Nuclear Transfer Technology; Stem cell differentiation; Stem cells cryopreservation	**12**	**CO-2**	**K1, K2, K3**
III	Characteristics of stem cell- cell cycle and applications of flow cytometry, Ras\Raf pathway, PI3K cell signalling, p53 check points, Role of LIF pathway in cell cycle control.	**12**	**CO-3**	**K1, K2, K4, K5**
IV	Structure of chromatin and chromosomes, heterochromatin, euchromatin. Chromatin modification and transcriptional regulation, chromatin modifying factors, Chromosomal inactivation. Human Embryonic Stem Cells and society. Human stem cells research: Ethical considerations; Stem cell religion consideration; Stem cell based therapies: Preclinical regulatory consideration and Patient advocacy.	**12**	**CO-4**	**K1, K2, K3, K4, K5**
V	Therapeutic applications of Embryonic stem cells, Bone marrow stem cells, Adipose derived stem cells and Hematopoietic stem cells in Heart regeneration and neural defects.	**12**	**CO-5**	**K3, K4, K5, K6**

Text Books:

1. Jonathan Slack, 2012. Stem cells: A very short introduction. Oxford University Press.
2. Vemuri C. Mohan. 2010. Stem Cell assay. Humana press, New Jersey.
3. Robert Lanza: 2005. Essentials of Stem Cell Biology. Academic Press.
4. Kursad Turksen. 2004. Adult Stem Cells. Humana Press, Inc.
5. Lakshmipathy, Uma. Thyagarajan, Bhaskar. 2012. Primary and stem cells gene transfer technologies and applications. Hoboken, NJ: John Wiley.
6. Hayat, M.A. 2012. Stem Cells and Cancer Stem Cells, Volume 3 Stem Cells and Cancer Stem Cells, Therapeutic Applications in Disease and Injury.1st Edition. Dordrecht: Springer Netherlands: Imprint: Springer.

Reference Books:

1. Rex Turner, 2015. Stem Cells: Biology and Diseases. Hayle Medical
2. Ann A. Kiessling. 2006. Human Embryonic Stem Cells. 2nd Edition, Jones and Bartlett Publishers, Inc.
3. Kondo, Motonari, 2010. Hematopoietic Stem Cell Biology.1st Edition. Totowa, NJ: Humana Press: Imprint: Humana
4. Proquest, Sidhu, Kuldip. S. 2012. Frontiers in pluripotent stem cells research and

therapeutic potentials bench-to-bedside.1st Edition. Dubai, United Arab Emirates: Bentham Science.
5. Mohan C. Vemuri, Navjot Kaur, 2015. Neural Stem Cell Assays. Wiley Blackwell Publisher,

Title of the paper	**Elective Paper 9 - Research Methodology**		
Category of the course	Year	Semester	Credits
	II	IV	3
Pre- requisites	Knowledge of biology at Higher Secondary level		
Objectives of the course	To introduce the student to basics of Research Methodology		
QUALIFICATION PACK	**NATIONAL OCCUPATIONAL STANDARDS**		
LFS/Q0605 Coordination Manager - Life Sciences	LFS/N0102	Involve in Data Collection and Analysing and Preparing Reports	
LFS/Q0203 Production Supervisor/In Charge	LFS/N0205		
LFS/Q0311 QMS Specialist/ In charge	LFS/N0327		
Course focusing on: Employability			

	Course Outcome
CO-1	Student Acquire knowledge about research, types and importance of research
CO-2	Students will learn about research proposal
CO-3	Student will gain knowledge about data and information collection
CO-4	Student will get basic concepts and immense knowledge about data collection
CO-5	This unit clearly gives the knowledge about usage of computer on research

UNIT	**CONTENT**	**HOURS**	**COs**	**COGNITIVE LEVEL**
I	Research Methodology - An Introduction: Meaning of Research, Objectives of Research,	**12**	**CO-1**	**K1, K2, K3, K4, K5, K6**

