GANDHI INSTITUTE OF TECHNOLOGY AND MANAGEMENT (GITAM)
(Deemed to be University, Estd. u/s 3 of UGC Act 1956)
VISAKHAPATNAM ∗HYDERABAD ∗BENGALURU
Accredited by NAAC with 'A^{+}' Grade

REGULATIONS AND SYLLABUS

of

MASTER OF SCIENCE
Biotechnology

(w.e.f. 2019-20 admitted batch)

Website: www.gitam.edu

Master of Science in Biotechnology

REGULATIONS
(W.e.f. 2019-20 admitted batch)

1. ADMISSION

1.1 Admission into M.Sc. in Biotechnology program of GITAM (Deemed to be University) is governed by GITAM admission regulations.

2. ELIGIBILITY CRITERIA

2.1. A pass in B.Sc. with Biochemistry, Biotechnology, Microbiology, Bioinformatics, Chemistry, Medical Lab Technology, Genetics, Home Science, Food and Nutrition, Zoology, Botany, Agriculture, Aquaculture, Veterinary Sciences, Environmental Science, B. Pharm., BPT and B. Tech. in allied subjects as one of the Subject(s) and with a minimum aggregate of 50% marks in degree or any other equivalent examination approved by GITAM (Deemed to be University).

2.2. Admission into M.Sc. Biotechnology will be based on an All India GITAM Science Admission Test (GSAT) conducted by GITAM (Deemed to be University) and the rule of reservation, wherever applicable.

3. CHOICE BASED CREDIT SYSTEM

Choice Based Credit System (CBCS) is introduced with effect from the admitted Batch of 2015-16 based on UGC guidelines in order to promote:

- Student Centered Learning
- Cafeteria approach
- Inter-disciplinary learning

Learning goals/ objectives and outcomes are specified leading to what a student should be able to do at the end of the program.

4. STRUCTURE OF THE PROGRAM:

4.1 The Program Consists of

i) Foundation Courses (compulsory) which give general exposure to a Student in communication and subject related area.

ii) Core Courses (compulsory).

iii) Discipline centric electives which

a) Are supportive to the discipline

b) Give expanded scope of the subject

c) Give interdisciplinary exposure

d) Nurture the student skills

iv) Open electives are of general nature either related or unrelated to the discipline.

v) Practical Proficiency Courses

a) Laboratory

b) Project work

4.2 Each course is assigned a certain number of credits depending upon the number of contact hours (Lectures/Tutorials/Practical) per week.

4.3 In general, credits are assigned to the courses based on the following contact hours per week per semester.

- One credit for each Lecture hour per week.
- One credits for two hours of practical per week
- Eight credits for project

4.4 The curriculum of the four semesters M.Sc. program is designed to have a total of **96** credits for the award of M.Sc. degree.

5. MEDIUM OF INSTRUCTION

The medium of instruction (Including examinations and project reports) shall be English.

6. REGISTRATION

Every student has to register himself/herself for each semester individually at the time specified by the Institute/University.

7. ATTENDANCE REQUIREMENTS

7.1 Student whose attendance is less than 75% in all the courses put together in any semester will not be permitted to attend the semester-end examination and he/she will not be allowed to register for subsequent semester of study. He/she has to repeat the semester along with his/her juniors.

7.2 However, the Vice Chancellor on the recommendation of the Principal/Director of the Institute/School may condone the shortage of attendance to the students whose attendance is between 66% and 74% on genuine grounds and on payment of prescribed fee.

8. EVALUATION

8.1 The assessment of the student's performance in a Theory and Practical courses shall be based on two components: Continuous Evaluation (40 marks) and Semester-end examination (60 marks).

8.2 A student has to secure an aggregate of 40% in the course in the two components put together to be declared to have passed the course, subject to the condition that the candidate must have secured a minimum of 24 marks (i.e. 40%) in the theory component at the semester-end examination. Details of Assessment Procedure are furnished below in Table 1.

8.3 Viva voce/Seminar/SEC etc. courses are completely assessed under Continuous Evaluation for a maximum of 100 marks, and a student has to obtain a minimum of 40% to secure Pass Grade. Details of Assessment Procedure are furnished below in Table 2.

8.4 Viva and Project work & seminar are assessed for maximum marks of 50 and 200 marks respectively. A student has to obtain a minimum of 40% to secure pass grade. Details of Assessment Procedure are furnished below in Table 2.

Table 1: Assessment Procedure

S. No.	Component of assessment	Marks allotted	Type of Assessment	Scheme of Examination
1	Theory (PC, PE, PF, OE)	40	Continuous evaluation	(i) Three mid semester examinations shall be conducted for 15 marks each. The performance in best two shall be taken into consideration. (ii) 5 marks are allocated for quiz. (iii) 5 marks are allocated for assignments.
		60	Semester-end examination	The semester-end examination Shall be for a maximum of 60 marks.
	Total	100		
2	Theory (SEC / AEC)	100	Continuous evaluation	100 marks for continuous evaluation.
3	Practicals	60	Continuous evaluation	60 marks for performance, regularity, record/ and case study. Weightage for each component shall be announced at the beginning of the semester.
		40	Continuous evaluation	40 marks (30 marks for experiment(s) and 10 marks for practical Viva-voce.) for the test conducted at the end of the Semester by the concerned lab Teacher.
	Total	100		
4	Project work & Seminar (IV semester)	200	Project evaluation	150 marks for evaluation of the project work dissertation submitted by the candidate. 50 marks are allocated for the project Viva-Voce. The project work evaluation and the Viva-Voce shall be conducted by one external examiner outside the University and the internal examiner appointed by the Head of the Department.
5	Viva-voce	50	Semester-end	Viva-voce examination based on theory and practical will be conducted at the end of each semester by the faculty members of the Department, as appointed by the HoD.

9. SUPPLEMENTARY EXAMINATIONS & SPECIAL EXAMINATIONS:

9.1 The odd semester supplementary examinations will be conducted on daily basis after conducting regular even semester examinations in April/May.

9.2 The even semester supplementary examinations will be conducted on daily basis after conducting regular odd semester examinations during November/December

9.3 A student who has completed his/her period of study and still has "F" grade in final semester courses is eligible to appear for Special Examination normally held during summer vacation.

10. PROMOTION TO THE NEXT YEAR OF STUDY

10.1 A student shall be promoted to the next academic year only if he/she completes the academic requirements of 60% of the credits till the previous academic year.

10.2 Whenever there is a change in syllabus or curriculum he/she has to continue the course with new regulations after detention as per the equivalency established by the BoS to continue his/her further studies

11. BETTERMENT OF GRADES

11.1 A student who has secured only a pass or second class and desires to improve his/her class can appear for betterment examinations only in 'n' (where 'n' is no.of semesters of the program) theory courses of any semester of his/her choice, conducted in summer vacation along with the Special Examinations.

11.2 Betterment of Grades is permitted 'only once', immediately after completion of the program of study.

12. REPEAT CONTINUOUS EVALUATION:

12.1 A student who has secured 'F' grade in a theory course shall have to reappear at the subsequent examination held in that course. A student who has secured 'F' grade can improve continuous evaluation marks upto a maximum of 50% by attending special instruction classes held during summer.

12.2 A student who has secured 'F' grade in a practical course shall have to attend Special Instruction classes held during summer.

12.3 A student who has secured 'F' grade in a combined (theory and practical) course shall have to reappear for theory component at the subsequent examination held in that course. A student who has secured 'F' grade can improve continuous evaluation marks upto a maximum of 50% by attending special instruction classes held during summer.

12.4 The RCE will be conducted during summer vacation for both odd and even semester students. Student can register a maximum of 4 courses. Biometric attendance of these RCE classes has to be maintained. The maximum marks in RCE be limited to 50% of Continuous Evaluation marks. The RCE marks are considered for the examination held after RCE except for final semester students.

12.5 RCE for the students who completed course work can be conducted during the academic semester. The student can register a maximum of 4 courses at a time in slot of 4 weeks. Additional 4 courses can be registered in the next slot.A student is allowed to Special Instruction Classes (RCE) 'only once' per course.

13. GRADING SYSTEM

13.1. Based on the student performance during a given semester/trimester, a final letter grade will be awarded at the end of the trimester/semester in each course. The letter grades and the corresponding grade points are as given in Table 3.

Table 3: Grades & Grade Points

S.No.	Grade	Grade Points	Absolute Marks
1	O (Outstanding)	10	90 and above
2	A+ (Excellent)	9	80 to 89
3	A (Very Good)	8	70 to 79
4	B+ (Good)	7	60 to 69
5	B (Above Average)	6	50 to 59
6	C (Average)	5	45 to 49
7	P (Pass)	4	40 to 44
8	F (Fail)	0	Less than 40
9	Ab (Absent)	0	--

13.2 A student who earns a minimum of 4 grade points (P grade) in a course is declared to have successfully completed the course, subject to securing an average GPA (average of all GPAs in all the semesters) of 5 at the end of the Program to declare pass in the program.

13.3 Candidates who could not secure an average GPA of 5 at the end of the program shall be permitted to reappear for a course(s) of their choice to secure the same.

14. GRADE POINT AVERAGE

14.1 A Grade Point Average (GPA) for the semester/trimester will be calculated according to the formula:

$$GPA = \frac{\Sigma [CxG]}{\Sigma C}$$

Where
C = number of credits for the course
G = grade points obtained by the student in the course

13.1 To arrive at Cumulative Grade Point Average (CGPA), a similar formula is used considering the student's performance in all the courses taken, in all the semesters up to the particular point of time.

13.2 CGPA required for classification of class after the successful completion of the program is shown in Table 4.

Table 4: CGPA required for award of Class

Class	CGPA Required
First Class with Distinction	≥ 8.0*
First Class	≥ 6.5
Second Class	≥ 5.5
Pass Class	≥ 5.0

* In addition to the required CGPA of 8.0 or more the student must have necessarily passed all the courses of every semester in first attempt.

15. ELIGIBILITY FOR AWARD OF THE M.Sc. Biotechnology DEGREE

14.1 Duration of the program: A student is ordinarily expected to complete M.Sc. program in four semesters of two years. However a student may complete the program in not more than four years including study period.

14.2 However the above regulation may be relaxed by the Vice Chancellor in individual cases for cogent and sufficient reasons.

14.3 A student shall be eligible for award of the M.Sc. Degree if he/she fulfills all the following conditions.

a) Registered and successfully completed all the courses and projects.

b) Successfully acquired the minimum required credits as specified in the curriculum corresponding to the branch of his/her study within the stipulated time.

c) Has no dues to the Institute, hostels, Libraries, NCC / NSS etc.

d) No disciplinary action is pending against him/her.

14.4 The degree shall be awarded after approval by the Academic Council.

16. Discretionary Power:

Notwithstanding anything contained in the above sections, the Vice Chancellor may review all exceptional cases, and give his decision, which will be final and binding.

Note: Rules and regulations to be changed as per resolutions of 16th Academic Council-2019.

M.Sc. BIOTECHNOLOGY

SCHEME OF INSTRUCTION AND EVALUATION

(w.e.f Academic year 2019-20)

Course Code	Title of the paper	Category	Scheme of Instruction	No. of credits	Scheme of Examination		
					Duration of Exam (Hrs.)	Maximum Marks (100)	
			Hours per Week			Continuous evaluation	Semester-end examination
I Semester							
SBT 701	Biomolecules	PC	4	4	3	40	60
SBT 703	Microbiology	PC	4	4	3	40	60
SBT 705	Bioanalytical Techniques and Biostatistics	PC	4	4	3	40	60
SBT 707	Cell Biology and Genetics	PF	4	4	3	40	60
SEC (Choose any one)							
SSE 701	Basic Computer Concepts	SEC	2	2	3	100	--
SSE 703	Information Technology Tools						
SBT 721	Microbiology and Cell Biology Lab	PP	6	3	3	60	40
SBT 723	Biochemical Analysis and Techniques Lab	PP	6	3	3	60	40
SBT 791	Viva-voce	PP		1		50	
Total				**25**		**750**	
II Semester							
SBT 702	Immunology	PC	4	4	3	40	60
SBT 704	Molecular Biology	PC	4	4	3	40	60
SBT 706	Enzymology and Enzyme Technology	PC	4	4	3	40	60
SBT 708	Metabolism and Bioenergetics	PF	4	4	3	40	60
SAE 702	Professional Communication Skills	AEC	2	2	3	100	--
SBT 722	Enzymology and Immunology Lab	PP	6	3	3	60	40
SBT 724	Molecular Biology Lab	PP	6	3	3	60	40
SBT 792	Viva-voce	PP		1		50	
Total				**25**		**750**	

Course Code	Title of the paper	Category	Scheme of Instruction	No. of credits	Scheme of Examination		
					Duration of Exam (Hrs)	Maximum Marks (100)	
			Hours per Week			Continuous evaluation	Semester-end examination
III Semester							
SBT 801	Genetic Engineering	PC	4	4	3	40	60
SBT 803	Plant Biotechnology	PC	4	4	3	40	60
SBT 805	Bioprocess Engineering and Technology	PC	4	4	3	40	60
Program Elective I (Choose any one)							
SBT 841	Animal Biotechnology	PE	4	4	3	40	60
SBT 843	Food Biotechnology						
SBT 845	Aqua culture and Marine Biotechnology						
SBT 847	Cancer Biology						
Open Elective (Choose any one)		OE	3	3	3	40	60
SBT 821	Industrial Biotechnology and Genetic Engineering Lab	PP	6	3	6	60	40
SBT 823	Plant and Animal Biotechnology Lab	PP	6	3	6	60	40
SBT 891	Viva - voce	PP		1		50	
Total				**26**		**750**	
IV Semester							
SBT 802	Bioinformatics	PC	4	4	3	40	60
Program Elective II (Choose any one)							
SBT 842	Medical and Pharmaceutical Biotechnology	PE	4	4		40	60
SBT 844	Nanobiotechnology						
SBT 846	Protein Engineering						
SBT 848	Stem Cell Biology						
SBT 822	Bioinformatics Lab	PP	6	3	3	60	40
SBT 892	Project work	PP		8		150	
	Seminar					50	
SBT 894	Viva-Voce	PP		1		50	
Total				**20**		**550**	
Grand Total for Four Semesters				**96**		**2800**	

PC- Program Core **PF- Program Foundation** **PP- Practical Proficiency**
PE- Program Elective **AEC- Ability Enhancement Course** **OE- Open Elective**
SEC- Skill Enhancement Course

Open Elective should be selected from the list of open elective subjects offered by the University.

Program Elective I should be selected from SBT 841, SBT 843, SBT 845 & SBT 847.

Program Elective II should be selected from SBT 842, SBT 844, SBT 846 & SBT 848.

*** Open Electives offered by the Department:**

S. No.	Course code	Title of the paper	Course offered semester	Course offered to the students of
01	SOE 831	Fundamentals of Biotechnology	III Semester	All programmes other than M.Sc. Biotechnology
02	SOE 833	Fundamentals of Plant Biotechnology	III Semester	All programmes other than M.Sc. Biotechnology

* Students who are having these papers / content of these papers in their curriculum are not allowed to opt for the respective electives.

SBT 701: BIOMOLECULES

Hours per week : 04 **End examination : 60 Marks**
Credits : 04 **Sessional : 40 Marks**

Preamble:

This course has been designed to enrich the students' knowledge about the classification, structure, properties, and functions of biomolecules. The course shall make the students' aware of the significance of various biomolecules necessary to maintain the living organisms

Course Objectives

The objectives of this course are to build the knowledge of post graduate students about the classification, structure, properties, functions and interactions of different biomolecules. The course shall make the students aware of significance of various biomolecules necessary to maintain the living organisms.

UNIT-I
Structure and Properties of water, intra and intermolecular forces, non-covalent interactions-electrostatic, hydrogen bonding, Vander Waals interactions, hydrophobic and hydrophilic interactions. Disulphide bridges. pH, pK, acid base reactions and buffers.

