

APPENDIX – 32 (R&S)
UNIVERSITY OF MADRAS

SRI SANKARA ARTS AND SCIENCE COLLEGE
(AUTONOMOUS)

B.Sc., BIOTECHNOLOGY
(effective from the academic year 2018 – 2019)

REGULATIONS
Choice based credit system.

1. ELIGIBILITY FOR ADMISSION:

Candidates for admission to the first year of the Degree of Bachelor of Science courses shall be required to have passed the Higher Secondary Examinations (Academic or Vocational Stream) conducted by the Government of Tamil Nadu or an Examination accepted as equivalent thereof by the Syndicate of the University of Madras. Provided that candidates for admission into the specific main subject of study shall possess such other qualifying conditions as may be prescribed by the University.

2. ELIGIBILITY FOR THE AWARD OF DEGREE:

A candidate shall be eligible for the award of the Degree only if he /she has undergone the prescribed course of study in a College affiliated to the University for a period of not less than three academic years, passed the examinations all the Six-Semesters prescribed earning 140 Credits (in Parts-I, II, III, IV & V).

3. DURATION:

- a) Each academic year shall be divided into two semesters. The first academic year shall comprise the first and second semesters, the second academic year the third and fourth semesters and the third academic year the fifth and sixth semester respectively.
- b) The odd semesters shall consist of the period from June to November of each year and the even semesters from December to April of each year. There shall be not less than 90 working days for each semester.

4. COURSE OF STUDY:

The main Subject of Study for Bachelor Degree Courses shall consist of the following

PART – I TAMIL / OTHER LANGUAGES

PART – II ENGLISH

PART – III CORE SUBJECTS
ALLIED SUBJECTS
PROJECT/ELECTIVES WITH THREE
COURSES

PART – IV

1. (a) Those who have not studied Tamil up to XII Std. and taken a Non-Tamil Language under Part-I shall take Tamil comprising of two course (level will be at 6th Standard).

- (b) Those who have studies Tamil up to XII Std. and taken a Non-Tamil Language under Part-I shall take Advanced Tamil comprising of two courses.

- (c) Others who do not come under a + b can choose non-major elective comprising of two courses.

2. SKILL BASED SUBJECTS
(ELECTIVE) - (SOFT SKILLS)

3. ENVIRONMENTAL STUDIES

4. VALUE EDUCATION

PART – V EXTENSION ACTIVITIES

5. EXTENSION ACTIVITIES:

A candidate shall be awarded a maximum of 1 Credits for Compulsory Extension Service.

All the Students shall have to enroll for NSS /NCC/ NSO (Sports & Games) Rotract/ Youth Red cross or any other service organizations in the college and shall have to put in Compulsory minimum attendance of 40 hours which shall be duly certified by the Principal of the college before 31st March in a year. If a student

LACKS 40 HOURS ATTENDANCE in the First year, he/she shall have to compensate the same during the subsequent years.

Students those who complete minimum attendance of 40 hours in One year will get HALF A CREDIT and those who complete the attendance of 80 or more hours in Two Years will ONE CREDIT.

Literacy and population Education Field Work shall be compulsory components in the above extension service activities.

6. SCHEME OF EXAMINATION:

Scheme of Examination shall be given in

Model Scheme

Course Component Name of the course	Inst. Hour	Credits	Exam Hours	Max. Marks		
				Ext. mark	Int. mark	Total
PART-I Language				75	25	100
PART-II English				75	25	100
PART-III Core subject :				75	25	100
Core Subject				75	25	100
Allied Subject				75	25	100

PART – IV

1.(a) Those who have not studied Tamil up to XII Std. and taken a Non-Tamil Language under Part-I shall take Tamil comprising of two course (level will be at 6th Standard).

(b) Those who have studies Tamil up to XII Std. and taken a Non-Tamil Language under Part-I shall take Advanced Tamil comprising of two courses.

(c) Others who do not come under a + b can choose non-major elective comprising of two courses.

2*Skill based subjects(Elective) – (Soft Skill)						
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The following procedure is followed for Internal Marks:

Theory Papers: Internal Marks 25

- INTERNAL MARKS

Tests (2 out of 3) = 10

Attendance = 5

Seminars = 5

Assignments = 5

25 marks

Break-up Details for Attendance

Below 60% - No marks

60% to 75% - 3 marks

76% to 90 % - 4 marks

91% to 100% - 5 marks

Practical: Internal Marks 40

Attendance 5 marks

Practical Test best 2 out of 3 30 marks

Record 5 marks

Project:

Internal Marks	best 2 out of 3 presentations	20 marks
Viva		20 marks
Project Report		60 marks

7. REQUIREMENTS FOR PROCEEDING TO SUBSEQUENT SEMESTER:

- i. Candidates shall register their names for the First Semester Examination after the admission in UG Courses.
- ii. Candidates shall be permitted to proceed from the First Semester up to Final Semester irrespective of their failure in any of the Semester Examination subject to the condition that the candidates should register for all the arrear subject of earlier semesters along the current (subsequent) Semester Subjects.
- iii. Candidates shall be eligible to go to subsequent semester, only if they earn sufficient attendance as prescribed therefore by the Syndicate from time to time.

Provided in case of a candidate earning less than 50% of attendance in any one of the Semesters due

to any extraordinary circumstances such as medical grounds, such candidates who shall produce Medical Certificate issued by the Authorised Medical Attendant (AMA), duly certified by the Principal of the college, shall be permitted to proceed to the next semester and to complete the Course of study. Such Candidates shall have to repeat the missed Semester by rejoining after completion of Final Semester of the course, after paying the fee for the break of study as prescribed by the University from time to time.

8. PASSING MINIMUM:

A candidate shall be declared to have passed:

- a) There shall be no Passing Minimum for Internal.
- b) For External Examination, Passing Minimum shall be of 40% (Forty Percentage) of the maximum marks prescribed for the paper for each Paper/Practical/Project and Viva-voce.
- c) In the aggregate (External + Internal) the passing minimum shall be of 40%.
- d) He/She shall be declared to have passed the whole examination, if he/she passes in all the papers and practicals wherever prescribed / as

per the scheme of examinations by earning 140 CREDITS in Parts-I, II, III, IV & V. He/she shall also fulfill the extension activities prescribed earning a minimum of 1 Credit to qualify for the Degree.