	Types of Research, Research Approaches, Importance of knowing how research is done, Research Process, Criteria of good research. Defining the Research Problem; Research Design; Selecting the problem.			
II	Hypothesis What is hypothesis Research hypothesis and Null hypothesis. Research Design Meaning of research Objective of research Motivation of research Significance of research. How to prepare a research proposal Literature survey for the proposed research work. How to conduct field survey Sampling fundamentals Important sampling distributions.	**12**	**CO-2 CO-3**	**K1, K2, K3, K4, K5, K6**
III	Methods of data and information collection, Collection of primary data Observation method Interview method, Collection of secondary data Selection of appropriate method for data collection. Processing and analysis of data Basic statistical techniques Analysis.	**12**	**CO-2 CO-3**	**K1, K2, K3, K4, K5, K6**
IV	Measurement and scaling technique Refining Skills in Regression Analysis Advanced Multivariate Analysis. Sampling errors Theory of errors and residuals, precision, measure of precision, Probable error of function, rejection of observation, Experimental designs Design of experiments, completely randomized and random block design, factorial experiments, missing plot technique, Modeling and simulation.	**12**	**CO-4**	**K1, K2, K3, K4, K5, K6**
V	Computer aided statistical analysis Electronic data processing, operating system-common software available, Internet applications, database and bioinformatics. Use of statistical software packages-SPSS. Scientific writing and publication Interpretation, technical Report writing and presentation (oral/poster), Overhead projector power point slides, Journal selection.	**12**	**CO-5**	**K1, K2, K3, K4, K5, K6**

Text Books:

1. Donald H. Mc Burney. 2006. Research Methods, 5th Edition, Thomson Learning.'

2. Kothari C.K. 2014. Research Methodology- Methods and Techniques, 3rd Edition, New Age International, New Delhi

Reference Books:

1. Research methods and statistics, I Walker, Macmillan International Higher Education (2010).

2. Montgomery, Douglas C. & Runger, George C. 2007. Applied Statistics & Probability for Engineers, 3rd Edition, Wiley India.

3. Krishnaswamy, K.N., Sivakumar, Appa Iyer and Mathiranjan M. 2006. Management Research Methodology; Integration of Principles, Methods and Techniques, 1st Edition, Pearson Education, New Delhi.

Title of the paper	**Elective Paper 10 - Marine Biotechnology**		
Category of the course	Year	Semester	Credits
	II	IV	3
QUALIFICATION PACK	**NATIONAL OCCUPATIONAL STANDARDS**		
LFS/Q0214 Environment, Health and Safety Manager	LFS/N0230	Relevant Environmental Health and Safety standards pollution control, pollution prevention and recycling programs	
	LFS/N0232	Local/ state/national environmental health and safety standards and regulations	
AGR/Q4904 Aquaculture worker	AGR/N4918	Routine Physico-chemical testing of water. A fully aware of the dosage, toxicity level and method of application of chemicals / medicines used for fish culture Ensure safety, hygiene and sanitation practices for culture operations Fertilize the pond with inorganic fertilizer to get desired plankton.	
Course focusing on: Employability			

	Course Outcome
CO-1	The students will gain knowledge in principles of marine biotechnology and analyze Physico-chemical parameters
CO-2	The students get knowledge about biodiversity of the marine ecosystem
CO-3	Students study in detail about marine microalgae, sponges, cultivation of algae and Sponges, screening bioactive compound from algae and sponges.
CO-4	The students will know about the various enzymes from marine organisms and their recovery
CO-5	The students will study about the methods of genetically modified products from marine organisms

UNIT	**CONTENT**	**HOURS**	**COs**	**COGNITIVE LEVEL**
I	Principles of oceanography Marine Ecology Estuaries, coastal and deep sea. Major oceans and sea. Physico chemical parameters-Temperature, Salinity, Oxygen, BOD, COD and Light. Marine Bioresources in India.	12	CO1	K1, K2, K3