Learning Outcomes:

On completion of this unit, students should be able to:
- Understand the chemical structure and properties of water
- Understand the role of non-covalent interactions in biomolecules
- Understand the role of pH and buffers in biological system

UNIT-II

Classification and biological functions of carbohydrates, structure and properties of monosaccharides, disaccharides, polysaccharides (starch, glycogen, cellulose andchitin) and glycosaminoglycans (chondroitin sulfate andHyaluronic acid).Carbohydrate microarray and applications.

Learning Outcomes:

On completion of this unit, students should be able to:
- Understand the chemical structure and properties of carbohydrates
- Understand the biological functions of carbohydrates

UNIT-III

Classification, structure and properties of amino acids, essential and nonessential aminoacids.Protein isolation and purification.Primary structure of protein- determination of amino acid composition and sequence.Secondary structure-α-helix, β-pleated sheet, collagen triple helix, β-bends and structural motifs.Tertiary and quaternary structures.Solid phase peptide synthesis. Glycoproteins

Learning Outcomes:

On completion of this unit, students should be able to:

- Understand the chemical structure, properties and biological functions of amino acids
- Understand the chemical structure, properties and biological functions of proteins
- Understand the chemical synthesis of proteins

UNIT-IV

Classification, structure, properties and functions of fatty acids, triglycerides, phospholipids,sphingolipids. Terpenes, Cholesterol and eicosanoids.Structure and functions of vitamins – A, D, E, K and B-complex and Vitamin C.

Learning Outcomes:

On completion of this unit, students should be able to:

- Understand the chemical structure and properties of lipids
- Understand the biological functions of lipids
- Understand the structure and functions of vitamins

UNIT-V

Structure and properties of DNA. Alternative forms of DNA -A, B, Z. Circular DNA and DNA supercoiling, tripleand quadruple helix structures of DNA. Structure and properties of RNA,different types of RNA- mRNA and non-coding RNA – tRNA, rRNA, scRNA, snRNA,siRNA, miRNA, exRNA, and piRNA

Learning Outcomes:

On completion of this unit, students should be able to:

- Understand the chemical structure and properties of DNA and RNA
- Understand the biological functions of nucleic acids

Student Learning Outcomes:

On completion of this course, students should be able to:

- Gain fundamental knowledge in biochemistry
- Understand the classification of biomolecules
- Understand the chemical structure and properties of biomolecules
- Understand the function and interaction of various biomolecules

RECOMMENDED BOOKS:

1. Lehninger Principles of Biochemistry by Nelson, D and Cox, D. –7th Edition. Mcmillan Pub.
2. Biochemistry by L.Stryer– 8th Edition. (Freeman-Tappan).
3. Biochemistry by D.Voet and J.G.Voet– 4th Edition. (John weily).
4. Biochemistry by Garrett and Grisham 6th Edition. (Cengage Learning)
5. Biochemistry Concepts and Connections by Mathews et. al.,Global Edition.
6. Principles of Biochemistry by David Rawnetal., 5th Edition (Pearson)
7. Essentials of Glycobiology. 3rd Edition. (CSHL press)
8. Harper's Biochemistry by Robert K. Murray et al., – 30thEdition. (Langeman).
9. Biochemistry by U.Satyanarayana—4thEdition. (Elsevier)

SBT 703: MICROBIOLOGY

Hours per week : 04 **End examination: 60 Marks**
Credits : 04 **Sessional : 40 Marks**

Preamble:

This course has been designed to introduce field of microbiology with special emphasis on microbial diversity, morphology, physiology and nutrition; methods for control of microbes, microbial infections and viruses.

Course Objectives:

- To identify major categories ofmicroorganisms and analyze theirclassification,diversity and ubiquity.
- Toidentify and demonstrate how tocontrol microbial growth.
- To learn about viruses, their classification and infections caused by them.

UNIT-I

Introduction to microbiology - History, evolution and development. Diversity of microorganisms - scope and importance. Ultra structure of microorganisms, Microscopy - Principles and applications of light, phase, fluorescent and electron microscopy, confocal microscopy. Different methods of staining. Bergey's classification of bacteria, classification of Achaea, Sterilization - physical, chemical and radiation methods.

Learning outcomes:

By the end of the course, the student will be able to:

- Learn microscopic techniques to study ultrastructure of microorganisms and their diversity.
- Understand the classification of bacteria and archaea
- Learn different methods of sterilization and their mechanisms.

UNIT-II

Culture dependent techniques - concept of pure culture, enrichment culture techniques, single cell isolation. Preservation methods and maintenance of microbial cultures, Characterization and Identification of bacteria based on morphology, physiology, biochemistry, ecology, Numerical taxonomy, chemotaxonomy and ribotyping. Culture independent techniques - metagenomics.

Learning outcomes:

By the end of the course, the student will be able to:

- Learn how to classify the microorganisms based on culture dependent techniques.
- Identify the taxon of bacteria based on various characteristic features.
- Learn how to characterize the bacteria based on culture independent technique.

UNIT-III

Microbial nutrition, nutritional types, types of nutrient media, microbial growth - principles, kinetics and methods. Synchronous, batch and continuous cultures. Bacterial reproduction and growth. Quantitative measurement of growth, factors affecting growth. Cultivation of aerobes and anaerobes. Toxic effects of oxygen.

Learning outcomes:

By the end of the course, the student will be able to:

- Learnabout the nutrients which enhance the growth of microorganisms
- Understand bacterial doubling time, measurement of growth and growth kinetics.
- Learn the effect of physical factors that influence the microbial growth.

UNIT-IV

Bacterial recombination - Transformation, conjugation and transduction. Mapping of procaryotic genome. Transposons, Insertion sequences, and mechanism of transposition, retrotransposons and Plasmids; Clinically important bacteria - S.*aureus, V.cholera, M. tuberculi*, Fungi - *Candidiosis*. SCP, economic importance of algae and fungi.

Learning outcomes:

By the end of the course, the student will be able to:

- Understand the bacterial gene recombination and its genetics
- Learn types of transposons and the mechanism of transposition.
- Learn the effect of physical factors that influence the microbial growth.

UNIT-V

Viruses: ICTV, Baltimore classification, bacteriophages (Lytic And Lysogenic cycles) Isolation, Cultivation and purification of viruses, Transmission of viruses, Prions, Clinically important viruses *HIV, Hepatitis, Influenza.*

Learning outcomes:

By the end of the course, the student will be able to:

- Study about viruses and their classification
- Learn culturing of viruses and their propagation.
- Learn pandemic infections caused to humans by viruses.

RECOMMENDED BOOKS:

1. Microbiology by Tortora, Funk & Case, 11th Edition, Pearson Education.
2. Textbook of Microbiology by Ananthanarayan and Paniker's, 10th Edition.
3. Brock Biology of Microorganisms by Michael T Madigan & Kelly S Bender, 14th Edition, Pearson Education.
4. Microbiology - Principles and Explorations, 9th Edition, John Wiley & Sons.
5. Prescott's Microbiology, 11th Edition, McGraw-Hill Publishers.
6. Human Virology by Flint, 4th Edition, ASM Press.
7. Textbook of Microbiology and Immunology by Parija, 3rd Edition.
8. Understanding Viruses by Teri Shors, 3rd Edition, Jones and Bartlett Publishers.

SBT 705: BIOANALYTICAL TECHNIQUES AND BIOSTATISTICS

Hours per week	**: 04**	**End examination**	**: 60 Marks**
Credits	**: 04**	**Sessional**	**: 40 Marks**

Preamble:

The bioanalytical methods predominately embraces a broad cross-section of modern analytical techniques and latest sophisticated instruments like HPLC, XRD, NMR, GC-MS, ORD…etc. The course will help to build the knowledgeabout the bioanalytical techniques used to analyze various biomolecules and also the use of radio tracer techniques in biology.

Course Objectives

- To make the students aware of the principle, operation and applications of various techniques used to analyze biomolecules.
- To understand the description, tabulation and graphical representation of scientific data by means of statistical tools.

UNIT-I

Principles and applications of chromatographic techniques: paper chromatography, thin layer chromatography, gel filtration, ion-exchange chromatography, affinity chromatography, GC, HPLC and GC-MS.

Learning Outcomes:

By the end of this Unit, the student will be able to

- Explain the various chromatographic techniques and their applications in various fields of biology.
- Understand separation and purification of various biomolecules using these techniques.

UNIT-II

Principles and concepts of electrophoretic techniques: native PAGE, SDS-PAGE, agarose gel electrophoresis, capillary electrophoresis, isoelectric focusing, two dimensional, pulse field and diagonal electrophoresis.

Learning Outcomes:

By the end of this Unit, the student will be able to

- Understand separation of proteins based on mass and charge.
- Distinguish the process of identifying the sub-units in a protein.

UNIT-III

Principles and applications of UV-Visible, Raman, infrared, ORD, CD, X-ray diffraction, NMR, ESR, Mass spectrometry, MALDI-TOF and fluorescence spectroscopy. Principles and applications of preparative and analytical ultracentrifuges.

Learning Outcomes:

By the end of this Unit, the student will be able to

- Understand the separation of biomolecules based on spectroscopic techniques.
- Comprehend how three dimensional structure of a protein can be predicted using various techniques.

UNIT-IV

Radioactive and non-radioactive tracer techniques and their applications in biological sciences. Detection and measurement of radioactivity. Principles of electrochemical techniques - operation and applications of pH, oxygen, ion-selective and gas sensing electrodes. Biosensors - principle, design and applications.

Learning Outcomes:

By the end of this Unit, the student will be able to

- Be acquainted with the role of radioactive tracer techniques and apply them in various fields of biology.
- Be familiar with the principle, operation and applications of various electrodes and biosensors.

UNIT-V

Scientific data description, tabulation and graphical representation. Measures of central tendency and dispersion - mean, median, mode, range, standard deviation, variance. Types of errors and level of significance. Tests of significance - F and *t* - tests, chi-square tests, ANOVA. Simple linear regression and correlation.

Learning Outcomes:

By the end of this Unit, the student will be able to

- Gain knowledge in representing the scientific data in various formats.
- Calculate the statistical significance of the given raw data by applying various methods.

RECOMMENDED BOOKS:

1. Practical Biochemistry by Keith Wilson & Walker, 5th Edition, Cambridge University Press.
2. A Biologists guide to Principles and techniques of practical Biochemistry by BD Williams (Edward Arnold).
3. Principles and Techniques of Biochemistry and Molecular Biology by Keith Wilson & John Walker, 7th Edition, Cambridge University Press.
4. Biophysical chemistry principles and techniques by UpadyayUpadyay&Nath, Himalaya publishing House.
5. Instrumental methods of chemical analysis by Chatwal &Anand, 5th Edition, Himalaya Publishers.
6. Modern Experimental Biochemistry by Rodney F Boyer, 3rd Edition.
7. Fundamentals of Biostatistics by Khan &Khanum, Ukaaz publications.
8. Biostatistics by Daniel, 10th Edition, Wiley Publishers.
9. Physical Chemistry: Science of Biology by Atkins, Freeman & Company.

SBT 707: CELL BIOLOGY AND GENETICS

Hours per week	**: 04**	**End examination**	**: 60 Marks**
Credits	**: 04**	**Sessional**	**: 40 Marks**

Preamble:
This course has been designed to offer students a good knowledge on concepts of cell biology and genetics and applying this understanding to enhance skills in genetics.

Course Objectives

1. To familiarize the students with the basic concepts of cell structure and cell division.
2. To enable students understand classical genetics and concepts of population genetics.
3. Students will be exposed to different theories of evolution.

UNIT-I

Structure of bacteria, plant and animal cells. Ultrastructure and composition of plasma membrane, membrane channels and pumps, membrane transport, exocytosis and endocytosis, mechanism of cell division - mitosis and meiosis. Cell cycle and its regulation.

Learning outcomes:

By the end of the course, the student will be able to:

- Learn fundamentals on structure of bacteria plant and animal cells.
- Understand mechanism of exocytosis and endocytosis
- Basic knowledge on cell cycles and control.

UNIT-II

Structure and functions of cell organelles - mitochondria, chloroplast, nucleus, endoplasmic reticulum, golgi, lysosomes, ribosomes and structure and function of cytoskeleton elements. Extracellular matrix, cell-cell interactions. Cell-matrix interaction.

Learning outcomes:

By the end of the course, the student will be able to:

- Learn role of cell organelles and function of cytoskeleton elements
- Significance of Extracellular matrix and its components
- Understand cell-matrix interactions

UNIT-III

Mechanism of action of steroid, protein and amino acid derived hormones. Signal transduction. G proteins, Secondary messenger concept - cAMP, cGMP, calcium, phosphotidyl inositol, nitric oxide, membrane receptor tyrosine kinases and growth factor signaling cascades.

Learning outcomes:

By the end of the course, the student will be able to:

- Understand mechanism of action of various hormones
- Significance and role of secondary messenger in various signaling

UNIT-IV

Mendel's laws and their limitations. Dominance relationships. Interaction of genes, multiple alleles, linkage and crossing over. Linkage groups and mapping. Sex-linkage and recombination in diploids. Mendelian genetics in humans, mutations - types and significance.

Learning outcomes:
By the end of the course, the student will be able to:

- Learn Mendel's laws with limitations
- Understand interactions of genes and crossing over.
- Learn mechanism of sex-linkage and mapping concepts.
- Knowledge in types of mutations and significance.

UNIT-V

Extra-chromosomal inheritance - episomes, mitochondria and chloroplast. Genepool, gene frequency, genetic equilibrium and Hardy-Weinberg law, QTLs. Basics of developmental genetics - vertebrate body plan, signaling pathways, evolution and development.

By the end of the course, the student will be able to:

- Understand Extra-chromosomal inheritance State functions of packaging
- Learn Hardy-Weinberg law and gene frequency.
- Understand basics of developmental genetics.

RECOMMENDED BOOKS:

1. Molecular Biology of the Cell by B Alberts *et al*., 5th Edition, Garland publications incorporation.
2. Principles of Development by Lewis Wolpert, 4th Edition, Oxford University press.
3. Molecular Cell Biology by Harvey Lodish *et. al*., 7th Edition, W.H. Freeman and Company.
4. Cell and Molecular Biology by DeRoberties & DeRoberties, 8th Edition, S Chand & Co.
5. The Cell: A molecular approach by G M Cooper & R E Hausman, 6th Edition, Ingram Publishers.
6. Principles of Genetics by Sinnet, 5th Edition, McGraw Hill.
7. Harper's Biochemistry by Robert K Murray, 28th Edition, McGraw Hill-Lange Publishers.
8. Principles of Heredity by Robert Tymarin A, 7th Edition, Tata McGraw Hill.
9. Genetics by MW Strickberger, 3rd Edition, McMillan Publishers.
10. Genetics by PK Gupta, Rastogi Publications.

SSE 701: BASIC COMPUTER CONCEPTS

Hours per week : 02 **Sessional Evaluation : 100 Marks**
Credits : 02

Preamble: The course gives an understanding about the characteristics and classification of computers, various components of computer along with different operating systems that are available. It gives a hands on training on the packages MS-Word, MS-Power Point and MS-Excel. The course also comprehends AI tools.

Course Objectives:

- To introduce components of digital computer and their working along with the outline of Operating Systems.
- To give hands on training on MS-Word, Power Point and Excel features

Basics of Computers: Definition of a Computer - Characteristics and Applications of Computers – Block Diagram of a Digital Computer – Classification of Computers based on size and working – Central Processing Unit – I/O Devices, Primary, Auxiliary and Cache Memory – Memory Devices. Software, Hardware, Firmware and People ware – Definition and Types of Operating System – Functions of an Operating System – MS-DOS –MS Windows, UNIX. Introduction to AI tools.

MS-Word
Features of MS-Word – MS-Word Window Components – Creating, Editing, ormatting and Printing of Documents – Headers and Footers – Insert/Draw Tables, Table Auto format – Page Borders and Shading – Inserting Symbols, Shapes, Word Art, Page Numbers, Equations – Spelling and Grammar – Thesaurus – Mail Merge.