9. CLASSIFICATION OF SUCCESSFUL CANDIDATES:

PART- I TAMIL / OTHER LANGUAGES

TAMIL/OTHER LANGUAGES: Successful candidates passing the Examinations for the Language and securing the marks (i) 60 percent and above and (ii) 50 percent and above but below 60 percent in the aggregate shall be declared to have passed the examination in the **FIRST** and **SECOND** class, respectively. All other successful candidates shall be declared to have passed the examination in the **THIRD** Class.

PART – II ENGLISH

ENGLISH: Successful candidates passing the examinations for English and securing the marks (i) 60 percent and above and (ii) 50 percent and above but

below 60 percent in the aggregate shall be declared to have passed the examination in the FIRST and SECOND Class, respectively. All other successful candidates shall be declared to have passed the examination in the THIRD class.

PART – III consisting of CORE SUBJECTS, ALLIED SUBJECTS, PROJECT / ELECTIVE with three courses:

Successful candidates passing the examinations for Core Courses together and securing the marks (i) 60 percent and above (ii) 50 percent and above but below 60 percent in the aggregate of the marks prescribed for the Core courses together shall be declared to have passed the examination in the FIRST and SECOND Class respectively. All other successful candidates shall be declared to have passed the examinations in the Third Class.

PART – IV (consisting of sub items 1 (a), (b) & (c), 2, 3 and 4) as furnished in the Regulations 4 Part-IV supra.

PART – V EXTENSION ACTIVITIES:

Successful Candidate earning of 1 credit SHALL NOT BE taken into consideration for Classification/Ranking/ Distinction.

10. RANKING:

Candidates who pass all the examinations prescribed for the course in the FIRST APPEARANCE ITSELF ALONE are eligible for Ranking/ Distinction.

Provided in the case of Candidates who pass all the examinations prescribed for the Course with a break in the First Appearance due to the reasons as furnished in the Regulations. 7 (iii) supra are only eligible for classification.

11. TRANSITORY PROVISION:

Candidates who have undergone the course of study prior to the academic year 2018 – 2019 will be permitted to appear for the examinations under those Regulations for a period of TWO years i.e. up to and inclusive of April/May 2021 Examinations. Thereafter, they will permit to appear for the examination only under the Regulations then in force.

Question Paper Pattern

SECTION – A (30 words)

10 OUT OF 12 - 10 X 2 marks = 20 marks

SECTION – B (200 words)

5 out of 7 - 5 x 5 marks = 25 marks

SECTION – C (500 words)

3 out of 5 - 3 x 10 marks = 30 marks

TOTAL = 75 marks

QUESTION PAPER FOR PRACTICALS

The external examiner will prepare a question paper on the spot with the help of the Question Bank supplied by the Controller's office.

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SYLLABUS

FIRST SEMESTER

S. No	Course component	Name of course	Inst. hours	Credits	Theory/ Practical (External : Internal)	Max. marks
1	Part I	Language/ Tamil Paper 1	4	3	75 : 25	100
2	Part II	English Paper 1	4	3	75 : 25	100
3	Part III	Core: Paper1: Cell biology	6	4	75 : 25	100
4	Part III	Core: Paper 2: Practical 1*	6	4	60 : 40	100
5	Part III	Allied	6	5	75 : 25	100

		:Paper1: Microbiology				
6	Part IV	<p>1.a. Those who have not studied Tamil up to XII std and taken a non-Tamil language under Part – I shall take Tamil comprising of two courses (level will be at 6th std).</p> <p>b. Those that have studied Tamil up to XII std and taken a non-Tamil language under Part- I shall take Advanced Tamil comprising of two</p>	2	2	75 : 25	100

		courses. c. Others that do not come under a+b can choose non- major elective comprising of two courses.				
7		2.Skill based subject (Elective): Soft skill -1	2	3	50 : 50	100
Total Credits						24

* Practical examination will be conducted at the end of second semester.

SECOND SEMESTER

S. No	Course component	Name of course	Inst. hours	Credits	Theory/ Practical External : Internal	Max. marks
1	Part I	Language/ Tamil Paper 2	4	3	75 : 25	100
2	Part II	English Paper 2	4	3	75 : 25	100
3	Part III	Core: Paper3: Developmental Biology and Genetics	6	4	75 : 25	100
4	Part III	Core: Paper 4: Practical 2*	6	4	60 : 40	100
5	Part III	Allied :Paper2: Chemistry	6	5	75 : 25	100
6	Part IV	1. A. Those who have not studied Tamil				

	<p>up to XII std and taken a non- Tamil language under Part – I shall take Tamil comprising of two courses (level will be at 6th std).</p> <p>b. Those that have studied Tamil up to XII std and taken a non- Tamil language under Part- I shall take Advanced Tamil comprising of two courses.</p>	2	2	75 : 25	100
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		c. Others that do not come under a+b can choose non-major elective comprising of two courses.				
7		2. Skill based subject (Elective) : Soft skill-II	2	3	50 : 50	100
Total Credits						24

* Practical examination will be conducted at the end of second semester.

THIRD SEMESTER

Course components	Subject	Inst Hrs.	Credits	Exam Hrs.	Max. Marks		
					Ext. Marks	Int. Marks	Total
Part-I	Language Paper-III	5	3	3	75	25	100
Part-II	English Paper- III	5	3	3	75	25	100
Part III - Core Courses	Paper-V – Immunology	6	4	3	75	25	100
Practical*	Paper- VI Immunology and Biochemistry (Practical)	6	4	3	60	40	100
Allied Subject-II	Paper – I Biochemistry	6	5	3	75	25	100
Part-IV	2. Soft Skill-III	2	3	3	50	50	100
Total Credits							22

* Practical examination will be conducted at the end of fourth semester.