II	Planktonic Microorganisms Diversity-Marine Viruses, Marine Bacteria and Archaea, Eukaryotic Phytoplankton, Zooplankton.	12	CO2	K1, K2
III	Marine Microalgae-genome. Gene transfer methods in Microalgae, metabolic engineering. Photobioreactors of Microalgae. Sponges- sponges associated Bacteria's, Archaea, Eubacteria. Sponge specific microorganisms. Molecular method to elucidate the sponge symbiosis. Metagenomic screening of natural products form marine sponges.	12	CO3	K4, K5, K6
IV	Marine Enzymes-Polysaccharide degrading enzymes, proteases, Halogenating enzymes, downstream process of marine enzymes. Bioprospecting of marine environment culturing technique and culture independent. Gene target method. Omics and metagenomics approaches. Applications of genomics and proteomics to marine biotechnology, biomaterials and bioengineering, and public policy.	12	CO4	K3, K4
V	Marine microorganisms source of valuable natural products (seaweed and microbes) and the cell factory-Biomass production and Novel Biocatalysts. Transgenic marine organisms- selection of organism's, Gene transfer method, identification of transgenic animals. Enhancing the disease resistance, somatic growth. Increase the color of ornamental fishes. Model to studying Human disease Transgenic a fish as environmental indicator, Application of Biotechnology in Aquaculture–use of antibodies, protein, antifreeze protein, antibiotics and microbes.	12	CO5	K4, K5, K6

Text books:

1. Jeffrey S. Levinton. 2016. Marine biology Function, Biodiversity, Ecology. Oxford University press, Oxford.
2. Kim, Se-Kwon. 2015. Springer Handbook of Marine Biotechnology. Springer-Verlag Berlin Heidelberg. 3. Philip V. Mladenov. 2013. Marine Biology: A Very Short Introduction. Oxford University Press.
4. Yves Le Gal, Roland Ulber. 2010. Marine Biotechnology I / Edition 1. Springer Berlin Heidelberg.

References Books:

1. Abhijit Mitra, Sufia Zaman, 2016. Basics of Marine and Estuarine Ecology 1st Edition. Springer. 769
2. N.V. Prasad 2012. Ecology of Mangrove Estuarine Zooplankton: Composition, Distribution, Production, BIS
3. Yves Le Gal, Roland Ulber. 2010. Marine Biotechnology I / Edition 1. Springer Berlin Heidelberg.

Title of the paper	**Core - 14 Project**	
Category : Core **Project**	Year & Semester	Credits
	Second year, Sem IV	8
Objectives of the course	To introduce research concepts and execute their ideas through project.	

PSO –CO MATRIX

Course	Course outcome	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
Biochemistry	**CO-1**	✓	✓	✓	✓	✓
	CO-2	✓	✓		✓	✓
	CO-3	✓		✓	✓	✓
	CO-4	✓		✓	✓	✓
	CO-5	✓	✓	✓	✓	✓
Cell and Developmental Biology	**CO-1**	✓	✓	✓	✓	✓
	CO-2	✓		✓	✓	
	CO-3	✓		✓	✓	
	CO-4	✓			✓	✓
	CO-5	✓			✓	
Molecular Genetics	**CO-1**	✓			✓	
	CO-2	✓		✓	✓	✓
	CO-3	✓	✓		✓	
	CO-4	✓	✓	✓	✓	✓
	CO-5	✓		✓	✓	✓
Practical 1	**CO-1**		✓	✓		✓
	CO-2		✓	✓		✓
	CO-3		✓	✓		✓
Elective Environmental Biotechnology	**CO-1**	✓			✓	
	CO-2	✓		✓	✓	✓
	CO-3	✓		✓	✓	✓
	CO-4	✓		✓	✓	✓
	CO-5	✓		✓	✓	✓
Elective Biostatistics	**CO-1**	✓		✓		
	CO-2	✓		✓		
	CO-3	✓		✓		
	CO-4	✓		✓		
	CO-5	✓		✓		
Ecology and Evolution	**CO-1**	✓			✓	
	CO-2	✓		✓	✓	
	CO-3	✓			✓	
	CO-4	✓			✓	
	CO-5	✓		✓	✓	✓