MS-PowerPoint
Features of PowerPoint – Creating a Blank Presentation - Creating a Presentation using a Template - Inserting and Deleting Slides in a Presentation – Adding Clip Art/Pictures -Inserting Other Objects, Audio, Video- Resizing and Scaling of an Object –Slide Transition – Custom Animation.

MS-Excel
Overview of Excel features – Creating a new worksheet, Selecting cells, Entering and editing Text, Numbers, Formulae, Referencing cells – Inserting Rows/Columns –Changing column widths and row heights, auto format, changing font sizes, colors, shading.

Learning Outcomes:

- Able to understand fundamental hardware components that make up a computer's hardware and the role of each of these components
- Understand the difference between an operating system and an application program, and what each is used for in a computer.
- Acquire knowledge about AI tools.
- Create a document in Microsoft Word with formatting that complies with the APA guidelines.
- Write functions in Microsoft Excel to perform basic calculations and to convert number to text and text to number.
- Create a presentation in Microsoft PowerPoint that is interactive and legible content

Reference Books:

1. Fundamentals of Computers by V.RajaRaman, PHI Learning Pvt. Ltd, 2010.
2. Microsoft Office 2010 Bible by John Walkenbach, Herb Tyson, Michael R. Groh andFaithe Wempen, Wiley Publications, 2010.

SSE 703: INFORMATION TECHNOLOGY TOOLS

Hours per week : 03 **Sessional Evaluation : 100 Marks**
Credits : 02

Preamble: The course enables the student to understand networking concepts related to Internet and introduce the social Networking sites and working of Email. It gives orientation of Block Chain technology. It give hands on training in SPSS, R Programming and creation of simple HTML documents.

Course Objectives:

- To enable the student to understand networking concepts related to Internet and introduce the social Networking sites and working of Email.
- To give orientation of Block Chain technology.
- To give hands on training in SPSS, R Programming and creation of simple HTML documents

Introduction to Internet: Networking Concepts, Data Communication –Types of Networking, Internet and its Services, Internet Addressing –Internet Applications–Computer Viruses and its types –Browser –Types of Browsers.

Internet applications: Using Internet Explorer, Standard Internet Explorer Buttons, Entering a Web Site Address, Searching the Internet– Introduction to Social Networking: twitter, tumblr, Linkedin, facebook, flickr, skype, yahoo!, google+, youtube, WhatsApp, etc.

E-mail : Definition of E-mail, Advantages and Disadvantages,User Ids, Passwords, Email Addresses, Domain Names, Mailers, Message Components, Message Composition, Mail Management, Email Inner Workings.

WWW-Web Applications, Web Terminologies, Web Browsers ,URL–Components of URL, Searching WWW –Search Engines and Examples.

Block Chain technology: What is Block Chain, Blockchain Architecture, How Block chain Transaction Works? Why do we need Blockchain? Block chain versions, Block chain Variants, Block chain Use Cases, Important Real-Life Use Cases of Block chain Bitcoin cryptocurrency: Most Popular Application of Block chain, Block chain vs. Shared Database, Myths about Block chain, Limitations of Block chain technology.
SPSS : SPSS Commands, Descriptive Statistics, Hypothesis Testing, Test of Difference, Analysis of Variance- One Way ANOVA, Non Parametric Tests, Correlation Analysis, Regression Analysis.

R Programming: Becoming familiar with R, Working with Objects, Introduction to Graphical Analysis.

HTML: WEB Terminology, Structure of HTML Document, HTML – Head and Body tags, Semantic tags- HR- Heading, Font, Image & Anchor tags, Different Types of Lists using Tags, Table Tags, Image Formats – Creation of Simple HTML Documents.

Learning Outcomes:

- Enable to understand the basic networking concepts, types of networks, Internet Explorer and www.
- Outline the Block chain architecture, Bitcoin Crypto currency and Limitations of Block Chain.
- Choose different statistical tests to be performed on the data sets.
- Demonstrate the R programming with simple graphs.
- To make use of commands to structure HTML document.

REFERENCE BOOKS:

1. In-line/On-line : Fundamentals of the Internet and the World Wide Web by Raymond Greenlaw and Ellen Hepp, 2nd Edition, TMH.
2. Microsoft Office 2010 Bible by John Walkenbach, Herb Tyson, Michael R. Groh and Faithe Wempen, WileyPublications.

3. SBT 721: MICROBIOLOGY AND CELL BIOLOGY LAB

Hours per week	**: 06**	**End examination**	**: 40 Marks**
Credits	**: 03**	**Sessional**	**: 60 Marks**

Preamble:

This course has been designed to train students with basic techniques of cell biology and the role of microbes in the daily life as well as in the various fields of science, Imparts advanced training in Microbiology for the students and also how the microbes can be controlled is also dealt with.

Course Objectives:

- Is to provide practical skills on basic microbiological techniques.
- Is to isolate, characterize and identify common bacterial organisms.
- Is to preserve bacterial cultures and to determine sensitivity test.
- Is to identify different stages of mitotic and meiotic cell division process.

1. Isolation of bacteria by streaking and serial dilution methods.
2. Biochemical characterization of selected bacteria
3. Staining techniques- simple, differential, acid fast and spore staining.
4. Determination of doubling time of *E.coli*.
5. Determination of potability of water by MPN test
6. Microbiological examination of milk by resazurin test.
7. Oligodynamic action of copper on bacteria
8. Detection of bacterial motility by hanging drop method
9. Antibiotic sensitivity test by disc and well diffusion method.
10. Isolation of bacteriophages from sewage.
11. Microscopic examination of thallus and fruiting bodies of algae and fungi
12. Microtomy-cross sections of plant/animal tissues.
13. Identification of different stages of mitosis (onion root tips) by squash method
14. Identification of different meiotic stages by smear method (in onion flower buds)
15. Isolation of sub-cellular organelles(nucleus / mitochondria / chloroplast) by centrifugal techniques

Learning outcomes:

By the end of the course, the student will be able to:

- Learn how to make slides for cytological examinations and will equip themselves with the basic cytology aspects to be performed in the laboratory.
- Learn all aspects of microbiology as it is required for Biotechnology course.
- Isolate and characterize the microorganisms based on morphology, biochemical characteristics, distribution and reproduction.
- Enumerate the microbes from various samples and to understand the role of microorganism in environment by their biochemical activities.

RECOMMENDED BOOKS:

1. Handbook of Microbiological Media by Atlas R.L, 4th Edition, CRC Press.
2. Manual of Clinical Microbiology by Murray PR et al., 9th Edition.
3. A Laboratory manual of Microbiology: Microbes in action by HW Seeley *et al*., 4th Edition.
4. Molecular Biology of the Cell by B.Alberts *et al.*.
5. Handling of Chromosomes by Darlington & Lacor, 3rd Edition, George Allen & Unwin Publishers

SBT 723: BIOCHEMICAL ANALYSIS AND TECHNIQUES LAB

Hours per week : 06 **End examination : 40 Marks**

Credits : 03 **Sessional : 60 Marks**

Course Objectives

The objectives of this course are to provide hands on experience to post graduate students on quantitative analysis and separation of biomolecules by chromatography techniques and analysis of biomolecules by spectroscopy.

1. Ultraviolet absorption spectra of nucleic acids and protein
2. Determination of molar extinction coefficient of aromatic amino acid
3. Determination of Isoelectric point of glycine
4. Estimation of ascorbic acid by 2,6 - dichlorophenol indophenol method
5. Estimation of proteins by Lowry and BCA methods
6. Estimation of carbohydrate by Anthrone method
7. Estimation of cholesterol by Zak's method
8. Determination of iodine value of oils
9. Separation of amino acids by paper chromatography
10. Separation of lipids by thin layer chromatography.
11. Separation of amino acids by ion exchange chromatography
12. Separation of proteins by gel filtration and determination of molecular weight
13. Separation of proteins by SDS PAGE and determination of molecular weight
14. Purification of protein by affinity chromatography
15. Separation of biomolecules by HPLC
16. Separation and determination of molecular weight of lipids by GCMS

Student Learning Outcomes:

On completion of this course, students should be able to:

- Quantify the biomolecules.
- Understand the principle of various biochemical separation techniques.
- Understand the principle and biochemical analysis by spectroscopy.

RECOMMENDED BOOKS

1. Modern experimental Biochemistry by Rodney Boyer – 3rd edition (Benjamin Cummings)
2. Biochemical methods by Sadasivam and Manikam– 3nd edition (New Age International Pvt Ltd Publishers)
3. An introduction to practical biochemistry by D.T.Plummer– 2nd Edition (McGraw Hill)
4. Laboratory manual in Biochemistry by J.Jayaraman (Wilety Eastern limited)
5. Biochemistry - a laboratory courses by J.M.Beckar– 2nd edition (Academic Press)
6. Introductory practical Biochemistry by S.K.Sawhney and Randhir Singh– 2nd edition (Narosa)

SBT 702: IMMUNOLOGY

Hours per week	**: 04**	**End examination**	**: 60 Marks**
Credits	**: 04**	**Sessional**	**: 40 Marks**

Preamble: This course deals about the structure and organization of different components of the immune system. The course makes the student understand about the biological function of various cells and organs of the sentinel system and their critical role in orchestrating an appropriate response in resisting the unwanted hostile intruders. The course explains how the immune system responds in transplantation and how does it resist cancer. The course also helps to understand the principles and significance of various immunoassays.

Course objectives:

- Course helps students to get knowledge about different cells, organs and other components of the immune system
- Course gives a view on understand the immune response manifested by different components.
- Course enlightens about the response of immune system in different pathological conditions and also learns about different techniques based on antigen and antibody interactions

UNIT-I

Introduction to Immune system-innate Immunity and adaptive immunity. Immunological barriers. Pattern recognition receptors. Toll like receptors in innate immunity. Cells of the immune system - lymphocytes, macrophages, neutrophils, NK, NKT cells and Innate lymphoid cells. Organization and structure of lymphoid organs. Antigens, Immunogens, Adjuvants, Haptens. Factors contributing to antigenecity. Superantigens. B and T cell epitopes.

Learning Outcomes: Student will learn about

- Different cells of the immune system
- Various lymphoid organs
- Requirements of antigenicity

UNIT-II

B cell ontogeny–B cell development, maturation, activation and memory. BCR.Types of B cells Classification, fine structure and functions of antibodies. Antigenic determinants-isotypes, allotypes and idiotypes. The generation of antibody diversity. Effector cell mechanisms of humoral response.Complement system–Classical, alternate and mannose binding lectin pathways, biological functions and regulation.

Learning Outcomes: Student will learn about

- Ontogeny of B cell
- Functions of different classes of antibodies and antibody diversity
- Biological function and regulation of complement system

UNIT-III

T cell ontogeny–Development, maturation, activation and memory. TCR. Types of T cells. MHC restriction. Recognition of antigen by B-Cell and T-Cell receptors. MHC& HLA-Types, structure and properties. Antigen processing and presentation. Cell mediated immune responses. Regulation of immune response.Cytokines-Properties and biological functions. JAK-STAT Signaling Pathway. Inflammation-Mechanism of inflammation., Inflammasome activation.

Learning Outcomes: Student will learn about

- Ontogeny of T cell
- Significance of MHC in antigen processing and presentation
- Biological functions of cytokines

UNIT-IV

Immunological tolerance-Factors involved in maintaining tolerance. Autoimmune diseases-Organ specific and Systemic.Hypersensitivity-Mechanism and pathophysiology of different types of hypersensitivity, Immune responses against infectious agents.

Learning Outcomes: Student will learn about

- Immunological tolerance, autoimmunity
- Hypersensitivity
- Immune response against infections

UNIT-V

Transplantation-Types of graft, Immune response in transplantation, Tissue typing, GVHD-Immune response. Cancer immunology-Antigens involved in tumors, Immune response to tumors. Evasion of tumors from the immune system. Cancer Immunotherapy. Immunological techniques: principles of antigen and antibody interactions-Affinity, Avidity, Antibody valency, agglutination, precipitation. Gel diffusion methods-Single and double immunodiffusion. Complement fixation test. ELISA. ELISPOT. Immunoelectrophoresis. Western blot. RIA. FACS. Immunostaining.

Learning Outcomes: Student understands about

- Immune responses in transplantation
- Cancer biology and immune system responses in cancer
- Learns about antigen and antibody interactions and different immunological techniques

RECOMMENDED BOOKS

1. Immunology a short course by E Benjamin and S Leskowitz, Wiley Liss NY.
2. Fundamental Immunology by William E Paul, 4th Edition, Garland Science publishers.
3. Immunology by Roitt*et.al.,* 8th Edition, Elsevier.
4. Immunology by Kuby*et al.,* 5th Edition, WH Freeman and Co.
5. Principles of Microbiology and Immunology by Davis *et.al.,* Harper International Publishers.
6. Immunology-understanding of immune system by KlansD.Elgret, Wiley-LissPublishers,NY.
7. Cellular and Molecular Immunology by AK Abbas & AH Lichtman, 9th Edition, Elsevier.
8. The Immune System by Charles Janeway, *et al.,* Garland Publishing.

SBT 704: MOLECULAR BIOLOGY

Hours per week	**: 04**	**End examination**	**: 60 Marks**
Credits	**: 04**	**Sessional**	**: 40 Marks**

Preamble: This course introduces about the nature of genetic material, its chemical composition, mechanism of replication, transciption and protein synthesis. This course enlightens about gene expression and factors contribute in fine tuning the gene expression.

Course Objective:

The objectives of this course are to make students understand how molecular machines are constructed and regulated so that they can accurately copy, repair, and interpret genomic information in prokaryotes and eukaryotic cells. Further, to appreciate the subject of molecular biology as a dynamic and ever-changing experimental science.

UNIT-I

Nature of genetic material, organization of genetic material in prokaryotes and eukaryotes. Structure of chromatin, Fine structure of the gene. Different kinds of genes- split genes, overlapping, assembled, polyprotein and nested genes. Gene amplification and polytene chromosome. C - Value paradox, Mitochondrial and plastid genomes.

Learning Outcomes:

- Students should be able to acquire basic knowledge on molecular architecture of prokaryotic and eukaryotic genomes.

UNIT-II

DNA replication – Types of DNA polymerases. Mechanism of DNA replication. Enzymes and accessory proteins involved in DNA replication. Replication of telomeres and its significance. Differences in prokaryotic and eukaryotic DNA replication and regulation. DNA damage and repair.

Learning Outcomes:

- Students should be able to learn various molecular events that lead to duplication of DNA. Also, the mechanisms by which DNA could be damaged and repairs itself will be also studied.

UNIT-III

Transcription in prokaryotes and eukaryotes. Mechanism of transcription, types of RNA Polymerases and Promoter-Polymerase interactions. Transcriptional factors. Processing of mRNA, tRNA and rRNA. RNA editing and transport. Molecular Tools- Run-Off Transcription and G-Less Cassette Transcription. Nuclear Run-On Transcription, Reporter Gene Transcription,

Learning Outcomes:

- Students should be able to learn the basic mechanism and methods to measure rate of gene expression

UNIT-IV

Translation in prokaryotes and eukaryotes: Genetic code, translational machinery, mechanism of initiation, elongation and termination. Regulation of translation, Co- and Post- translational modifications. Leader sequences and protein targeting. Measuring Protein Accumulation in vivo. Methods for studying DNA-protein interactions: EMSA, DNase I footprinting, methylation interference assay and CHIP. Methods for studying protein-protein interactions: Co-immunoprecipitation, Pull-down assay, Cross-linking protein interaction analysis, Label transfer protein interaction analysis, Far–western blot analysis**.**

Learning Outcomes:

- Students should be able to learn how expressed genes can be translated into proteins following a central dogma. Also, the methods to study DNA and protein interactions.