FOURTH SEMESTER

Course	Subject	Hr	edi	m	Max. Marks
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Componen ts					Ext. Marks	Int. Marks	Total
Part-I	Language Paper-IV	6	3	3	75	25	100
Part-II	English Paper-IV	6	3	3	75	25	100
Part III Core Courses	Paper-VII - Animal and Medical Biotechnology	6	4	3	75	25	100
	Paper-VIII – Animal and Medical Biotechnology (Practical)	3	4	3	60	40	100
Allied Subject-II	Paper-II - Biophysics and Biostatistics	5	5	3	75	25	100
Part-IV	2. Soft Skill-IV	2	3	3	50	50	100

3. Environmental Studies		2	2	3	75	25	100
Total Credits							24

FIFTH SEMESTER

Course components	Subject	Inst Hrs	Credits	Exam Hrs.	Max. Marks		
					Ext. Marks	Int. Marks	Total
Part-III Core Courses	Paper- IX – Plant Biotechnology	6	4	3	75	25	100
	Paper- X - Environmental Biotechnology	6	4	3	75	25	100
	Paper-XI - Bioinformatics	5	4	3	75	25	100

Practical*	Paper- XII - Plant Biotechnology and Environmental Biotechnology	6	4	3	60	40	10 0
Project (at VI Semester) or Three Electives	Project/Elective -I Methods in Biology	5	5	3	75	25	10 0
Part-IV 4. Value Education		2	2				
Total Credits						18/23	

* Practical examination will be conducted at the end of sixth semester.

SIXTH SEMESTER

Course components	Subject	Inst Hrs.	Credits	Exam Hrs.	Max. Marks		
					Ext. Marks	Int. Marks	Total
Part-III Core Courses	Paper- XIII - Genetic Engineering.	5	4	3	75	25	100
	Paper- XIV – Industrial Biotechnology	5	4	3	75	25	100
Practical	Paper-XV - Genetic Engineering and Industrial Biotechnology (Practical).	6	4	3	60	40	100
Project or Three Electives	Project/Elective –II Microbial Biotechnology	6	5	3	75	25	100

	Project/Elective –III Environmental Biotechnology	6	5	3	75	25	100
	Student project	12	15		240 (40- work book, 150- Disserta tion + 50- Viva)	60	300
Part-V - Extensio n Activitie s		2	1				
Total Credits						13/23	

SEMESTER – I

Title of the paper	Paper 1 - Cell Biology		
Category : Part III Core	Year & Semester First year, Sem 1	Credits 4	
Pre- requisites	Knowledge of biology at Higher Secondary level		
Objectives of the course	To introduce the student to various biological activities occurring at cellular level		

Unit- I

Introduction to the cell: Cell theory, Prokaryotic and Eukaryotic cell, Differences between animal cell and plant cell. Structure and Functions of Cell wall, Plasma membrane (fluid mosaic model) Cell division: mitosis and meiosis cell cycle. Programmed cell death.

Unit- II

Endoplasmic Reticulum Rough and Smooth- ultra structure. Structure and Functions of Ribosome, Mitochondria, Chloroplast, Nucleus, Chromosomes, Golgi apparatus, Lysosomes and peroxisomes.

Unit- III

Introduction to molecular biology: Central dogma, Nucleic acids, DNA Structure (Watson and Crick model). DNA replication, methods of DNA replication, Enzymes and accessory proteins involved in DNA replication, DNA repair mechanism.

Unit- IV

Prokaryotic transcription-Eukaryotic transcription-RNA polymerase-General and specific transcription factors, post transcriptional modifications, Gene expression (Lac operon concept).

Unit- V

Genetic code; characteristics of genetic code, Translation: Prokaryotic translation-Eukaryotic translation-Mechanism of initiation-elongation and termination, Post translational modifications of proteins.

Text Books:

1. Gupta, P. K. 2015 .Cell and Molecular Biology, 4th edition, Rastogi Publications.
2. Cooper, G.M. 2000. The Cell- A molecular approach, 2nd edition. A.S.M. Press, Washington DC.

Reference Books:

1. David Baltimore.2002.Molecular cell biology4th edition. W H Freeman & Co publisher

2. Brown, T.A. 2001. Gene Cloning & DNA analysis. Blackwell Science, London.
3. Lodish, H., Berk, A., Zipursky, S.L., Matusudaria, P., Baltimore, D. and Darnell, J., 2000. Molecular Cell Biology, Media Connected, W.H. Freeman and Company, New York.
4. Benjamin Lewis, 2001. Genes VII. Oxford University Press, London.

Title of the paper	Paper 2 - Practical – 1 Cell Biology and Microbiology		
Category : Part III Core	Year & Semester First year, Sem 1	Credits 4	
Pre- requisites	Knowledge of biology at Higher secondary level		
Objectives of the course	To introduce the student to various laboratory exercises pertaining to cell biology and microbiology.		

(A)Cell Biology: Microscopy- RBC and WBC counting- Enumeration of WBC- Differential leukocyte Count- Salivary gland preparation from Chironomous larva- Mitosis preparation from onion root tip and meiosis

preparation from grasshopper testis- Enumeration of prokaryotic cell- Buccal smear preparation- Cell fractionation (nucleus, mitochondria- Demonstration).

(B) Microbiology: Sterilization techniques: Preparation of media, inoculation techniques – Pour plate, spread plate and dilution techniques. Demonstration of microbial contamination on culture plates. Micrometry- Wet preparation: Hay infusion broth, Hanging drop- Simple staining, Differential staining- Capsule staining- Spore staining- Inoculation techniques: Pour plate- spread plate- Dilution techniques. Biochemical tests for identification of bacteria: - Catalase test- Oxidase test- Urease test- IMVIC test- LAO test- Gelatin liquefaction- Starch Degradation- Carbohydrate fermentation- Viable Bacteria; - morphological identification of Fungi.

Title of the paper	Allied 1 - Paper 1- Microbiology		
Category : Part III Allied	Year & Semester First year,	Credits 5	

	Sem 1		
Pre-requisites	Knowledge of biology at Higher secondary level		
Objectives of the course	To introduce the student to various aspects of basic microbiology.		

UNIT- I

History and Scope of Microbiology- Anatomy of Prokaryotes and Eukaryotes- Bacteria, Fungi, Algae, Protozoa and Viruses- structure and functions of the cellular components- Growth and nutrition- media and culture.