Course	Course outcome	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
Microbiology &Bioprocess Technology	CO-1	✓	✓		✓	
	CO-2	✓	✓	✓	✓	
	CO-3	✓	✓	✓	✓	✓
	CO-4	✓	✓	✓	✓	✓
	CO-5	✓	✓	✓	✓	✓
Immunology	CO-1	✓	✓	✓	✓	
	CO-2	✓		✓	✓	
	CO-3	✓	✓	✓	✓	✓
	CO-4	✓		✓	✓	
	CO-5	✓	✓	✓	✓	✓
Genetic Engineering	CO-1	✓			✓	
	CO-2	✓	✓	✓	✓	
	CO-3	✓	✓	✓	✓	✓
	CO-4	✓	✓	✓	✓	✓
	CO-5	✓	✓	✓	✓	✓
Practical 2	CO-1		✓	✓		✓
	CO-2		✓	✓		✓
	CO-3		✓	✓		✓
Intellectual Property Rights& Biosafety	CO-1	✓		✓	✓	
	CO-2	✓		✓		
	CO-3	✓		✓		✓
	CO-4	✓		✓		
	CO-5	✓		✓	✓	✓
Methods in Biology	CO-1	✓		✓	✓	✓
	CO-2	✓	✓	✓	✓	✓
	CO-3	✓		✓	✓	✓
	CO-4	✓		✓	✓	✓
	CO-5	✓	✓	✓	✓	✓
Plant Physiology	CO-1	✓		✓	✓	✓
	CO-2	✓		✓	✓	✓
	CO-3	✓		✓	✓	✓
	CO-4	✓		✓	✓	✓
	CO-5	✓		✓	✓	✓

Course	Course outcome	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
Plant and Animal Biotechnology	CO-1	✓	✓			
	CO-2	✓		✓	✓	
	CO-3	✓	✓			
	CO-4	✓				
	CO-5	✓		✓	✓	✓
Bioinformatics	CO-1	✓		✓	✓	
	CO-2	✓	✓	✓	✓	
	CO-3	✓				
	CO-4	✓				
	CO-5	✓				✓
Molecular Biology	CO-1	✓	✓	✓	✓	✓
	CO-2	✓		✓	✓	✓
	CO-3	✓		✓	✓	✓
	CO-4	✓		✓	✓	✓
	CO-5	✓		✓	✓	✓
Practical 3	CO-1		✓	✓		✓
	CO-2		✓	✓		✓
	CO-3		✓	✓		✓
Nano-Biotechnology	CO-1	✓		✓		
	CO-2	✓		✓		
	CO-3	✓		✓		
	CO-4	✓		✓		
	CO-5	✓		✓		✓
Virology	CO-1	✓			✓	
	CO-2	✓	✓	✓	✓	✓
	CO-3	✓	✓	✓	✓	✓
	CO-4	✓	✓	✓	✓	✓
	CO-5	✓	✓	✓	✓	✓
Animal Physiology	CO-1	✓			✓	
	CO-2	✓		✓	✓	
	CO-3	✓			✓	
	CO-4	✓			✓	
	CO-5	✓		✓	✓	✓

Course	Course outcome	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
Stem Cell Biology	CO-1	✓		✓	✓	✓
	CO-2	✓		✓	✓	✓
	CO-3	✓		✓	✓	✓
	CO-4	✓		✓	✓	✓
	CO-5	✓		✓	✓	✓
Research Methodology	CO-1	✓		✓	✓	
	CO-2	✓		✓	✓	✓
	CO-3	✓		✓	✓	✓
	CO-4	✓		✓	✓	✓
	CO-5	✓		✓	✓	✓
Marine Biotechnology	CO-1	✓		✓		
	CO-2	✓		✓		
	CO-3	✓		✓		
	CO-4	✓	✓	✓		
	CO-5	✓	✓	✓	✓	✓

Teaching - learning process

The Learning Outcomes-Based Approach to curriculum planning and transaction requires that the teaching-learning processes are oriented towards enabling students to attain the defined learning outcomes relating to the courses within a programme. The outcome- based approach, particularly in the context of undergraduate studies, requires a significant shift from teacher-centric to learner-centric pedagogies, and from passive to active/participatory pedagogies. Planning for teaching therein becomes critical. Every programme of study lends itself to well-structured and sequenced acquisition of knowledge and skills. Practical skills, including an appreciation of the link between theory and experiment, will constitute an important aspect of the teaching learning process. Teaching methods, guided by such a framework, may include:

- ✓ **Classroom Teaching** for topics which are intensely information-based. This a very regular feature of all the courses in Biotechnology.
- ✓ **Power Point slides** for topics which involve information, use of Power Point presentations are also made whenever the lectures are to be summarized in a crisp and pointwise manner to highlight salient / important conclusions from the topics.
- ✓ **Classroom Discussions** are a regular feature while teaching. The students are drawn into impromptu discussions by the teacher during the process of teaching.
- ✓ **Video Displaying**, both real-time and animations, are used for topics which require 3D dimensional viewing of the biological mechanisms to drive the point home. These have

proved to be very helpful while teaching concepts of molecular biology like DNA replication, transcription and translation.