UNIT-V

Regulation of gene expression in prokaryotes and eukaryotes- the operon concept, Negative and Positive control and Attenuation. Role of Enhancers, Cis-trans elements, DNA methylation and Chromatin remodeling in gene expression. Environmental regulation of gene expression. RNAi and gene silencing, Genome editing mechanisms- ZFNs, TALENS, CRISPR-Cas9.

Learning Outcomes:

- Students should be able to understand molecular mechanisms behind different modes of gene regulation in bacteria and eukaryotes

RECOMMENDED BOOKS:

1. Biochemistry by L Stryer, 8th Edition, WH Freeman publishers.
2. Lewin's Genes XI by JE Krebs, ES Goldstein & ST Kilpatrick, Student Edition, Jones & Bartlett publishers.
3. Cell and Molecular Biology by DeRoberties & DeRoberties, 8th Edition, S Chand & Co..
4. Freifelder's Essentials of Molecular Biology by GM Malacinski, 4th Edition, Jones & Bartlett.
5. DNA Science: A First Course by DA Micklos et al., 2nd Edition, Carolina Publishing Company.
6. Molecular Biology of the Gene by JD Watson et. al., 7th Edition, Benjamin-Cummings Pub. Co.
7. Molecular Biology by Robert F Weaver, 5th Edition, McGraw-Hill.

SBT 706: ENZYMOLOGY AND ENZYME TECHNOLOGY

Hours per week	**: 04**	**End examination**	**: 60 Marks**
Credits	**: 04**	**Sessional**	**: 40 Marks**

Preamble:

This course enables a learner to makes an insight into the enzymes, known as macromolecular biological catalysts that enhances the basic biochemical reactions and fine-tunes the metabolism with high accuracy. Understanding the basic process of biochemistry and are very much crucial for many applications of biological research with specific emphasis on enzyme kinetics, inhibition and regulation. The course shall make the students aware of various functions of enzymes within the context of each topic.

Course Objectives:

1) To educate students about the fundamental concepts of Enzymology & Enzyme Technology and its related commercial applications, thus preparing them to meet the challenges in medicine and industry.
2) To improve the basic knowledge and to bring awareness on enzyme inhibition and regulatory processes.
3) To improve the knowledge about the enzyme immobilization

UNIT-I

Basic Concepts: Nomenclature and classification of enzymes, Enzyme specificity, Factors effecting enzyme activity: enzyme concentration, substrate concentration, pH, temperature and metal ions. Enzyme assay and units of enzyme activity. Coenzymes and metalloenzymes.

Learning outcomes:

By the end of the unit, the student will be able to:

- Gain fundamental knowledge on basic concepts of enzymes
- Give account on various factors which influence enzyme activity

UNIT-II

Enzyme Kinetics: Determination of initial velocity, Michaelis - Menten equation and Steady state assumption theory, Significance of Km, Vmax and Kcat, Lineweaver - Burk plot. Enzyme inhibition: Irreversible inhibition and Reversible inhibition & kinetics - competitive, non-competitive and uncompetitive inhibition.

Learning outcomes:

By the end of the unit, the student will be able to:

- Understand the molecular basis of enzyme kinetics and various types of inhibitions from the perspective of biochemical pathways occur in biological cellular environments, which are very important in the understanding the life processes.

UNIT-III

Active site determination / investigation; Mechanism of enzyme action of Carboxypeptidase A and Ribonuclease - A. Multienzyme systems (PDH complex & Fatty acid synthase complex). Isolation and purification of enzymes. Enzyme regulation: Allosteric enzymes, Zymogen activation, Covalent modification and isoenzymes.

Learning outcomes:

By the end of the unit, the student will be able to:

- Understand the active site investigation to decipher the key active site residues.
- Gain knowledge about the fine-tuning of metabolism by means of enzyme regulation.
- Purify the enzymes under controlled conditions.

UNIT-IV

Techniques of enzyme immobilization: adsorption, entrapment, covalent binding and cross linking. Properties and applications of Immobilized enzymes, Application of enzymes in medicine and industry.

Learning outcomes:

By the end of the unit, the student will be able to:

- Be familiar with various types of enzyme immobilization .
- Apply the knowledge of enzyme immobilization technology in medicine and industry.

UNIT-V

Abzymes – Types and strategies for designing abzymes. Ribozymes – Types and mechanism of action. Synzymes, Enzyme engineering by site directed mutagenesis. Production of extracellular microbial enzymes: protease and amylase.

Learning outcomes:

By the end of the unit, the student will be able to:

- Gain knowledge about design strategies for making abzymes.
- Understand the synzymes and ribozymes with respect to their mechanism and functions.
- Produce extracellular microbial enzymes

RECOMMENDED BOOKS:

1. Enzymology: Biochemistry, Biotechnology and Clinical chemistry by T Palmer & P Bonner, 2nd Edition, Horwood series.
2. Lehninger Principles of Biochemistry by Nelson D & Cox D, 5th Edition, WH Freeman and Co.
3. Biochemistry by L Stryer, 8th Edition, WH Freeman publishers.
4. Textbook of Biochemistry by ES West & WR Todd, 4th Edition. McMillan Publishers.
5. Harper's Biochemistry by Robert K Murray, 28th Edition, McGraw Hill-Lange Publishers.
6. Biochemistry by D Voet & JG Voet, 4th Edition, John Wiley Publishers.
7. Biochemistry by Mathews *et. al.*, 2nd Edition, Pearson Publishers.
8. Biochemical engineering fundamentals by Bailey & Ollis, 2nd Edition, McGraw Hill-Lange Publishers.

SBT 708: METABOLISM AND BIOENERGETICS

Hours per week : 04 **End examination : 60 Marks**

Credits : 04 **Sessional : 40 Marks**

Preamble:

This course has been designed to enrich the students' knowledge about the metabolism of biomolecules. The course shall make the students' aware of the significance of metabolism and bioenergetics of living organisms.

Course Objectives:

The objectives of this course are to build the knowledge of post graduate students about the metabolic significance of various catabolic and anabolic pathways and their integration. The course shall make the students awareof significance of metabolism and its regulation and disorders of metabolic pathways

UNIT- I

Principles of bioenergetics – free energy concept, enthalpy, entropy, redox potential, phosphate group transfer potential. Coupled reactions, high energy compounds in biological systems.Substrate level phosphorylation, electron transport -oxidative phosphorylation and photophosphorylation.

Learning Outcomes:

On completion of this unit, students should be able to:

- Understand the Principles of Bioenergetics
- Understand the role of high energy compounds in biological systems
- Understand the different mechanisms of phosphorylation reactions

UNIT-II

Glycolysis and its regulation. Alcoholic and homolactic fermentation. TCA cycle and its regulation-amphibolic nature of TCA cycle, anapleurotic reactions. Significance of gluconeogenesis, HMP shunt and glyoxylate cycle.Glycogen metabolism-glycogenesis, glycogenolysis and their regulation.Glycogen storage diseases.

Learning Outcomes:

On completion of this unit, students should be able to:

- Understand the anaerobic and aerobic energy yielding pathways
- Understand the significance of gluconeogenesis, HMP shunt and Glyoxylate cycle
- Understand the importance ofGlycogen metabolism

UNIT-III

Saturated and unsaturated fatty acids - synthesis, β-oxidation and regulation.Ketone bodies. Synthesis of triacylglycerides, phospholipids, and cholesterol. Sphingolipids - synthesis and storage disorders

Learning Outcomes:

On completion of this unit, students should be able to:

- Understand the β-oxidation of fatty acids
- Understand the Synthesis of Triacyl glycerides, Phospholipids, Cholesterol and Sphingolipids
- Understand the causes of lipid storage disorders

UNIT-IV

Protein turnover, transamination and oxidative deamination, urea cycle.Biosynthesis and degradation of aromatic and branched chain amino acids. Inborn errors of amino acid metabolism.

Learning Outcomes:

On completion of this unit, students should be able to:

- Understand the protein turnover and formation of urea
- and degradation of amino acids
- Understand the causes of inborn errors of amino acid metabolism

UNIT-V

Synthesis and regulation of purine nucleotides by *denovo*pathway. Salvage of purine nucleotides. Synthesis and regulation of pyramidine nucleotides.Formation of deoxyribonucleotides and their regulation. Degradation of purines and pyrimidine nucleotides, disorders of nucleotide metabolism-Lesch-nyhan syndrome, Gout and Severe combined immunodeficiency disorder (SCID).

Learning Outcomes:

On completion of this unit, students should be able to:

- Understand the synthesis and degradation of purines and pyrimidine nucleotides
- Understand the causes of nucleotide metabolismdisorders

Student Learning Outcomes

On completion of this course, students should be able to:

- Gain fundamental knowledge in metabolic pathways;
- Understand the energy pathways of metabolism
- Understand the integration of metabolism.

RECOMMENDED BOOKS

1. Lehninger Principles of Biochemistry by Nelson, D and Cox, D. –7th Edition. Mcmillan Pub.
2. Biochemistry by L.Stryer– 8th Edition. (Freeman-Tappan).
3. Biochemistry by D.Voet and J.G.Voet– 4th Edition. (John weily).
4. Biochemistry by Garrett and Grisham 6th Edition. (Cengage Learning)
5. Biochemistry Concepts and Connections by Mathews et. al.,Global Edition.
6. Principles of Biochemistry by David Rawnetal., 5th Edition (Pearson)
7. Essentials of Glycobiology. 3rd Edition. (CSHL press)
8. Harper's Biochemistry by Robert K. Murray et al., – 30thEdition. (Langeman).
9. Biochemistry by U.Satyanarayana—4thEdition. (Elsevier)

SAE 702: PROFESSIONAL COMMUNICATION SKILLS

Hours per week : 03 **Sessional Evaluation : 100 Marks**
Credits : 02

Preamble

This course is designed to expose students to the basics of academic and professional communication in order to develop professionals who can effectively apply communication skills, theories and best practices to meet their academic, professional and career communication needs.

Course objectives:

To enable students to
- acquaint themselves with basic English grammar
- acquire presentation skills
- develop formal writing skills
- develop creative writing skills
- keep themselves abreast with employment-readiness skills

UNIT – I

BACK TO BASICS: Tenses, Concord – Subject Verb Agreement, Correction of Sentences-Error Analysis, Vocabulary building.

Learning Outcomes:
At the end of the unit, the student will be able to:
- Use structures and tenses accurately
- apply the right verb to the right subject in a sentence
- Detect incorrect sentences in English and write their correct form
- Acquire new vocabulary and use in speaking and writing

UNIT – II

ORAL PRESENTATION: What is a Presentation? Types of Presentations, Technical Presentation – Paper Presentation, Effective Public Speaking, Video Conferencing.

Learning Outcomes:
At the end of the unit, the student will be able to:
- Overcome speaking anxiety prior to presentation
- Plan and structure effective presentations that deliver persuasive messages
- Prepare slides that can catch the attention of the audience
- Engage the audience
- Skills in organizing, phrasing, and expressing the ideas, opinions and knowledge.
- Facilitate and participate in a video conference effectively

UNIT III

DOCUMENTATION : Letter –Writing, E-mail Writing & Business Correspondence, Project Proposals, Report Writing, Memos, Agenda, Minutes, Circulars, Notices, Note Making.

Learning Outcomes:

At the end of the unit, the student will be able to:

- Write a business letter, which includes appropriate greetings, heading, closing and body and use of professional tone.
- Draft crisp and compelling emails
- Draft project proposals, reports and memos
- Prepare agenda and draft minutes
- Prepare circulars, notices and make notes.

UNIT IV

CREATIVE WRITING: Paragraph Writing, Essay writing, Dialogue Writing, Précis Writing, Expansion of Hints, Story Writing.

Learning Outcomes:

At the end of the unit, the student will be able to:

- Write paragraphs on familiar and academic topics using a topic sentence, supporting detail sentences and a conclusion sentence.
- Learn the structure of a five-paragraph essay and write essays that demonstrate unity, coherence and completeness
- Structure natural, lucid and spontaneous dialogues
- Draft clear, compact logical summary of a passage
- Recognize the elements of a short story and develop their functional writing skills.

UNIT V

PLACEMENT ORIENTATION: Resume preparation, group discussion – leadership skills, analytical skills, interviews –Types of Interviews, Preparation for the Interview, Interview Process.

Learning Outcomes:

At the end of the unit, the student will be able to:

- Write a professional resume that highlights skills, specific to the student's career field
- Acquire the personality traits and skills required to effectively participate in a G.D
- Understand the purpose of interviews
- Be aware of the processes involved in different types of interviews
- Know how to prepare for an interview
- Learn how to answer common interview questions

RECOMMENDED BOOKS :

1. Essentials of Business Communication by Rajendra Pal and J S KorlahaHi, Sultan Chand & Sons.
2. Advanced Communication Skills by V. Prasad, Atma Ram Publications.
3. Effective Communication by Ashraf Rizvi, McGraw Hill Education; 1st Edition , 2005.
4. Interviews and Group Discussions How to face them by T.S.Jain, Gupta,1st Edition, Upkar Prakashan,2010.
5. High School English Grammar and Composition by P.C.Wren & Martin, N.D.V.Prasada Rao S.Chand.

SBT 722: ENZYMOLOGY AND IMMUNOLOGY LAB

Hours per week	**: 06**	**End examination**	**: 40 Marks**
Credits	**: 03**	**Sessional**	**: 60 Marks**

Preamble : Enzymology is the study of enzymes, their structure and function. Enzymes are highly specific towards their substrates. Their specificity is due to their sequence and structural conformation. Sensitive to various physical and biochemical factors. Whereas, Immunology deals with the immune system and is a very important branch of medicine and biological sciences. Immunological cells and immuno-active molecules are significant in protecting from infection through various lines of defense. The non-functioning of immune system leads to various serious disorders and diseases. This course enables the learner to be acquainted with laboratory skills in assaying, quantifying various enzymes and immunological molecules. Further, enhances the ability of understanding the kinetics aspects of enzymes.

Course objectives:

- To train students in the practical aspects of Enzymology and immunology so that they can perform quantification and assay procedures.
- To conduct the experiments on enzymes to study their kinetic behavior at various temperatures, pH etc with respect to the kinetic parameters such as Km and Vmax
- To make students gain expertise in conducting various diagnostic tests.

1. Assay of salivary amylase
2. Assay of bovine pancreatic trypsin.
3. Assay of potato acid-phosphatase
4. Assay of bovine pancreatic RNase / DNase
5. Effect of pH on enzyme activity and determination of optimum pH.
6. Effect of temperature on enzyme activity and calculation of activation energy.
7. Effect of substrate concentration on enzyme activity and determination of Km.
8. Effect of metal ions on enzyme activity.
9. Partial purification of enzyme
10. Immunoprecipitation methods: ODD and RID
11. Immunoelectrophoresis.
12. Quantitative precipitin assay.
13. Complement fixation test.
14. Latex agglutination test
15. Western blotting.
16. Enzyme Linked Immunosorbent Assay (ELISA).
17. Immunodiagnostics- pregnancy test, VDRL test, widal test, blood grouping

Student Learning Outcomes :

By the end of this practical course, the student will be able to

- Gain hands-on experience in conducting various enzyme assays and analysis
- Perform enzyme kinetics related experiments.
- Conduct diagnostic experiments in identifying the cause of various diseases or disorders
- Understand the response of immune system in different pathological conditions and also about different techniques based on antigen and antibody interactions

RECOMMENDED BOOKS:

1. Enzyme assay: A Practical Approach by R. Eisenthal and MJ Danson, 1992 Edition, IRL Press.
2. Biochemical methods by Sadasivam and Manickam, Wiley Eastern limited.
3. An introduction to practical Biochemistry by DT Plummer, 3rd Edition, McGraw Hill.
4. Biochemistry - a laboratory courses by JM Beckar, 2nd Edition, Academic Press.
5. Immunology methods manual - The comprehensive source book by Ivan Lefkovits, Academic Press
6. Manual of clinical laboratory immunology by NR Rose, 6th Edition, ASM Publiushers.
7. The experimental foundations of modern immunology by WR Clark, 2nd Edition, John Wiley & Sons Inc.
8. Introductory practical Biochemistry by SK Sawhney & Randhir Singh (Eds), Narosa Publishing House.