UNIT- II

Classification of microbes- DNA analysis, Ribosomal RNA analysis- Numerical taxonomy- Molecular taxonomy- methods of microbial identification.

UNIT- III

Environmental Microbiology- role of microorganisms in the productivity of ecosystems- Role of microorganisms in food production; dairy and non-dairy products- fermented foods and alcoholic beverages- production of food (single cell protein), Fuel (ethanol).

UNIT- IV

Medical Microbiology- Pathogenic microbes- Bacterial, Viral, Fungal and Protozoan diseases. Cure, control and prevention- Pharmaceuticals (antibiotics, vaccines etc.),

production of vitamins, organic acids Biofertilizers (BGA), Biopesticides, biopolymers, biosurfactants.

UNIT- V

Industrial use of microbes- fermentation products- bioconversions- products of industrial microbiology- Streptomyces, yeasts (Saccharomyces, Hansenula), Spirulina and Penicillium.

Text Books:

1. Lucy Phillip, 2016. Microbiology: Concepts and Applications. Syrawood Publishing House, USA.
2. Ananthanarayan, R. and Paniker, C.K.J. 2016 A text book of Microbiology. 8th edition. Orient Longman Ltd., Hyderabad.
3. Pelzar, 2000. Microbiology. 5th edition. Tata McGraw Hill., New Delhi.

Reference books:

1. Puvanakrishnan, R, Sivasubramanian, S and Hemalatha, T. 2015. Microbes and enzymes basics and applied, 1st edition MJP Publishers, India
2. Kathleen Park Talaro and Talaro, A. 2012. Foundation in Microbiology, 3rd edition, McGraw-Hill, New York.
3. Daniel Lim, 2002. Microbiology, 2nd edition. McGraw-Hill, New York.

Non-major elective: Plant Physiology

Unit I

Photosynthesis: Light harvesting complexes; mechanisms of electron transport; photo protective mechanisms; CO₂ fixation-C₃, C₄ and CAM pathways.

Unit II

Respiration and photorespiration: Glycolysis, Citric acid cycle; plant mitochondrial electron transport and ATP synthesis; alternate oxidase; photo respiratory pathway.

Unit III

Nitrogen metabolism: Nitrate and ammonium assimilation; nif genes, amino acid biosynthesis.

Unit IV

Plant hormones: Biosynthesis, storage, breakdown and transport; physiological effects and mechanisms of action.

Unit V

Stress physiology: Responses of plants to biotic (pathogen and insects) and abiotic (water, temperature and salt) stresses; mechanisms of resistance to biotic stress and tolerance to abiotic stress.

Text Books:

1. V.K.Jain. 2015.Fundamentals of Plant physiology 8th edition, S Chand Publisher.
2. S. N. Pandey, B. K. Sinha, 2009.Plant Physiology, 4th Edition, Vikas publishing company, Noida.
3. N.K. Gupta, S. Gupta, 2005. Plant Physiology Oxford & IBH Publishing Company Pvt Ltd, New Delhi.
4. Rajiv Kumar Sinha, 2004. Modern Plant Physiology, Alpha Science International Ltd, England.
5. Janat Shah, 2003.Plant Physiology., New Age International Pvt Ltd, New Delhi.

Reference books:

1. Lincoln Taiz, Eduardo Zeiger. 2014. Plant Physiology and Development.6th edition.
Sinauer Associates.
2. William G. Hopkins, Norman P. A. Huner .2008. Introduction to plant physiology, 5th Edition. Wiley publishers

Non-major elective: Animal Physiology

Unit I

Blood and circulation: Blood corpuscles, haemopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, hemoglobin, immunity, haemostasis.

Unit II

Cardiovascular System: Comparative anatomy of heart structure, myogenic heart, specialized tissue, ECG – its principle and significance, cardiac cycle, heart as a pump, blood pressure, neural and chemical regulation of all above.

Unit III

Respiratory system: Comparison of respiration in different species, anatomical considerations, transport of gases, exchange of gases, waste elimination, neural and chemical regulation of respiration.

Unit IV

Nervous system: Neurons, action potential, gross neuroanatomy of the brain and spinal cord, central and peripheral nervous system, neural control of muscle tone and posture.

Unit V

Excretory system: Comparative physiology of excretion, kidney, urine formation, urine concentration, waste elimination, micturition, regulation of water balance, blood volume, blood pressure, electrolyte balance, acid-base balance.

Text Books:

1. Surendra Nath Paipuru, 2013. Essentials of Animal Physiology. Lap Lambert Academic Publishing GmbH KG.
2. S. C. Rastogi, 2005. Essentials of Animal Physiology, 3rd Edition, New Age International Pvt Ltd, New Delhi.

Reference books:

1. Richard W. Hill, Gordon A. Wyse, Margaret Anderson, 2012. Animal Physiology. Sinauer Associates Publishers.U.K.
2. Lauralee Sherwood, 2008. Human Physiology from Cells to Systems Cengage, Learning Publishing Company.

SEMESTER – II

Title of the paper	Core Theory 2- Developmental Biology and Genetics		
Category : Part III Core Theory	Year & Semester First year, Sem 2	Credits 4	
Pre- requisites	Knowledge of biology at Higher secondary level and cell biology at		

	Bachelors level.
Objectives of the course	To introduce the student to various molecular aspects of developmental biology and genetics

UNIT- I

Gamete cells: Spermatogenesis, Oogenesis, Sperm and oocyte maturation, Cellular regulation – cell cycle control, important signalling pathways in vertebrate development.

UNIT- II

Fertilization: Types of fertilization, Molecular recognition of egg and sperm, fusion and prevention of Polyspermy, rearrangement of egg cytoplasm and activation of egg. Blastulation, Gastrulation, Types of cleavage, Fate Maps, Nieuwkoop center, molecular role of organizer,

UNIT- III

Myogenesis in mammals- growth factors: Mitogens and Oncogenes. Neurogenesis in Drosophila and chick - Regional specification in Drosophila. Embryogenesis- Mammalian homologs in Drosophila ANT-C and BC-X.