- ✓ **Model Making** is also used especially for understanding and building a perception of the students.
- ✓ **Laboratory Practical** are an integral part of every course included in PG programme in Biotechnology. The is also a daily affair for PG students of Biotechnology.
- ✓ **Problem Solving** is encouraged during the laboratory work.
- ✓ **Group Activity** as well as discussions with the laboratory supervisor/ among the students themselves/ Mentor is also encouraged during laboratory work.
- ✓ **Project Work** is included in the programme where students work individually or in groups to design experiments to solve/answer a problem suggested by the Mentor or identified by the students in consultation with the Mentor. The students are mentored regularly during the duration the project is in progress.
- ✓ **Presentations by the Students** are regularly done. The students are mentored in presentation of data, interpretation of data and articulation with the students/teachers/Research Scholars during their presentation.
- ✓ **Presentation by Experts** in different specialties of Biotechnology are arranged to broaden the horizons of the students.
- ✓ **Interaction with Experts** is also encouraged during/after presentations to satisfy/ignite curiosities of the students related to developments in the different areas of Biotechnology.
- ✓ **Visit to Industries/Laboratories** related to Biotechnology like fermentation, food, Pharmaceutical, diagnostics etc. are organized to acquaint the students with real-life working environments of the professional biotechnologist with a view to broaden their perspective of the subject of Biotechnology.

Assessment methods

It is important that the students of PG Biotechnology program achieve the desired results in terms of the learning outcomes to be professionally sound and competitive in a global society. Achieving the desired learning outcomes is also imperative in terms of job employment leading to a happy and prosperous individual further leading to a happy and prosperous family and thereby a happy and prosperous society or nation. The assessments tasks are pivotal to get an authentic feedback for the teaching learning process and for mid-course corrections and further

improvements in future. The assessment tasks are carried out at various stages of the duration of the PG Biotechnology programme like Mid-term assessments, End-term assessments, Semester examinations, Regular assessments, viva-voce etc. The assessment tasks are listed below:-

- ✓ **Short-Answer Questions** during term and semester examinations are used to assess the ability of the student to convey his thoughts in a coherent way where prioritization of the information in terms of their significance is tested.
- ✓ **Surprise Quizzes** are regularly used during continuous assessment while the teaching learning process is continuing which prepares the student to quickly recall information or quickly analyze a problem and come up with proper solutions.
- ✓ **Impromptu Opinions** on biotechnological problems are sought from student during regular teaching learning which help them to think quickly in a given context. This help build their ability to come up with solutions to problems which the students might not have confronted previously.
- ✓ **Problem Solving question** are generally given during the laboratory work.
- ✓ **Data Interpretation** is also another assessment task which is used to develop analytical skills of the students. This assessment is used during laboratory work as well as during conduction of project work.
- ✓ **Analytical Skills** are assessed during work related to several experiments like enzyme kinetics, growth of bacteria and bacteriophages, mutation frequencies.
- ✓ **Paper/ Project presentations** are used to assess the articulation skills of the student. These are carried out both during the duration of the teaching learning processes as well as during end-Semester examinations.
- ✓ **Report Writing** is used to assess the keenness of the students for details related to Biotechnology while visiting laboratories / industries as students invariably are required to submit a report after such visits.
- ✓ **Assignment Writing** are used to assess the writing abilities of the students during midterm vacations.
- ✓ **Viva-voce** during the laboratory working hours and during laboratory examination are used to assess the over-all knowledge and intelligence of the students.

Key Words:

Biotechnology, Teaching, Learning outcomes, Curriculum, Curriculum Framework, Programme outcomes, Course outcomes, PG Programme, Postgraduate programme, Teaching learning processes, Assessment Tasks, Evaluation Tasks, Online Courses, MOOCS, NPTEL, SWAYAM, UGC, India, Higher Education Institutions, HEI