SBT 724: MOLECULAR BIOLOGY LAB

Hours per week	**: 06**	**End examination**	**: 40 Marks**
Credits	**: 03**	**Sessional**	**: 60 Marks**

Course Objective:

This course would familiarize Students with facile molecular techniques involved in isolation and manipulation of genetic material for achieving the desired goal.

1. Isolation of genomic DNA from bacteria.
2. Isolation of plasmid DNA from bacteria.
3. Isolation of Eukaryotic genomic DNA plant /animal.
4. Southern blotting technique.
5. Estimation of DNA using Diphenylamine reagent.
6. DNA denaturation and Hyperchromic effect.
7. Isolation of RNA from yeast.
8. Estimation of RNA using orcinol reagent.
9. Demonstration of cDNA synthesis from RNA.
10. Northern Blotting technique.

Course Learning Outcomes:

Students have learned to

1. Apply landmark discoveries in developing a number of facile molecular techniques used in rDNA technology.
2. isolate DNA and RNA from prokaryote and eukaryotes
3. know the extraordinary power of restriction and other enzymes in molecular cloning and genetic manipulations.
4. perform transformation and cloning of gene (s) for basic and applied research.
5. gain hands-on training in various molecular techniques for gene manipulation

RECOMMENDED BOOKS:

1. Molecular Cloning: A laboratory manual by Gren & Sambrook, 4th Edition, CSHL Press
2. Laboratory manual in Biochemistry by J Jayaraman, 2nd Edition, Wiley Eastern limited.
3. Biochemistry - a laboratory courses by JM Beckar, 2nd Edition, Academic Press.

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SBT 801: GENETIC ENGINEERING

Hours per week	**: 04**	**End examination**	**: 60 Marks**
Credits	**: 04**	**Sessional**	**: 40 Marks**

Preamble:

This course has been designed to enrich students' ability to understand modern areas of biology. Students would learn how engineers apply their understanding of DNA to manipulate specific genes to produce desired traits, and how engineers have used this practice to address current problems facing humanity.

Course Objectives:

1) To enlighten the knowledge of the Students on rDNA technology.
2) To teach students the various approaches in conducting genetic engineering and their application in biotechnology industry

UNIT-I

Isolation of DNA, cDNA synthesis, chemical synthesis of DNA by Phosphoramidite method. Enzymes used in genetic engineering. Restriction endonucleases and Restriction mapping, DNA Ligase, DNA polymerase I, Taq polymerase, Reverse transcriptase, Sl nuclease, Terminal nucleotide transferase, Alkaline phosphatase, Polynucleotide Kinase, Polynucleotide phosphorylase.

Learning outcome:

By the end of this unit, students would

- Understand the isolation of DNA and cDNA synthesis
- Appreciate the different enzymes used in genetic engineering
- Learn about the chemical synthesis of DNA

UNIT-II

Cloning vectors - Salient features, plasmid vectors, phage vectors, cosmids, phagemids (Lambda and M13 phages), viral vectors (SV40, Baculo virus and CMV), Artificial chromosomes - BAC, YAC and MAC. Ligation of DNA to vectors - cohesive end, blunt end, homopolymer tailing, linkers and adaptors.

Learning outcome:

By the end of this unit, students would

- have a clear idea about different vectors used in genetic engineering
- understand DNA ligation
- be able to distinguish viral and bacterial vectors

UNIT-III

Gene transfer Techniques - Transformation, Transfection, Microinjection, Electroporation, Lipofection and Biolistics. Reporter gene assay, selection and expression of rDNA clones, purification of recombinant proteins by affinity tags. Polymerase Chain Reaction, Variants of PCR (Nested PCR, Inverse PCR, RT-PCR, MT-PCR and Real-time PCR) and their applications.

Learning outcome:

By the end of this unit, students would

- understand various gene transfer techniques
- perceive the concept of recombinant protein production
- have clarity on PCR and its variants

UNIT-IV

Construction of genomic libraries and cDNA libraries. Colony and Fluorescent *in situ* hybridization, Southern, Northern and Dot blotting techniques. Nucleic acid probes and probe construction. DNA microarray technology.

Learning outcome:

By the end of this unit, students would

- be able to distinguish genomic and cDNA library construction
- visualize the concept of in situ hybridization
- understand the principle of molecular probes

UNIT-V

DNA sequencing by Chemical, Enzymatic, Automated and NGS methods. Salient features of human genome project. Applications of genetic engineering in Agriculture, Animal husbandry, Medicine and Industry.

Learning outcome:

By the end of this unit, students would

- understand the concept of DNA sequencing
- appreciate the salient features of human genome project
- analyse the application of genetic engineering in different areas

RECOMMENDED BOOKS:

1. From genes to clones by Winneker, 3rd Edition, VCH Publishers.
2. Molecular Biotechnology: Principles and applications of recombinant DNA technology by BR Glick, JJ Pasternak & CL Patten, 4th Edition, ASM Press.
3. Gene cloning and DNA analysis an introduction by TA Brown, 5th Edition, Blackwell publishers.
4. Genomes by TA Brown, 3rd Edition, Garland Science publishers.
5. Principles of Gene Manipulation by Old & Primrose, 7th Edition, Blackwell Publishers.
6. Recombinant DNA: Genes and Genomes - A Short Course by Watson, 3rd Edition, Cold Spring Harbor Laboratory Press.
7. Lewin's GENES XI by JE Krebs, ES Goldstein & ST Kilpatrick, 11thEdition, Jones and Bartlett Learning Publishers.

SBT 803: PLANT BIOTECHNOLOGY

Hours per week : 04 **End examination: 60 Marks**
Credits : 04 **Sessional : 40 Marks**

Preamble:

This course has been designed to enrich students to understand basic principles and impart theoretical knowledge on various techniques of plant tissue culture and plant genetic transformation and their application in crop improvement. This course introduces students to key principles of marker assisted selection and applications of DNA markers for crop improvement.

Course Objectives:

To impart theoretical knowledge on various techniques of plant biotechnology like tissue culture, plant genetic transformation, molecular markers, marker assisted selection, biofertilizers and their application in Agri -biotech industries.

UNIT-I

Plant tissue culture: Historical perspective, Sterilization techniques, media preparation - nutrients and plant hormones. Establishment of *in vitro* cultures - callus culture, cell suspension culture, organogenesis, somatic embryogenesis and cytodifferentiation. Mode of action and significance of Phytohormones.

Learning outcomes:
By the end of the course, the student will be able to:

- Gain fundamental knowledge in media preparation and the role of nutrients in plant growth and development.
- Develop and understand the establishment of *in vitro* cultures
- Understand the action and significance of Phytohormones in Plant tissue culture

UNIT-II

Micropropagation - Stages and applications. Methods to detect pathogens in propagation sources, procedures to eliminate pathogens from plant parts. Production of haploids - Anther, Pollen, Embryo and Ovule culture and their applications. Protoplast isolation, culture and usage. Somatic hybridization - methods and applications, cybrids, somaclonal variations, artificial seeds and germplasm conservation.

Learning outcomes:
By the end of the course, the student will be able to:

- Gain knowledge in various techniques of Plant tissue culture and their applications and in situ and ex situ conservation methods.
- Understand the methods to detect and eliminate pathogenes during *in vitro* propagation.
- Identify the advantages and limitations of haploid cultures and the process of somatic hybridization.

UNIT-III

Methods of gene transfer in plants - *Agrobacterium* mediated (Ti and Ri plasmids, T-DNA transfer), PEG - mediated, Particle bombardment gene gun transformation. Advanced methodologies - cisgenesis, intragenesis and genome editing. Identification of transgenic plants.
Molecular markers (RFLP, RAPD, AFLP and SSR) - Principle and their applications in crop improvement. Marker assisted selection (MAS) - strategies for introducing genes of agronomic importance.

Learning outcomes:

By the end of the course, the student will be able to:

- Understand various methods of gene transfer in plants and their advantages and limitations.
- Learn key principles of molecular markers and strategies used in introducing genes for crop improvement.

UNIT-IV

Transgenic crop technology: Development of herbicide resistant transgenic crops; insect resistance – Bt toxin, Protease inhibitor and other plant derived insecticidal genes; crop engineering for disease resistance (bacterial, fungal and viral) and genetic improvement of abiotic stress tolerance. Molecular Pharming: Production and applications of edible vaccines and plantibodies in plants.

Learning outcomes:

By the end of the course, the student will be able to:

- Gain knowledge in transgenic technology and their applications to overcome biotic and abiotic stress
- Learn the techniques involved in molecular pharming and their applications.

UNIT-V

Engineering for nutritional quality - Improved seed storage proteins, improving and altering the composition of starch and plant oils. Enhancement of micro-nutrients - beta carotene and iron. Introduction, types and industrial improtance of Plant Secondary metabolites. Types of nitrogen fixing microorganism - Rhizobium, Azotobacter, Azolla, Cyanobacteria and Fungal biofertilizers, *nif* gene. Mode of action of Biofungicides (*Trichoderma*, *Pseudomonas fluorescens*) and Bioinsecticides (*Bacillus thuringiensis*, Baculoviruses).

Learning outcomes:

By the end of the course, the student will be able to:

- Learn the applications of genetic engineering and gene transfer technique in improvement of nutritional quality in various crops.
- Develop and understand the types and importance of Plant secondary metabolites.
- Understand the mode of action of various biofertilizers and enhancement of crop yield by its application.

RECOMMENDED BOOKS:

1. Plant Biotechnology: The genetic manipulation of plants by A Slater, NW Scott & MR Fowler, 2nd Edition, Oxford University press.
2. Biotechnologies of Crop Improvement, Volume 1: Cellular Approaches by SS Gosal & SH Wani, Reprint 2018, Springer.
3. Plant Breeding principles & Methods by BD Singh, Reprint 2015, Kalyani Publishers.
4. Plant Cell and Tissue Culture by JW Pollard & JM Walker, Springer Publishers.
5. Agricultural biotechnology by SS Purohit, 3rd Edition, Agrobios Publications.
6. An Introduction to Plant Tissue Culture by MK Razdan, 3rd Edition, Oxford and IBH Publishing.
7. Introduction to Plant Biotechnology by HS Chawla, 3rd Edition, Oxford and IBH Publishing.
8. Molecular Biotechnology: Principles and Applications of Recombinant DNA by Glick & Pasternak, 4th Edition, ASM Press.

SBT 805: BIOPROCESS ENGINEERING AND TECHNOLOGY

Hours per week	**: 04**	**End examination:**	**60 Marks**
Credits	**: 04**	**Sessional**	**: 40 Marks**

Preamble :

The significance of this course is to provide knowledge with principles relevant to Bioprocess Engineering and Technology. This course helps to understand various principles of fermentation processes and downstream processing At the outset, the learner can understand product development having market viability using microorganisms.

Course Objectives:

To educate students about the fundamental concepts of bioprocess engineering & technology and its related applications, thus preparing them to meet the challenges of the new and emerging areas of biotechnology industry. To develop skills about the screening and maintenance of industrially useful microorganisms, the sterilization kinetics, fermentation processes, reactor design, product development and recovery. To improve the base knowledge and to bring awareness on various industrial processes. To improve the knowledge about various energy crops, renewable and non-renewable resources, biofuels, bioremediation and intellectual property rights.

UNIT-I

Isolation screening and maintenance of industrially useful microorganisms, strain improvement by mutations, site directed mutagenesis and genetic recombination. Media for industrial fermentation, sterilization of air and media, thermal death kinetics.

Learning outcomes:

By the end of the unit, the student will be able to:

- Isolate and screen the microorganisms from the soil, air or water and preserve the selected strains.
- Improve the wild strains at genetic level to make industrial applications
- Understand the concept of thermal death kinetics to develop sterilization protocols
- Acquire knowledge about the various media used for industrial processes for large scale production of the products using microorganisms

UNIT-II

Types of fermentation process-batch, fed batch and continuous cultures. Bioreactors-design, parts and their functions. Types of Bioreactors-airlift, packed bed, fluidized and photo bioreactors, tower fermenter, continuous stirred tank bioreactor.

Learning outcomes:

By the end of the unit, the student will be able to:

- Know the various types of fermentation process and understand the basic principles of batch, fed batch and continuous process.
- Carry out stoichiometric calculations and specify models of microbial growth.
- Gain knowledge about the design parameters and operations of the bioreactors.

UNIT-III

Industrial production of vitamins (Vitamin B_{12} and Riboflavin), Amino acids (lysine, glutamic acid) organic acids (citric acid, acetic acid), alcoholic beverages (beer and wine), organic solvents (ethanol, acetone, butanol), antibiotics (penicillin, streptomycin). Production of single cell proteins.

Learning outcomes:

By the end of the unit, the student will be able to:

- Give an account of important microbial / industrial processes in beverage, pharma, food and nutraceutical industry
- Present unit operations together with the fundamental principles for basic methods in production technique for bio-based products.

UNIT-IV

Downstream processing, removal of microbial cells and solid matter, cell disruption, extraction, concentration, purification, drying and crystallization of the products, *In-situ* recovery of the products.

Learning outcomes:

By the end of the unit, the student will be able to:

- Be familiar with different methodologies involved in the downstream processing in removing the microbial cells and solid matter from the fermentation broth and finishing of product purification.
- Understand the significance of operations during product recovery under *In-situ* and *Ex-situ* conditions.

UNIT-V

Energy crops- Production of first, second and third generation Biofuels - biodiesel. Solid waste and waste water treatment and management. Role of microbes in removal of oil spills, bioremediation and bioleaching. Global environmental problems: ozone depletion, UV-B, green house effect, acid rain - their impact and biotechnological approaches for management. IPR, patent protection for biological inventions.

Learning outcomes:

By the end of the unit, the student will be able to:

- Develop knowledge about energy crops and biofuels
- Be familiar with the processes of bioremediation and bioleaching.
- Understand the global environmental problems and their management using biotechnological strategies.
- Be acquainted with intellectual property rights and protection of biological inventions.

RECOMMENDED BOOKS:

1. Principle of fermentation technology by Stanbury, 2nd Edition, Elsevier.
2. Industrial Biotechnology by Creuger & Creuger, 2nd Edition, Panima publishers.
3. Industrial Microbiology: An Introduction by MJ Waites *et al.*, 1st Editon, Blackwell Science Ltd.
4. Modern Industrial Microbiology and Biotechnology by Nduka Okafor & BC Okeke, 2nd

Edition, CRC Publishers.
5. Industrial Microbiology by LE Casida Jr., 2nd Edition, New Age International Publishers.
6. Biochemical engineering fundamentals by Bailey & Ollis, 2nd Edition, Intl. Pub.
7. Molecular Biotechnology: Principles and applications of recombinant DNA technology by BR Glick, JJ Pasternak & CL Patten, 4th Edition, ASM Press.
8. Biotechnology and genomics by PK Gupta, Rastogi Publications.
9. Environmental Biotechnology by Forster CF & Wase DAJ, Ellis Horwood Ltd.

PROGRAM ELECTIVE I

SBT 841 ANIMAL BIOTECHNOLOGY

Hours per week : 04 **End examination: 60 Marks**
Credits : 04 **Sessional : 40 Marks**

Preamble:

This course deals with basic methodology associated with cell, tissue and organ culture and importance of media and kinetics of cell growth. This paper explains the properties of stem cells and their culture. This course also deals with induced pluripotency. This course gives a detailed view on aquaculture practices and *in vitro* fertilization methodology and transgenic techniques.

Course objectives:

Student will learn techniques of cell, tissue and organ culture and learns about stem cells and induced pluripotency. Student will learn about aquaculture practices and human reproductive physiology *in vitro* fertilization methods. Student will learn about different methods used in the production of transgenic plants/animals.