UNIT- IV

Mendelian laws of Inheritance - Dominance, segregation, independent assortment, deviation from Mendelian inheritance. Allele, multiple alleles, pseudo allele,

complementation tests. Pedigree analysis, karyotypes, genetic disorders.

UNIT- V

Identification of the DNA as the genetic material. Genetic recombination in bacteria: Conjugation, transduction, and transformation. Transcription, expression and regulation.

Text Books:

1. Monroe Strickberger, W. 2015. Genetics, 3rd edition Pearson education, India
2. Verma, P.S. and Agarwal, V.K. 2010. Genetics, 9th edition, S. Chand Publishers
3. Karvita, B. Ahluwalia, 2010. Genetics. 2nd edition. New Age International Pvt Ltd, New Delhi.
4. Gardener, E.J, Simmons, M.J and Peter Snustad, D. 2006. Principles of Genetics, 8th edition. Wiley Publishers.
5. Gilbert, S. 2000. Developmental Biology, 7th edition. Sinauer Associates Inc. Publishers, USA.

Reference Books:

1. Peter Snustand, D and Simmons, M.J. 2011. Genetics, 6th edition John Wiley and sons publication
2. Lewis, R. 2001. Human genetics- concepts and application, 4th edition. McGraw Hill.

3. Lodish, H., Berk, A., Zipursky, S.L., Matsudaria, P., Baltimore, D and Darnell, J. 2000. Molecular Cell Biology. Media Connected. W.H. Freeman and Company, New York.
4. Winter, P.C., Hickey, G.J. and Fletcher, H.L.2000. Instant notes in Genetics. Viva books, Ltd.

Title of the paper	Core Paper 4 - Practical 2 - Developmental Biology and Genetics & Chemistry		
Category : Part III Core Practical	Year & Semester First year, Semester 2	Credits 4	
Pre- requisites	Knowledge of biology at Higher Secondary level		
Objectives of the course	To introduce the student to various laboratory exercises in molecular developmental biology and genetics		

Molecular developmental biology and Genetics

1. Observation of sperm from Frog
2. Observation of egg from Frog
3. Observation of living gametes from Grasshopper
4. Observation of living chick embryos 12 hrs development
5. Observation of living chick embryos 24 hrs development
6. Observation of living chick embryos 48 hrs development
7. Observation of living chick embryos 72 hrs development
8. Preparations of culture medium for drosophila.
9. Identification of mutants in Drosophila population
10. Blood grouping
11. Meiosis from grass hopper testis
12. Giant chromosomes from Chironomous larvae

Chemistry Practical

VOLUMETRIC ANALYSIS

- Estimation of Sodium hydroxide using standard Sodium carbonate.

- Estimation of Hydrochloric acid using standard Oxalic acid.
- Estimation of Ferrous sulphate using standard Mohr's salt
- Estimation oxalic acid using standard Ferrous Sulphate.
- Estimation of Potassium permanganate using standard Sodium hydroxide.
- Estimation of Magnesium using EDTA.
- Estimation of Ferrous iron using diphenylamine as internal indicator.

ORGANIC ANALYSIS

Detection of Elements (N, S, Halogens)

To distinguish between aliphatic and aromatic Saturated and unsaturated compounds. Functional group tests for phenol, acids (mono, di) aromatic primary amine, amide, aldehyde & Carbohydrate Glucose. Systematic analysis of organic compounds containing one functional group and characterization by confirmatory test. (Phenol/cresol, cinnamic acid, benzoic acid, phthalic acid, Succinic acid, benzamide, urea, glucose, benzaldehyde & aniline).

REFERENCE

Basic Principles of practical Chemistry: Venkateswaran, Veerasamy & Kulandaivel, S.Chand &Co.

Title of the paper	Allied Theory 2- Chemistry		
Category : Part III Allied Theory	Year & Semester First year, Semester 2	Credits 5	
Pre- requisites	Knowledge of Chemistry at Higher secondary level		
Objectives of the course	To introduce the student to advanced level of Chemistry.		

UNIT- I

Structure of atoms and chemical bonding:

Dalton's Atomic theory- Subatomic particles- concepts of atoms and molecules- General electronic configuration of s,p and d block elements – isotopes, isobars and isotones- shapes of atomic orbitals - periodic table- periodic classification- periodicity, valency. Types of bond - ionic, covalent, coordinate and hydrogen bonding.

UNIT-II

Acids-Bases and Solutions:

Arrhenius concept of acid and bases, proton transfer theory of acid and bases, Lewis concept of acids and bases, concentration of solution, ways of expressing concentrations of solutions – per cent by weight, normality, molarity, molality, mole fraction, pH of solution, pH scale, measurement of pH, buffer solutions, mechanism of buffer action of acid buffer and basic buffer.

UNIT – III

Chemical kinetics and thermodynamics:

Rate – factors influencing rate of reactions - order and molecularity – integrated rate expression for first and zero order reactions – Half life period - Techniques used to study kinetics of reaction – volumetry, polarimetry and manometry. Pseudo first order reaction, methods to determine order of the reaction- Effect of temperature on rate – concept of activation energy – Arrhenius equation. Catalysis – Enzyme catalysis (derivation of Michaelis Menten equation). Terminology of thermodynamics - Types of systems, Reversible, irreversible, isothermal, adiabatic processes, exothermic and endothermic reactions - Spontaneous processes –First law of thermodynamics –Need for the second law - different statements of second law – concepts of Entropy and its significance.

UNIT- IV

Fundamentals of organic chemistry

Classification of organic compounds -.Hybridization in methane, ethane, acetylene, and benzene .Definition with examples- electrophiles, nucleophiles and free radicals.

Types of reactions: addition, substitution, elimination, condensation and polymerisation. (One example each)
Electrophilic substitution reaction in benzene (nitration and sulphonation)

Optical isomerism - symmetry, elements of symmetry - Cause of optical activity, Optical isomers of tartaric acid, Racemisation, Resolution by salt formation method - Geometric isomerism of maleic and fumaric acids. - Keto-enol tautomerism in acetoacetic ester.