UNIT-I

Basic techniques of cell, tissue and organ culture. Primary culture and subculture of cells. Kinetics of cell growth. Properties of transformed cells. Role of carbondioxide, serum, and other supplements in cell culture. Different types of culture media- natural media, BSS, MEM, serum free media. Different methods for the estimation of cell viability and cytotoxicity. Applications of cell culture. Bioethics and Biosafety. Different types of microbial contamination and eradication

Learning outcomes: The student should be able to understand
- Basic requirements for cell, organ and tissue culture and culture kinetics
- Management of culture contamination
- Bioethics and biosafety

UNIT-II

Stem cells– embryonic and adult stem cells. Isolation and culture of stem cells. Cancer stem cells. Stem cell markers. Induced pluripotency. Stem cell plasticity and differentiation. Application of stem cells in medicine. Apoptosis- mechanism and significance with reference to degenerative diseases – Parkinson's disease, stroke and diabetes.

Learning outcomes The student should be able to understand
- Properties and types of stem cells and cancer stem cells
- Induced pluripotency
- Apoptosis

UNIT-III

Reproductive physiology of male and female-Menstrual cycle, Oogenesis, Ovulation and Spermatogenesis. Types and causes of male and female infertility. *In vitro* fertilization methodology in humans. Sperm collection, and superovulation. Embryo culture and transfer. Cryopreservation. Artificial insemination. Amniocentesis, immunocontraception.

Learning outcomes: The student should be able to understand
- Reproductive physiology of male and females
- Infertility of males and females
- Artificial insemination

UNIT-IV

Concept of aquatic biotechnology. General cultural practices of fish, prawn and shrimp. Pearl culture technology. Fish byproducts. Induced breeding techniques. Hypophysation and Eyestalk oblation. Economically important aquatic resources

Learning outcomes: The student should be able to understand

- Culture practices of fish, prawn and shrimp
- Pearl culture technology
- Artificial breeding techniques

UNIT-V

Production of transgenic animals-mouse, sheep, cattle and fish by microinjection, retroviral vector method and embryonic stem cell method. Animal cloning-somatic cell nuclear transfer and embryonic stem cell nuclear transfer methods. Biopharming and gene knockout.

Learning outcomes: The student should be able to understand

- The process of production of transgenic animals
- The mechanism of animal cloning
- Biopharming and gene knockout

RECOMMENDED BOOKS:

1. Culture of Animal cells; A manual of Basic techniques by R Ian Freshney, 6th Edition, Wiley-Blackwell publishers.
2. Molecular Biotechnology: Principles and applications of recombinant DNA technology by BR Glick, JJ Pasternak & CL Patten, 4th Edition, ASM Press.
3. Elements of Biotechnology by PK Gupta, Rastogi Publications.
4. Biotechnology by U Satyanarayana, 3rd Edition, Books and Allied Sciences Publishers.
5. Concepts of Biotechnology by Balasubrahmanian*et al.*, Revised edition, University press.
6. Aquaculture: Principles and practices by TVR Pillay, Reprint 1993, Wiley publishers.
7. Coastal aquaculture in India by Santhanam, CBS Publishers.
8. A Textbook of Fisheries Science and Indian Fisheries by CBL Srivatsava, Kitab Mahal publishers.

SBT 843: FOOD BIOTECHNOLOGY

Hours per week : 04 **End examination: 60 Marks**

Credits : 04 **Sessional : 40 Marks**

Preamble:

This course has been designed to offer students a good command of basic principles of food science and technology and applying this understanding to growing and dynamic needs of food industries.

Course Objectives:
Demonstrate a level of comprehension of concepts of food science. Critically evaluate and solve issues or problems pertaining to food science.

UNIT-I

Energy: Energy content of foods - physiological fuel value - review. Measurement of energy expenditure: BMR, RMR, thermic effect of feeding and physical activity, methods of measurement. Estimating energy requirements of individuals and groups.

Learning outcomes:

By the end of the course, the student will be able to:
- Learn fundamentals of food biotechnology
- Basic knowledge of Measurement of energy expenditure
- Estimating energy requirements

UNIT-II

Microorganisms in foods. Factors affecting the microbial growth. Microbial food borne diseases. Food poisoning, control measures for food poisoning out breaks. Analysis of microorganisms and their products in foods, Fermented foods, role of microbes in fermented foods and genetically modified foods.

Learning outcomes:

By the end of the course, the student will be able to:
- Learn Factors affecting the microbial growth and Microorganisms in foods
- Analysis of microorganisms
- Fermented foods and genetically modified foods.

UNIT-III

Food groups, functions of foods. Nutritive value, composition, storage and preservation of cereals, pulses, nuts & oil seeds, milk & milk products, egg, fish, meat, vegetables, fruits, sugars, fats and oils. Food additives: Synthetic & natural colorants, natural & artificial sweeteners, stabilizers and emulsifiers.

Learning outcomes:

By the end of the course, the student will be able to:
- Obtain an appreciation for role and importance of nutrition in preserved foods
- Importance of Synthetic & natural food additives
- Role of stabilizers and emulsifiers

UNIT-IV

Applications of enzymes in food industry: Amylases, Proteases, Lipases, Glucose isomerase, lactase, pectinase and Renin in food industry. Production of bread, cheese, idly, beverages and appetizers. Food packaging methods and materials.

Learning outcomes:

By the end of the course, the student will be able to:

- Co-relate enzymes used in various branches of food and feed industry
- Learn mechanism of action of enzymes used in specific processes

UNIT-V

Functional foods: Advances in Biotechnology for the production of functional foods; Probiotics, Regulatory aspects of food biotechnology; Future strategies for development of biotechnology-enhanced functional foods for human nutrition. Food safety, evaluation of food quality and quality assurance (PFA, FSSAI, HACCP, ISO and FSO systems).

Learning outcomes:

By the end of the course, the student will be able to:

- Understand State functions of packaging
- Learn various forms of packaging materials in common use contemporarily
- Understand various food safety parameters

RECOMMEDED BOOKS:

1. Text book of Human Nutrition by MS Bamji, 3rd Edition, Oxford and IBH publishing Pvt. Ltd.
2. Food Processing Principles & Applications by Ramaswamy and Marcotte, Taylor and Francis- CRC Publications.
3. Food Packaging: Principles and practice by GL Robertson, 3rd Edition, Taylor and Francis group.
4. Food Chemistry by LH Meyer, Affiliated East and west Press Ltd., Bombay, 1987.
5. FSSAI Training manual.
6. Nutrition Science by B Srilakshmi, 2nd Edition, New Age International (P) Ltd.
7. Food Science by B Srilakshmi, 2nd Edition, New Age International (P) Ltd.
8. Food facts and Principles by N Shakuntala Manay & M Shadakshara Swamy, New Age International Publishers (P) Ltd., 1987.
9. Food Microbiology by Frazier, 4th Edition, W.C. Mc Graw Hill Incorporation.

SBT 845: AQUACULTURE AND MARINE BIOTECHNOLOGY

Hours per week : 04 **End examination: 60 Marks**
Credits : 04 **Sessional : 40 Marks**

Preamble:

This course has been designed for giving students a thoroughunderstanding of basic science behind the aquaculture and salient marine biological processesrelated to marine ecosystem and microbiology as well as familiarize them withthe possible applications leading to fisheries and marine biotechnology.

Course Objectives:

To teach sustainable use of aquatic resources with various approaches in biotechnology. Introduce students to marine environment and its physical features; Introduce students to principal marine fisheries of coastal areas. Educate students on status and trends of major fish resources and their conservation in region.

UNIT-I

Ocean: Physical Properties -Temperature, turbidity, light transparency, pressure, water currents, tides and waves. Chemical properties -salinity, dissolved oxygen and pH. Composition of sea, estuarine and brackish waters.

Learning outcomes:

By the end of the course, the student will be able to:
- Familiarise with various physical and chemical properties of ocean.
- Learn the composition of trace elements present various aquatic habitats.

UNIT-II

Marine Ecology: Classification of marine environment. General characteristics of primary biotic divisions-Plankton, Nekton and Benthos.

Learning outcomes:
By the end of the course, the student will be able to:
- Learn the marine ecological concepts and classification of marine environment
- Learn the characteristic features of phytoplanktons and zooplanktons.

UNIT-III

Status and importance of aquaculture. Design, construction and management of aquaculture - ponds, cages, pens, raceways, rafts. Maintenance of culture ponds. Diseases in aquaculture organisms, diagnosis, prevention and treatment methods.

Learning outcomes:

By the end of the course, the student will be able to:
- Study the management of aqua farms and construction of aquaculture ponds
- Learn the diseases, diagnosis and treatment methods of aquaculture organisms

UNIT-IV

Culture practices of fresh and brackish water-Fin fish, shell fish culture- prawn and shrimp. Monoculture, Polyculture and integrated farming.

Learning outcomes:

By the end of the course, the student will be able to:

- Study culture practices of different aquatic organisms
- Learn different farming practices in aquaculture.

UNIT-V

Remote sensing applications in coastal zone management-Territorial water, contigious zone and Exclusive Economic Zone. Exploitation of marine natural resources for the production of Antibiotics, Antifouling agents, ß –carotene, agar agar and pearls. Laws pertaining to aquaculture and exploitation of living resources.

Learning outcomes:

By the end of the course, the student will be able to:

- Understand the regulatory methods and coastal zone management
- Study economically important products from marine natural resources.
- Understand the Laws pertaining to aquaculture and EEZ

RECOMMENDED BOOKS:

1. Marine Ecology by O Kinne, Volumes I, II and III, John Wiley & sons.
2. The Oceans: Their Physics, Chemistry, and General Biology by Svedrop, Johnson & Fleming, Prentice hall publishers.
3. A text book of Marine biology by NB Nair & DM Thampy, Mcmillan publishers.
4. Plankton and productivity in oceans. Volume I: Phytopankton & Volume II: Zooplankton by JEG Raymont, 2nd Edition, Pergamon publishers.
5. Aquaculture: Principles and practices by TVR Pillay, Reprint 1993, Wiley publishers.
6. Coastal aquaculture in India by Santhanam, CBS Publishers.
7. A Textbook of Fisheries Science and Indian Fisheries by CBL Srivatsava, Kitab Mahal publishers.

SBT 847: CANCER BIOLOGY

Hours per week	**: 04**	**End examination: 60 Marks**	
Credits	**: 04**	**Sessional**	**: 40 Marks**

Hours per week	**: 04**	**End examination**	**: 60 Marks**
Credits	**: 04**	**Sessional**	**: 40 Marks**

Preamble:

The course is designed to give a detailed understanding of the field of cancer biology to students. Established concepts and emerging techniques are assembled together in this course. An universal perspective of cancer-causing agents, biological process involved in tumor formation, diagnosis and treatment options available are discussed in detail to give students a focus on cancer biology.

Course Objective:

This course is an introduction to the molecular and cellular basis of cancer. The course will take a mechanistic view of the dysregulation of cellular processes that occurs in cancer cells, including the mechanisms of action of anti-cancer drugs and radiation treatments.

UNIT-I

Introduction to cancer-tumour, neoplasia, benign and metastatic tumour, oncogenes, tumour suppressor genes; General features of cancer. Classification of cancers. TNM staging system of cancer. Carcinogens-physical, chemical- exogenous and endogenous, biological-DNA Viruses and RNA Viruses, DNA Adduct formation.

Learning outcome:
By the end of the unit, student would be able to

1) distinguish different tumors
2) describe the general features of cancer
3) explain the different types of carcinogens

UNIT-II

Cell cycle alterations in cancer. Genetic Variations in Cancer. Mechanisms of genetic instability and chromosome aneuploidy in cancer. Defects in DNA repair mechanisms. Telomeres and telomerase dynamics in cancer. Epigenetic elements and processes in cancer. e

Learning outcome:
By the end of the unit, student would be able to

1) explain the genetic variations in cancer
2) appreciate the role of DNA repair mechanisms
3) learn the role of epigenetic elements in cancer

UNIT-III

Role of growth factors, receptors, secondary messengers in signaling pathways of cancer induction and progression. Angiogenesis-Mechanism, molecular mediators endogenous inhibitors of angiogenesis. Metastasis-initiation and Progress. Apoptosis-changes in apoptosis leading to cancer. Mechanisms of Immune response and surveillance in tumor formation.

Learning outcome:
By the end of the unit, student would be able to

1) delineate the signaling pathways in cancer progression
2) decipher the process of angiogenesis and metastasis
3) describe cell death and immune response

UNIT-IV

Cancer diagnostics and therapeutics; Recent advances in new diagnostic tests. Tumor imaging, Detection of metastasis. Immunohistochemical diagnosis. Treatment of cancers in different organs of the body-Chemotherapy, Surgery, Radiation Therapy, endocrine therapy and Immunotherapy.
Learning outcome:
By the end of the unit, student would be able to

1) appreciate the recent advances in cancer diagnostics
2) understand different treatment forms available for cancer
3) gain expertise in tumor imaging

UNIT-V

Cancer genome and Proteome analysis. Present status of drug development, clinical trials and treatment. Future scope of research in design and development of new vaccines and other anticancer drugs. Ethical and regulatory issues involved in cancer drug design.
Learning outcome:
By the end of the unit, student would be able to

1) discuss the various clinical trials of cancer treatment
2) design effective research topics for anti-cancer drugs
3) debate on ethical and regulatory issues involved in cancer drug desgin

RECOMMENDED BOOKS:

1. Molecular Biology of Cancer: Mechanisms, Targets and Therapeutics by L Pecorino, Oxford University press.
2. Cancer: Principles and Practice of Oncology by VT DeVita Jr., TS Lawrence & SA Rosenberg, 9th Edition, Lippincott Williams and Wilkins publishers.
3. The Biology of Cancer by RA Weinberg, 2nd Edition, Garland Science.
4. Introduction to Cancer Biology by R Hesketh, Cambridge University Press.
5. Principles of Cancer Biology by LJ Kleinsmith, 1st Edition, Pearson publishers.

SBT 821: INDUSTRIAL BIOTECHNOLOGY AND GENETIC ENGINEERING LAB

Hours per week	**: 06**	**End examination**	**: 40 Marks**
Credits	**: 03**	**Sessional**	**: 60 Marks**

Preamble:

The course offers an excellent opportunity for students to gain practical experience in genetic engineering techniques. The course is designed for students to attain efficiency in performing techniques in industrial biotechnology.

Course objectives:

To train students in the practical aspects of genetic engineering so that they can perform gene cloning, amplify DNA and use these techniques in forensic sciences.To make students gain expertise in industrial techniques like bulk fermentation, production and estimation of enzymes and alcohol.To teach students the importance of strain improvement of industrially important microorganisms.

1. Amplification of DNA by PCR.
2. DNA restriction digestion and separation of DNA fragments by Agarose gel electrophoresis.
3. Elution of DNA from agarose gels.
4. Ligation of DNA fragments.
5. Bacterial transformation and identification of transformants by blue white colony / GFP.
6. RAPD and RFLP analysis.
7. Selective isolation of actinomycetes and fungi from soil samples.
8. Production of protease by shake flask method batch fermentation.
9. Production of amylase by shake flask method batch fermentation.
10. Immobilization of an enzyme by gel entrapment.
11. Immobilization of whole cells for enzyme production by gel entrapment.
12. Production of red wine from grapes and estimation of alcohol.

Learning outcomes:

1) Students would gain hands on expertise in genetic engineering techniques and experiments
2) Students will be able to understand the importance of PCR, and its application in forensic medicine by RAPD method.
3) Students would be able to successfully transfer and detect nucleic acids (DNA and RNA)
4) Students will appreciate the production of enzymes and alcohol in bulk by fermentation techniques
5) Students will be able to assess the immobilisation techniques of enzymes and their use in industry.

RECOMMENDED BOOKS:

1. Biotechnology: A laboratory course by JM Becker, 2nd Edition, Wiley publishers.
2. Molecular Cloning: A laboratory manual by Gren& Sambrook, 4th Edition, CSHL Press
3. Laboratory manual in Biochemistry by J Jayaraman, 2nd Edition, Wiley Eastern limited.
4. Biochemistry - a laboratory courses by JM Beckar, 2nd Edition, Academic Press.
5. A manual of Industrial Microbiology and Biotechnology by AL Demain*et al*., 3rd Ed, ASM press.
6. Immobilization of enzymes and cells: Methods in Biotechnology volume I by GF Bickerstaff, Springer publishers.
7. Principle of fermentation technology by Stanbury, 2nd Edition, Elsevier.

SBT 823: PLANT AND ANIMAL BIOTECHNOLOGY LAB

Hours per week	**: 06**	**End examination**	**: 40 Marks**
Credits	**: 03**	**Sessional**	**: 60 Marks**

Preamble:

This course has been designed to enrich and impart hands-on-training on various techniques of plant tissue culture and plant genetic transformation. To impart practical skills to students the principles, practices and application of animal biotechnology, plant tissue culture, genetic transformation of plants, cell viability and their application in biotech industries.

Course Objectives:

The objective of this laboratory course is to introduce students to cell culture basics, covering topics such as requirements of a laboratory dedicated to cell culture experiments, cell viability, growth and maintenance of cell lines. Introduce laboratory safety, aseptic technique and basic preservation methods, freezing, and thawing cultured cells. Further, impart skills in handling various explants of model plants for callus induction and plant regeneration methods.

1. Preparation of media for plant tissue culture (MS and B5).
2. Establishment of callus cultures from carrot cambial tissue
3. Embryo culture of maize/crotolaria.
4. Organogenesis and regeneration of plants from tobacco explants.
5. Anther culture and production of haploids.
6. Isolation of protoplasts and culture.
7. Polyethylene glycol (PEG) mediated fusion of protoplasts.
8. *Agrobacterium* mediated transformation.
9. Preparation of animal cell culture media and membrane filtration.
10. Preparation of single cell suspension from spleen and thymus.
11. MTT assay for cell viability and growth.
12. Estimation of viable cells using trypan blue
13. Calculation of doubling time for different cells
14. Trypsin/Collagenase for splitting and maintenance of cell lines.
15. Preparation of glycerol stocks and preservation of cell lines

Student Learning Outcomes:

On completion of this course, students will be able to perform basic experiments on plant and animal biotechnology and help them to take up plant and animal biological research as well as placement in relevant biotech industry.

RECOMMENDED BOOKS

1. Plant cell culture: A practical approach by RA Dixion & RA Gonzales, 2nd Edition, IRL press.
2. Plant tissue culture - Theory and practice by SS Bhojwani & MK Razdan, 1st Ed, Elsevier.
3. Biotechnology: A laboratory course by JM Becker, 2nd Edition, Wiley publishers.
4. Animal cell culture - A practical approach by JRW Masters, 3rd Edition, IRL Press.
5. Animal cell culture techniques, by M Clyenes, Springer publishers.
6. Culture of Animal cells: A manual of Basic techniques by RI Freshney, 6th Edition, Wiley-Blackwell publishers.

SBT 802: BIOINFORMATICS

Hours per week	**: 04**	**End examination**	**: 60 Marks**
Credits	**: 04**	**Sessional**	**: 40 Marks**

Preamble:

Bioinformatics is an information technology applied to the management and analysis of biological data with the aid of computers. It is the science of using information to understand biology. It is a field in which biological information collected, compared, Studied and analyses to find the interrelation between them for solving structural, functional and evolutionary problems using computational technologies.

Course Objectives:

The objective of this course is to provide theoretical and practical knowledge of the usage of computational tools and databases. This course enables investigation of molecular biology and evolution-related ideas by using various tools and databases.

UNIT-I

Introduction to computers, anatomy of computers and its accessories, types of computers, scope of computers in biological research. Introduction to operating systems – DOS, Windows, UNIX, Linux. Introduction to programming in C, SQL, PERL, HTML.

Learning Outcomes:

By the end of this Unit, the student will be able to

- Learn about the salient features of computers and internet.
- Acquire basic knowledge about the operating systems and programming languages that are useful in biological research

UNIT-II

Introduction to Bioinformatics, Biological databases – types of databases (Nucleotide sequence databases, Protein sequence databases, Structure databases, viral databases, immunodatabases, genome databases and Gene expression databases). Database searching using BLAST and FASTA.

Learning Outcomes:

By the end of this Unit, the student will be able to

- Gain knowledge of various biological databases and their uses in research.
- Know about the database searching using various *insilico* tools.

UNIT-III

Sequence alignment – pairwise sequence alignment (Dotplot, Dynamic programming), multiple sequence alignment. Genome sequencing and assembly. Genome annotation – identification of genes (promoter, ribosome binding sites, initiation codons, intron - exon boundaries in a gene, splice sites, termination codons) CpG Islands, repetitive elements, DNA barcoding.

Learning Outcomes:

By the end of this Unit, the student will be able to

- Be acquainted with the genome sequencing, assembly and its annotation using both wet-lab and dry-lab techniques
- Acquire knowledge on different barcoding strategies

UNIT-IV

Introduction to genomics and its applications, functional genomics, comparative genomics and metagenomics. Molecular phylogeny - phylogenetic trees, tree construction methods (Character based and distance based methods) and evaluation.

Learning Outcomes:

By the end of this Unit, the student will be able to

- Comprehend various fields in genomics and their importance in present day scenario
- Deal with the phylogenetic tree construction methods which gives a clear pictureof molecular evolution

UNIT-V

Introduction to proteomics, laboratory techniques in proteomics (protein isolation, purification and characterization). *Insilico* protein sequence analysis – primary, secondary, tertiary (homology modeling), Drug designing and Molecular docking.

Learning Outcomes:

By the end of this Unit, the student will be able to

- Learn about the isolation, purification and characterization of protein using both wet-lab and dry-lab techniques
- Distinguish between a drug and lead molecule

RECOMMENDED BOOKS:

1. Essential Bioinformatics by J Xiong, Reprint 2011, Cambridge University Press.
2. Biological Sequence Analysis by Richard Durbin *et al*., Indian Reprint, Cambridge University Press.
3. Bioinformatics and Functional Genomics by J Pevsner, 3rd Edition, Wiley-Blackwell publishers.
4. An Introduction to Bioinformatics by TK Attwood & DJ Parry-Smith, Reprint 2011, Addison Wesley Longman Limited.
5. Introduction to Bioinformatics by AM Lesk, 3rd Edition, Oxford University Press.
6. Bioinformatics: Sequence and Genome Analysis by DW Mount, 2nd Edition, CSHL Press.

PROGRAM ELECTIVE II

SBT 842: MEDICAL AND PHARMACEUTICAL BIOTECHNOLOGY

Hours per week	**: 04**	**End examination**	**: 60 Marks**
Credits	**: 04**	**Sessional**	**: 40 Marks**

Preamble:

This course deals about different methodologies involved in the production of various health care products and helps us to understand about the process of tissue engineering. This course enlightens on hybridoma technology and basic and new generation strategies to design vaccines and specific attempts to prepare vaccines against some of the diseases challenging mankind and discusses the application of various molecular probes. This course gives a comprehensive view on the design, discovery and metabolism of drugs. This course also deals with the synthesis of nanoparticles using biological systems and significance and applications of nanotechnology.

Course objectives:

This course helps us to understand about the production and applications of health care products and Hybridomas. Gives a view on the design of vaccines and problems associated with the development of vaccines against some of the diseases. This course critically examines the design and metabolism of drugs and the synthesis of nanoparticles and the applications of nanobiotechnology.

UNIT-I

Production of recombinant health care products- insulin, growth hormone, factor VIII, tissue plasminogen activator, urokinase, interferons, lymphokines and Hepatitis-B vaccine. Tissue Engineering: - production of artificial skin, liver and pancreas, advantages and disadvantages of tissue engineering and the ethical issues.

Learning Outcomes: Student will

- Be able to understand the process of production of healthcare products like insulin, growth hormone, factor VIII, tissue plasminogen activator, urokinase etc.
- Be able to enumerate various advantages and disadvantages of tissue engineering and explain about ethical issues.

UNIT-II

Hybridoma technology - production and applications of monoclonal antibodies. Antibody engineering, chimeric antibodies. Vaccines and vaccination technology-strategies for development of vaccines against HIV and malaria. Current development in diagnosis of tuberculosis, malaria and HIV. Disease diagnosis using DNA and enzyme probes. Molecular probes in forensic medicine. Gene therapy.

Learning Outcomes: Student will

- Understand about the production and application of hybridomas
- Can describe about strategies to design various vaccines and explain about the challenges faced in the design of vaccines against malaria and HIV
- Understand about the applications of DNA and enzyme probes and forensic medicine

UNIT-III

Drug discovery & drug delivery: Drug discovery without a lead, lead discovery (random Screening, targeted screening). Lead modifications – identification of active part (Pharmacophore) and functional group modifications. Structural modifications to increase potency. Drug delivery: oral delivery systems, pulmonary delivery systems, transmucosal and transdermal delivery systems. Ligand based targeting approach. Programmable drug delivery systems.

Learning Outcomes: Student will

- Understand about drug discovery and drug delivery various delivery systems
- Able to explain different lead modifications

UNIT-IV

Drug metabolism: Analytical methods in drug metabolism (isolation, separation, identification, quantification). Oxidative, reductive, hydrolytic and conjugative metabolism of drugs. Pharmacogenetics: genetic polymorphism in drug metabolism. Genetic polymorphism in drug transport and drug targets.

Learning Outcomes: Student will

- Understand about drug metabolism
- Be able to explain pharmacogenetics and genetic polymorphism

UNIT-V

Nanobiotechnology: synthesis of nanostructures using sol-gel process and biological production using fungi and bacteria, yeast and actinomycetes. Introduction to nanocarriers. Interaction of nanocarriers with blood stream. Cellular targeting of nanocarriers. Drug delivery and toxicity of nanocarriers.

Learning Outcomes: Student will

- Be able to explain the synthesis of nanoparticles by different methods
- Understand about nanocarriers and their toxicity

RECOMMENDED BOOKS:

1. Molecular Biotechnology: Principles and applications of recombinant DNA technology by BR Glick, JJ Pasternak & CL Patten, 4th Edition, ASM Press.
2. Gene cloning and DNA analysis an introduction by TA Brown, 5th Edition, Blackwell publishers.
3. Fundamentals of Ecology by EP Odum& GW Barrett, 5th Edition, McGraw Hill publishers.
4. Biotechnology by U Satyanarayana, 3rd Edition, Books and Allied Sciences Publishers.
5. Biotechnology and genomics by PK Gupta, Rastogi Publications.
6. Pharmaceutical biotechnology, concepts and applications by G Walsh, John Wiley publications.
7. Drug metabolism in drug design and development by D Zhang *et al*., Wiley publications.
8. The organic chemistry of drug design and drug action by RB Silverman & MW Holladay, 3rd Edition, Academic press.

SBT 844: NANOBIOTECHNOLOGY

Hours per week : 04 **End examination: 60 Marks**
Credits : 04 **Sessional : 40 Marks**

Preamble:

The course aims at providing a general and broad introduction to multi-disciplinary field of nanotechnology. It will familiarize students with the combination of the top-down approach of microelectronics and micromechanics with the bottomup approach of chemistry/biochemistry; a development that is creating new and exciting cross-disciplinary research fields and technologies. The course will also give an insight into complete systems where nanotechnology can be used to improve our everyday life.

Course Objectives:

Students should be able to learn basic science behind the properties of materials at nanometre scale. Understand advanced experimental and computational techniques for studying nanomaterials. Applications of nanaomaterials in allied fields of medicine.

UNIT-I

Nanomaterials: Introduction, examples of nanomaterials – quantum dots, metal nanoparticles, magnetic nanoparticles, carbon nanotubes and nanowires. Introduction to "Top – Down" and "Bottom – Up" approaches of synthesis of nanomaterials. Synthesis of nanostructures using Sol – gel process. Biological products of nanoparticles using fungi, bacterial, yeast and actinomycetes.

Learning outcomes:

By the end of the course, the student will be able to:

- Learn about different nanocomposite materials
- Learn the synthesis of nanomaterials by different approaches

UNIT-II

Characterization of nanomaterials: nanoscale probes: X-ray crystallography, Mossbauer spectroscopy, infrared spectroscopy, Raman spectroscopy, scanning electron microscopy, transmission electron microscopy, scanning tunneling microscopy, atomic force microscopy and scanning probe microscopy.

Learning outcomes:

By the end of the course, the student will be able to:

- Learn about the devices used to analyse the nanomaterials
- Understand the importance of XRD and TEM in determination of particles size and shape

UNIT-III

Protein based nanostructures: chemistry and structure of S-Layers, self-assembly, recrystallisation methods, lipid chips. Magnetosomes: magnetotactic bacteria, magnetic crystals in magnetosomes, biochemistry and gene expression in magnetosome formation, applications of magnetosomes. Bacteriorhodopsin: structure, function, properties and applications.

Learning outcomes:

By the end of the course, the student will be able to:

- Learn about the S layer producing archaea and their applications
- Understand the deposition of magnetite or gregite as magnetosome in magnetotactic bacteria
- Learn the mechanism of light derived ATP synthesis by Bacteriorhodopsin protein

UNIT-IV

DNA based nanostructures: DNA- protein nanostructures: oligonucleotide- enzyme conjugates, DNA – streptavidin conjugates, multifunctional protein assembly, DNA – protein conjugates in microarray technologies. DNA – based metallic nanowires and networks: Template design, DNA as biomolecular template, metallization, gold cluster – oligonucleotide conjugates, DNA nanowires, metal cluster labels with platinum, palladium, tungstanates and iridium.

Learning outcomes:

By the end of the course, the student will be able to:

- Learn about the protein nucleic acid nanobased conjugates and their applications
- Learn the process of DNA based template design and metallization by metal cluster labels.

UNIT-V

Nanometals in medicine: introduction to nanocarriers, interactions of nanocarriers with blood stream, cellular targeting, biological and chemical reagents for cell – specific targeting. Biodistribution of liposomes, dendrimers and nanoparticles, toxicity of nanoparticles, drug deliver, tissue regeneration, cancer detection, luminescent nanoparticles probes for bioimaging and diagnostics.

Learning outcomes:

By the end of the course, the student will be able to:

- Learn about the applications of nanoparticles in drug delivery and tissue /cell specific targeting as nanocarriers.
- Learn the importance of nanoparticle probes for bio-imaging and diagnostics.

RECOMMENDED BOOKS:

1. Nano chemistry: A chemical approach to nanomaterials by O Geoffrey *et al.,* Royal Society of Chemistry Publication.
2. Nanobiotechnology: Concepts, Applications and Perspectives by CM Niemeyer & CA Mirkin, Wiley-VCH publishers.
3. Nanobiotechnology II: More concepts and Applications' by CM Niemeyer & CA Mirkin, Wiley– VCH publishers.
4. Nanobiotechnology by PC Trivedi, 1st Edition, Pointer Publishers.
5. The hand book of Nanomedicine by KK Jain, 2nd Edition, Humana Press.

SBT 846: PROTEIN ENGINEERING

Hours per week : 04 **End examination: 60 Marks**

Credits : 04 **Sessional : 40 Marks**

Preamble:

Protein engineering is a valuable tool for the creation of novel or improved proteins for practical and therapeutic uses and provides new insights into protein structure and function.

Course Objectives:

The aim of this course is to introduce methods and strategies commonly used in rational protein designing to understand the protein's structure-function correlation and for therapeutic applications.

UNIT-I

Major functional groups of amino acids and their physical, chemical and biological significance in protein structure and activity. Principles of protein – DNA recognition. Conformation of proteins in general enzymes in particular.

Learning Outcomes:

- Students should be able to describe structure and functional classification of proteins.

UNIT-II

Cooperative transitions in protein molecules, energy status of a protein molecule, kinetics of protein folding and the energy landscape model, introduction to misfolding, aggregation, thermodynamics of protein folding, misfolding and aggregation; protein misfolding disorders: Alzhiemer's disease, Cystic fibrosis, defective p53 influenced / dependent cancer.