UNIT- V

Industrial chemistry:

Hardness of water: temporary and permanent hardness, disadvantages of hard water - Softening of hard water - demineralization process - Zeolite process, and reverse osmosis - Purification of water - for domestic use - use of chlorine, Ozone and UV light. Definitions of pH, TDS, TSS, BOD and COD - determination of BOD and COD. Fuels - Characteristics and Calorific value, Classification, gaseous fuels like water gas, producer gas, and liquefied petroleum gas, gobar gas, compressed natural gas. Fertilizers- Role of NPK fertilizers -urea, Ammonium sulphate, superphosphate, Triple super phosphate, potassium nitrate- manufacture.

Text Books:

1. P.C.Jain and others, 2009. Engineering Chemistry, Dhanpat Rai publishing company, New Delhi.
2. V. Veeraiyan, 2006. Text book of Ancillary

Chemistry, Highmount Publishing house, Chennai.

3. S.Vaithyanathan and Others. 2006. Textbook of Ancillary Chemistry, Priya Publications, Karur.

Reference books:

1. Leroy G. Wade, 2016. Organic Chemistry. Pearson, New Delhi.
2. Gary Wulfsberg, 2016. Inorganic Chemistry, Viva Student Edition, New Delhi.
3. Soni P.L. and Mohan Katyal. 2013. Textbook of Organic Chemistry, Sultan Chand and Company, New Delhi.
4. Puri B.R, Sharma L.R, Pathania M.S. 2006. Principles of Physical Chemistry, Vishal Publishing Co. New Delhi.

Non-major elective (Semester 2): BASICS OF ECOLOGY

Unit I

The Environment: Physical environment; biotic environment; biotic and abiotic

Interactions. Symbiosis. Concept of habitat and niche.

Unit II

Population ecology: Characteristics of a population; population growth curves;

population regulation; life history strategies (r and K selection); concept of metapopulation – demes and dispersal, interdemec extinctions, age structured

populations.

Unit III

Community ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.

Unit IV

Ecological succession: Types; mechanisms; changes involved in succession;

Concept of climax.

Unit V

Ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine).

Text Books:

1. S. S. Purohit, Ashok Agrawal, 2011. Ecology and Environmental Biology. Agrotech Publishing House, New Delhi.
2. Dash. 2009, Fundamentals of Ecology ^{3rd} Edition Tata Mac Graw Hill Education Pvt Ltd, New Delhi.

3. P. S. Verma, V. K. Agarwal, 2000. Environmental Biology: Principles of Ecology .S. Chand Limited, New Delhi.

Reference Book:

1. J. L. Chapman, M. J. Reiss, 2009. Ecology Principles and Applications 2nd Edition Cambridge Publishing
2. Eugene Pleasants Odum, 2005 Fundamentals of Ecology. Cengage Publishing Company.

Non-major elective: EVOLUTION

Unit I

Emergence of evolutionary thoughts: Lamarck; Darwin– concepts of variation,

adaptation, fitness and natural selection.

Unit II

Origin of molecules: Origin of basic biological molecules; abiotic synthesis of organic monomers and polymers.

Unit III

Origin of cells and unicellular evolution: Evolution of prokaryotes; origin of eukaryotic cells; evolution of unicellular eukaryotes.

Unit IV

Evolutionary history: The evolutionary time scale; eras, periods and epoch; major events in the evolutionary time scale.

Unit V

Human evolution: Stages in primate evolution including human.

Text Books:

1. Veer Bala Rastogi. 2014. Organic Evolution. Meddec, Publishing, New Delhi.
2. R. Rajagopalan, 2009, Environment & Ecology, Oxford University Press-New Delhi.
3. P.S.Verma, 2004, Cell Biology, Genetics, Evolution & Ecology (M.E.), 14th Edition. S.Chand Publishing.

Reference Book:

1. Brian K. Hall, Benedikt Hallgrimsson. 2013. Strickberger Evolution Fifth Edition, Jones and Bartlett publishers. New Delhi.
2. Carl Zimmer. 2011 Evolution: The Triumph of an Idea. Arrow books London.

SEMESTER III

Title of the paper	Core Theory 3- Immunology		
Category : Part III Core Theory	Year & Semester Second year, Semester 3	Credits 4	
Pre- requisites	Knowledge of biology at Higher Secondary level		
Objectives of the course	To introduce the student to basic understandings of our immune system.		

UNIT I

Introduction to the immune system: Innate immune response – protective barriers, inflammation. Adaptive immune response- Soluble components of the immune system, lymphocytes, antigen presenting cells. Major histocompatibility complex, Human leukocyte antigens, HLA typing.

UNIT II

Cells and organs of the immune system: Haematopoiesis, Cells involved in the immune response, lymphocytes, mononuclear phagocytes, granulocytes. Primary lymphoid organs, secondary lymphoid organs and tissues, Serum and lymph, Clonal selection of lymphocytes.

UNIT III

Antigen and antibody: Properties of antigen, Haptens, Adjuvants, epitopes. Antigen-antibody interaction. Structure of immunoglobulin, antibody classes and biological activities. Theories of antibody formation. Production and application of monoclonal antibody.

UNIT IV

Cytokines and complement: Properties and biological functions of cytokines. Cytokine related diseases. Complement components; complement activation-classical, alternative and lectin pathway. Membrane attack complex (MAC).

UNIT V

Hypersensitivity and autoimmunity: Hypersensitivity Type I, Type II, Type III, and Type IV. Vaccines- Types of vaccines, DNA vaccines. Autoimmune diseases-organ specific and systemic. Immune response during bacterial (tuberculosis), parasitic (malaria) and viral (HIV) infections, Immunological basis of AIDS and cancer.

Text Books:

1. Sunil Kumar, M, K. Sai, K. C. Nathsarma, 2013. Textbook of Immunology. 2 edition, Jaypee Brothers Medical Publisher, New Delhi.
2. B. Annadurai. 2010. A Textbook of Immunology & Immunotechnology, S. Chand Publisher, New Delhi.
3. Nandini Shetty. 2007. Immunology: Introductory

Textbook. Revised 2nd edition. New Age International publishers, Chennai.