Learning outcomes:

- Students will be able to review factors significant for protein folding processes and stability and their associated pathologies

UNIT- III

Basic concepts for design of a new protein molecule – solid phase peptide synthesis, site directed mutagenesis for specific protein function, physical methods such as x-ray crystallography, CD, NMR for determination of protein structure, design and construction of novel proteins and enzymes with specific examples of enzyme engineering, - dihydrofolate reductase, subtilisin.

Learning Outcomes:

- Students should be able to analyse structure of proteins

UNIT-IV

Structure alignment methods (CE, VAST, DALI, SSAP, TM-align). Ramachandran plot, Homology modeling – superimposition, template selection, backbone modeling, loop building, side chain generation, model evaluation and validation. Function prediction based on structural information.

Learning Outcomes:

- Students should be able to construct proteins by computer-based methods

UNIT-V

Protein engineering for protein purification – affinity tags, transit peptide, protein engineering for stability – temperature, pH, half life and function by combinatorial methods, protein engineering for biosensors, vaccine development, engineering proteins for the degradation of recalcitrant compounds, estrogen receptor as a target for new drug discovery, molecular bioscreening in oncology.

Learning Outcomes:

- Students should be able to analyse purity and stability of proteins and explain how to store them in best way

RECOMMENDED BOOKS:

1. Protein Engineering for Industrial Biotechnology by L Alberghina, 2005 Edition, Harwood academic press.
2. Protein Engineering Handbook by S Lutz and UT Bornscheuer, volume III, Wiley-VCH press.
3. Gene Structure and Transcription by T Beebe & T Burke, Oxford University Press
4. Protein Engineering (Nucleic Acids and Molecular Biology) by C Kohrer & UL Raj Bhandaray, 1st Edition, Spinger,
5. Protein Engineering: Principles and Practice by JL Cleland & CS Craik, 1st Edition, Wiley-Liss publishers.
6. Molecular Biology of the Cell by B Alberts et al., 5th Edition, Garland publications incorporation
7. Concepts in Biotechnology by D Balasubramanian et al., Revised Edition, Universities press.

SBT 848: STEM CELL BIOLOGY

Hours per week	**: 04**	**End examination:**	**60 Marks**
Credits	**: 04**	**Sessional**	**: 40 Marks**

Preamble:

This course offers an opportunity the students to understand the basics of stem cells, genetic mmanipulation of stem cells and their applications to various diseases affecting mankind.

Course objectives:

To teach students the importance and availability of stem cells in the body. To make students understand how stem cells function, divide and respond to various factors. To teach students how pluripotent stem cells can be produced in the laboratory and their applications. To teach students the applications of stem cells in transplantation and regenerative medicine. To make students understand how to handle, culture and preserve stem cells and the ethical issues behind the use of stem cells

UNIT-I

Introduction to stem cells. Types-Embryonic, adult stem cells. Properties, potency, Differences and similarities in adult and embryonic stem cells. Stem cell niches. Stem cells localized in different tissues- Hematopoieticand Umbilical cord blood stem cells., mesenchymal, skin, intestinal, neural, cardiac and skeletal stem cells.

Learning outcome:

By the end of this unit, students would

1. be able to differentiate the different types of stem cells that exist
2. understand differences between adult and embryonic cells
3. understand stem cells localized in different tissues of the body

UNIT-II

Isolation and characterization of stem cells. Stem cell markers and their roles in signaling cascades of LIF, Wnt, TGF-beta, PI3/Akt pathways. Mechanisms of self renewal. Epigenetics in stem cells development.Transcriptional control of gene expression in ESC: role of miRNAs, LincRNAs and RNA binding proteins. Cell cycle regulation in stem cells.

Learning outcome:

By the end of this unit, students would

1. develop an understanding on how stem cells can be isolated
2. appreciate the different markers that distinguish stem cells
3. perceive gene regulation and cell cycle in stem cells

UNIT-III

Tissue derivation from different germ layers. Differentiation of stem cells. Induced pluripotency of stem cells, Markers and factors involved in induced pluripotency. Production of induced pluripotent stem cells-earlier attempts and recent advancements. Applications of iPSCs

Learning outcome:

By the end of this unit, students would

1. appreciate the concept of induced pluripotency
2. comprehend the attempts and advancements in production of iPSCs
3. analyse the applications of iPSCs

UNIT-IV

Tissue engineering. Autologous and Allogenic Stem Cell Transplantation, Stem cells in gene therapy. Applications of stem cells in regenerative medicine-neurodegenerative diseases, stroke, cardiac disorders, cancer, and diabetes.Cancer stem cells.

Learning outcome:

By the end of this unit, students would

1. conceptualize tissue engineering and transplantation
2. understand the concept of regenerative medicine
3. comprehend stem cells application

UNIT-V

Cryopreservation of stem cells. Stem cell banking. Clinical trials in stem cell research. Challenges and promises of stem cell applications in medicine and research. Ethical and regulatory issues involving stem cell research.

Learning outcome:

By the end of this unit, students would

1. understand the principle of stem cell cryopreservation and banking
2. appreciate the use of stem cells in medicine and research
3. debate the ethical and regulatory issues of stem cells

RECOMMENDED BOOKS:

1. Essentials of Stem Cell Biology by R Lanza & A Atala, 3rd Edition, Academic Press.
2. Stem Cells: Basics and Applications by KK Deb & SM Totey, Reprint 2009, Tata McGraw-Hill Education, .
3. Stem Cells: From Mechanisms to Technologies by MK Stachowiak& E Tzanakaki, World Scientific publishers
4. Principles of Tissue Engineering by R Lanza *et al.*, 4th Edition, Academic Press.
5. Stem Cell Anthology: From Stem Cell Biology, Tissue Engineering, Cloning, Regenerative Medicine and biology by BM Carlson, Academic press.
6. Stem Cells: From Basic Research to Therapy, Volume I by F Calegari& C Waskow, 1st Edition, CRC Press.

SBT 822: BIOINFORMATICS LAB

Hours per week	**: 06**	**End examination**	**: 40 Marks**
Credits	**: 03**	**Sessional**	**: 60 Marks**

Preamble:

Bioinformatics is an interdisciplinary field that develops methods and software tools for understanding biological data. As an interdisciplinary field of science, bioinformatics combines biology, computer science, information engineering, mathematics and statistics to analyze and interpret biological data. This has been used for *in silico* analyses of biological queries using mathematical and statistical techniques.

Course Objectives:

The objective of this course is to provide practical training in bioinformatics methods including accessing major public sequence databases. It also aims in use of different computational tools in identification of candidate genes, SNPs, ESTs…etc. Analysis of protein and nucleic acid sequences by various software packages.

1.Using NCBI and Uniprot web resources.
2. Introduction and use of various genome databases.
3. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/TrEMBL,UniProt.,
4. Similarity searches using tools like BLAST and interpretation of results.
5. Similarity searches using tools like Psi-BLAST and interpretation of results
6. Multiple sequence alignment using ClustalW.
7. Construction of phylogenetic tree using UPGMA, NJ, Maximum parsimony and maximum likelihood methods using MEGA software.
8. Use of gene prediction methods (Genscan, Glimmer).
9. Using RNA structure prediction tools.
10. Use of various primer designing and restriction site prediction tools.
11. Use of miRNA prediction, designing and target prediction tools.
12. Use of different protein structure prediction databases (PDB, SCOP, CATH).
13. Homology modelling of proteins.
14. Molecular docking by using Swiss Dock tool.

Student Learning Outcomes:

On completion of this course students should be able to:

- Describe contents and properties of most important bioinformatics databases;
- Perform text- and sequence-based searches and analyze & discuss results in perspective of biological knowledge;
- Predict secondary and tertiary structures of protein sequences.
- Compute phylogenetic trees using both character-based and distance-based methods.

RECOMMENDED BOOKS:

1. Bioinformatics Practical Manual by M Iftekhar, Create Space Independent Publishing Platform.
2. Bioinformatics: Sequence and Genome Analysis by DW Mount, 2nd Edition, CSHL Press.
3. Introduction to Bioinformatics by AM Lesk, 3rd Edition, Oxford University Press.

SBT 892: PROJECT WORK AND SEMINAR

Credits : 08 **End evaluation : 200 Marks**

The student should submit a project report by the end of the IV semester based on the results of his/her research work done on a topic relevant to Biotechnology and should give a seminar on that work. The research work may be carried out in universities / institutes / research labs / industries.

DEPARTMENT OPEN ELECTIVE

SOE 831: FUNDAMENTALS OF BIOTECHNOLOGY

Hours per week	**: 03**	**End examination**	**: 60 Marks**
Credits	**: 03**	**Sessional**	**: 40 Marks**

Preamble:

Biotechnology is the broad area of biology involving living systems and organisms to develop or make products. It encompasses wide range of procedures for modifying living organisms according to human purposes like improvements in agriculture, livestock, genetic engineering, plant tissue culture .etc.

Course Objectives:

The objective of this course is to provide theoretical knowledge of genetic material with its composition and various cloning vectors used in rDNA technology. This course enables investigation of molecular biological techniques for transfer of genes, checking their presence through various methods and sequencing them.

UNIT-I

Biotechnology introduction, Nature of genetic material, organization of genetic material in prokaryotes and eukaryotes, fine structure of the gene and different kinds of genes. Isolation of DNA and cDNA synthesis.

Learning Outcomes:

By the end of this Unit, the student will be able to

- Learn about the salient features of genes and their organization.
- Acquire basic knowledge about the isolation process of different forms of DNA.

UNIT-II

Cloning vectors - salient features, plasmid vectors, phage vectors, phagemids, cosmids, viral vectors, artificial chromosomes - BAC and YAC. Enzymes used in genetic engineering, Ligation of DNA to vectors – cohesive end, blunt end, homopolymer tailing, linkers and adaptors.

Learning Outcomes:

By the end of this Unit, the student will be able to

- Gain knowledge of various biological cloning vectors.
- Acquire basic knowledge about the enzymes required in rDNA technology.

UNIT-III

Gene transfer techniques- transformation, transfection, microinjection, electroporation, lipofection and biolistics. Reporter gene assay, selection and expression of rDNA clones. Principles and concepts of electrophoretic techniques- native PAGE, SDS – PAGE, agarose gel electrophoresis and two dimensional gel electrophoresis,

Learning Outcomes:

By the end of this Unit, the student will be able to

- Comprehend various gene transfer techniques and their importance.
- Acquire basic knowledge about the electrophoretic techniques and their applications in genetic engineering.

UNIT-IV

Polymerase chain reaction, its variations and their applications. Construction of genomic and cDNA libraries. Blotting techniques-Northern, Southern, and Western.

Learning Outcomes:

By the end of this Unit, the student will be able to

- Learn about the salient features of PCR and its variants.
- Attain knowledge about the blotting techniques and their use.

UNIT-V

DNA sequencing-Chemical and enzymatic methods, Salient features of Human genome project. Applications of genetic engineering in agriculture, animal husbandry, medicine and industry.

Learning Outcomes:

By the end of this Unit, the student will be

- acquainted with the DNA sequencing strategiesusing wet-lab techniques.
- Aware of applications of genetic engineering in various fields.

RECOMMENDED BOOKS:

1. Principles of Gene Manipulation by Old & Primrose, 6th Edition, Blackwell publishers.
2. Molecular Biotechnology: Principles and applications of recombinant DNA technology by BR Glick, JJ Pasternak & CL Patten, 4th Edition, ASM Press.
3. Gene cloning and DNA analysis: An introduction by TA Brown, 6th Edition, Blackwell publishers.
4. Instrumental methods of chemical analysis by Chatwal &Anand, 5th Edition, Himalaya Publishers.
5. Recombinant DNA technology by JD Watson, 2nd Edition, Scientific American Books.
6. Plant Biotechnology by A Slater, NW Scott & MR Fowler, 2nd Edition, Oxford University press.
7. Biotechnology by U Satyanarayana, 3rd Edition, Books and Allied Sciences Publishers

DEPARTMENT OPEN ELECTIVE

SOE 833: FUNDAMENTALS OF PLANT BIOTECHNOLOGY

Hours per week : 03 **End examination: 60 Marks**
Credits : 03 **Sessional : 40 Marks**

Preamble:
This course has been designed to enrich students to understand basic principles and impart theoretical knowledge on various techniques of plant tissue culture and plant genetic transformation and their application in crop improvement. This course helps students to learn Fundamental of Plant Biotechnology and assist student to focus on multidisciplinary research in plant sciences.

Course Objectives:
To impart theoretical knowledge on various techniques of plant biotechnology like tissue culture, plant genetic transformation, molecular markers, biofertilizers and their application in Agri -biotech industries.

UNIT-I

Plant tissue culture. Composition of culture media, Plant growth hormones, Cellular totipotency, Aseptic tissue transfer, Somatic embryogenesis and organogenesis, Initiation and maintenance of callus, Suspension cultures.

Learning outcomes:
By the end of the course, the student will be able to:
- Gain fundamental knowledge in media preparation and the role of nutrients in plant growth and development.
- Develop and understand the establishment of *in vitro* cultures
- Understand the action and significance of Phytohormones in Plant tissue culture

UNIT-II

Micropropagation, Axillary bud, Shoot-tip and meristem culture, Embryo culture. Production of haploids. Principles of protoplast isolation. Somatic hybridization: Various methods for fusing protoplasts- chemical and electrical. Cybrids and their applications.

Learning outcomes:
By the end of the course, the student will be able to:
- Gain knowledge in various techniques of Plant tissue culture and their applications.
- Acquire knowledge on various explant development through *in vitro* practices
- Know the concepts of somatic hybridization, cybrids and their applications

UNIT-III

Modes of gene delivery in plants: *Agrobacterium* mediated gene transfer, Ti and Ri plasmids, Particle bombardment, PEG, microinjection. Screening and selection of transformants, Identification of transgenic plants.

Learning outcomes:

By the end of the course, the student will be able to:

- Understand various methods of gene transfer in plants and their advantages and limitations.
- Develop and understand various strategies followed in screening and selection of plant transformants
- Gain knowledge in methods of identification of transgenic plants.

UNIT-IV

Development of genetically engineered transgenic plants: Bt cotton, golden rice, herbicide tolerance, disease resistance, insect resistance. Abiotic stress tolerance. Edible vaccines.

Learning outcomes:

By the end of the course, the student will be able to:

- Gain knowledge in transgenic technology and their applications to overcome biotic and abiotic stress.
- Learn the techniques involved nutritional enhancement of crops and also in molecular pharming.

UNIT-V

Molecular markers (RFLP, RAPD, AFLP, SSR) and their applications, Plant secondary metabolites - types and applications, Biofertilizers- Blue green algae, Azolla, Rhizobium, Mycorrhiza (VAM).

Learning outcomes:

By the end of the course, the student will be able to:

- Learn key principles of molecular markers and secondary metabolites types and applications.
- Understand the mode of action of various biofertilizers and enhancement of crop yield by its application.

RECOMMENDED BOOKS:

1. Plant Biotechnology: The genetic manipulation of plants by A Slater, NW Scott & MR Fowler, 2nd Edition, Oxford University press.
2. Biotechnologies of Crop Improvement, Volume I: Cellular Approaches by SS Gosal & SH Wani, Reprint 2018, Springer.
3. Plant Breeding principles & Methods by BD Singh, Reprint 2015, Kalyani Publishers.
4. Plant Cell and Tissue Culture by JW Pollard & JM Walker, Springer Publishers.
5. Agricultural biotechnology by SS Purohit, 3rd Edition, Agrobios Publications.
6. An Introduction to Plant Tissue Culture by MK Razdan, 3rd Edition, Oxford and IBH Publishing.
7. Introduction to Plant Biotechnology by HS Chawla, 3rd Edition, Oxford and IBH Publishing.
8. Molecular Biotechnology: Principles and Applications of Recombinant DNA by Glick & Pasternak, 4th Edition, ASM Press.