Reference Books:

1. Judith A. Owen, Jenni Punt , Sharon A. Stranford. 2013, Kubey Immunology 7th edition W H Freeman & Co (Sd) Publisher.
2. Abbas AK, Lichtman AH, Pillai S. 2007. Cellular and Molecular Immunology. 6th edition Saunders Publication, Philadelphia.
3. Delves P, Martin S, Burton D, and Roitt IM. 2006. Roitt’s Essential Immunology. 11th edition Wiley-Blackwell Scientific Publication, Oxford.

Title of the paper	Core Practical 3 – Immunology and Biochemistry		
Category : Part III Core Practical	Year & Semester Second year, Semester 3	Credits 4	
Pre- requisites	Knowledge of biology at Higher Secondary level		
Objectives of the course	To introduce the student to basic techniques related to immunology		

Immunology Practical

1. Identification of human blood groups.
2. To separate serum from the blood sample.
3. To identify various immune cells from peripheral blood smear
4. To perform Total Leukocyte Count of the given blood sample.
5. To perform Differential Leukocyte Count of the given blood sample.
6. WIDAL Test
7. ASO Test
8. Rheumatoid arthritis Test
9. Pregnancy Test (HCG)
10. Handling and restraining of laboratory animals
11. Antigen preparation
12. Inoculation routes in laboratory animals
13. Bleeding method in laboratory animals
14. To perform radial immunodiffusion by Mancini method.
15. Double Immunodiffusion Test

16. To perform immunoelectrophoresis.
17. To perform counter current electrophoresis
18. To perform ELISA.

Biochemistry Practical

Volumetric analysis

- a. Estimation of ascorbic acid using 2,6 – dichlorophenol indophenol as link solution.
- b. Estimation of HCl using Na_2CO_3 as link solution.
- c. Estimation of Glycine by formal titration.
- d. Estimation of Glucose by Benedict's method.

2. **Qualitative analysis**

Qualitative analysis of carbohydrates- glucose, fructose, galactose, lactose, maltose and sucrose.

3. **Qualitative analysis**

Qualitative analysis of amino acids – arginine, cysteine, tryptophan and tyrosine.

Reference Books

1. Laboratory Handbook of Biochemistry, S. Shanmugam and T. Sathish Kumar, 1st Edition, 2010, PHI Learning Pvt Ltd.
2. Laboratory manual in Bio chemistry, J. Jayaraman, 1st Edition, 2000, New Age International Publisher.

Title of the paper	Allied Theory 3- Biochemistry		
Category : Part III Allied Theory	Year & Semester Second year, Semester 3	Credits 5	
Pre- requisites	Knowledge of biology and chemistry at Higher Secondary level		
Objectives of the course	To introduce the student to basics of biochemistry		

Unit I

Structure of atoms, molecules and chemical bonds. Van der Waals, hydrogen bonding. pH, buffer. Structure, Chemistry and properties of Carbohydrates, Lipids, Proteins.

Unit II

Classification of porphyrins, their structure and properties. Structure of metalloporphyrins – haeme and chlorophyll. Vitamins and Hormones.

Unit III

Principles of Bioenergetics, Metabolism of Carbohydrates, fat, proteins, purines, pyrimidines – their biosynthesis and degradation, mechanism of oxidative phosphorylation and its inhibitors, photo phosphorylation.

Unit IV

Enzymes – Nomenclature, Classification, Properties of enzymes, Enzyme Kinetics - Effect of substrate concentration, Effect of pH, Effect of temperature. Isoelectric point, Enzyme Regulation - Feedback Regulation, Allosteric enzymes, Isoenzymes.

Unit V

Diabetes mellitus, Atherosclerosis, In bone errors of metabolism - Glycogen storage disease, phenylketonuria, acute intermittent porphyria, Lipoid congenital adrenal hyperplasia, Gaucher's disease, Lesch-Nyhan syndrome. Serum lipids in diseases with special reference to cholesterol, lipidosis, triglyceridemia, hypo and hypercholesterolemia, Fatty Liver.

Text Books:

1. Nagini S. 2015. Textbook of Biochemistry. 2nd Edition. Scitech Publications Pvt Ltd. India.
2. Victor Rodwell, P. Anthony Weil, Kathleen M. Botham – 2015. Illustrated Biochemistry. 30th Edition. McGraw-Hill. Europe.
3. Charlotte W. Pratt, Donald Voet, and Judith G. Voet. 2012. Principles of Biochemistry, 4th Edition. Hoboken, N.J. Wiley; Chichester: John Wiley. New York, United States.
4. Sathyanarayana. U. 2007. Biochemistry. Books and allied Pvt. Ltd. India

Reference Books:

1. Lehninger, A.L., Nelson, D.L and Cox, M.M. 2017. Principles of Biochemistry, 7nd edition. WH Freeman Publishers. New York, United States.
2. Charlotte W. Pratt, Donald Voet, and Judith G. Voet. 2012. Principles of Biochemistry, 4th Edition. Hoboken, N.J. Wiley; Chichester: John Wiley. New York, United States.

FOURTH SEMESTER

Title of the paper	Core Theory 4- Animal and Medical Biotechnology		
Category : Part III Core Theory	Year & Semester Second year, Semester 4	Credits 4	
Pre- requisites	Knowledge of biology at Higher Secondary level		
Objectives of the course	To introduce the student to basics of animal biotechnology		

UNIT - I

Basic principles - Animal cell, tissues and organs culture, medium composition, primary culture and maintenance, secondary and continuous cell lines and suspension cultures. Applications cell culture technology in production of animal.

UNIT - II

Structure of sperms and ovum, cryopreservation of sperms and ova of livestock, artificial insemination, super ovulation, in vitro fertilization, culture of embryos, cryopreservation of embryos, embryo transfer, embryo-splitting, embryo sexing, transgenic manipulation of animal embryos.

Unit III

Historical aspects – Medical Biotechnology – Pathogenic microbes – Bacterial, Viral, Fungal and Protozoan disease – diagnosis using modern techniques – probes – Cure, control and prevention. Probes -disease diagnosis - existing and emerging in animal-Monoclonal antibody- Development of MAB as therapeutics. Vaccines: Conventional vaccines, Modern vaccine technologies, genetically improved subunit vaccines, DNA vaccines,

Unit IV

Gene transfer methods in Animals – Microinjection, Embryonic Stem cell gene transfer, Retrovirus, Gene transfer & Antibody engineering- Knockout mice- Gene-editing technology-TALEN

Unit V

Tools in medical biotechnology- Methods of nucleic acid analysis- Polymerase chain reaction, DNA finger printing, Southern blot and Western blot analysis, RAPD, AFLP, RFLP. Nanotechnology and Its Applications to Animal Biotechnology- Genetic engineered fish for human consumption. Ethical and social considerations surrounding animal biotechnology.

Text Books:

1. Ashish Verma, Anchal Singh. 2013. Animal Biotechnology, Models in Discovery and Translation, 1st Edition, Elsevier press.
2. Portner R. 2007. Animal Cell Biotechnology. Humana Press.
3. Ralf Portner, 2007. Animal cell biotechnology: Methods and protocols. 2nd edition, Humana Press, New Jersey
4. Gordon I. 2004. Reproductive Technologies in Farm Animals. 1st Edition, CABI press.

Reference Books

1. Ian Freshney, 2010. Culture of animal cells. 6th edition. Wiley-Blackwell publishers.
2. Leda R. Castilho, Angela Maria Moraes, Elisabeth F.P. Augusto and Michael Butler, 2008. Animal Cell Technology: From Biopharmaceuticals to Gene Therapy, Taylor & Francis Group.
3. Twyman RM, 2003. Advanced Molecular Biology. 3rd Edition, Bios Scientific publishers.

Title of the paper	Core Practical 4 - Animal and Medical Biotechnology		
Category : Part III Core Practical	Year & Semester Second year, Semester 4	Credits 4	
Pre- requisites	Knowledge of biology at Higher Secondary level		
Objectives of the course	To introduce the student to basic techniques related to animal biotechnology		

1. Preparation of tissue culture medium and membrane filtration
2. Preparation of single cell suspension from spleen and thymus
3. Primary cell culture
4. Introduction to Animal Cell culture: Procedure for handling cells and medium.
5. Cleaning and sterilization of glassware and plastic tissue culture flasks
6. Preparation of sera for animal cell culture
7. Cell counting

8. Acridine orange/Ethidium bromide staining
9. Macrophage monolayer from PEC and measurement of phagocytic activity
10. Cryopreservation and thawing
11. Measurement of doubling time
12. MTT assay for cell viability and growth
13. Cell fractionation (nucleus, mitochondria-Demonstration).
14. Identify any one of the pathogens form the given specimen
15. Preparation of metaphase chromosomes from animal cells
16. Isolation of genomic DNA

Title of the paper	Allied Theory 3- Biophysics and Biostatistics		
Category : Part III Allied Theory	Year & Semester Second year, Semester 4	Credits 5	
Pre- requisites	Knowledge of biology and chemistry at Higher Secondary level		
Objectives of the course	To introduce the student to basics of biophysics and biostatistics		

UNIT-I

Scope and methods of biophysics – levels of molecular organization – detailed structure of protein molecules at primary, secondary, tertiary and quaternary levels.

UNIT-II

Biological macromolecules - physical properties of proteins, three dimensional structure and confirmation using physical methods (principles and applications of electrophoresis, chromatography, viscosity, spectrophotometry, ORD, CD, NMR, ESR to study biomolecules). Analysis of protein, protein interaction and protein – nucleic acid interaction. Structure and chemical nature of polysaccharides.

UNIT-III

Definition - scope of biostatistics - Population and Sample collection, classification, and tabulation of data - graphical and diagrammatic representation - scale diagram - histograms - pie diagrams - frequency polygon - frequency curves.

UNIT-IV

Measures of central tendency - arithmetic mean, median, and mode - calculation of mean, median and mode in series of individual observation, discrete series continuous open - end classes. Measure of dispersion - standard deviation and standard curves.

UNIT V

Probability distributions – Binomial and negative binomial, compound and multinomial distributions – Tests of significance – t tests – F tests – Analysis of variance –

Spread sheets – Data entry – Graphics display – word processes.

Text Books:

1. A.K. Sharma. 2005. Text Book of Biostatistics. House. New Delhi
2. Mahajan. 2006. Methods in Biostatistics. 6th edition. Jaypee brother's publishers, New Delhi.
3. Roland Glaser, 2004. Biophysics, cbspd Publisher

Reference Books:

1. J. Richard and Sundar P. S. S. Rao, 2006. Introduction to Biostatistics and Research Methods 4th Revised edition edition Prentice-Hall of India Pvt.Ltd.
2. Protein structure and molecular properties. Creighton, T.E.2002. W.H. Freeman and Company.
3. DNA Science. Micklos, D.A. and Freyes, G.A. 2002. Cold Spring harbour Laboratory Press.

SEMESTER – V

Title of the paper	Core Theory 5- Plant Biotechnology		
Category : Part III Core Theory	Year & Semester Third year, Semester 5	Credits 4	
Pre- requisites	Knowledge of biology at Higher Secondary level		
Objectives of the course	To introduce the student to basics of plant biotechnology		

UNIT - I

Plant genome organization: Nuclear genome-structure of plant genes, chloroplast and its genome, mitochondria and its genome, cytoplasmic male sterility, Transposable elements.

UNIT - II

Plant growth regulators: Growth hormones-Biosynthesis and physiological effects of auxin, gibberellins, cytokinins, abscisic acid and ethylene.

UNIT - III

Plant tissue culture: culture media, Plant growth regulators, preparation and sterilization of explants. Callus and suspension cultures, protoplast isolation, fusion and

regeneration. Micropropagation, transformation-Direct and Agrobacterium mediated transformation.Ti plasmid.

UNIT – IV

Regulation of gene expression: Inducible control of gene expression-class I Promoters, hormone inducible gene expression, Class II promoters. Phytochrome.

UNIT - V

Transgenic plants: Guidelines for introduction of transgenic plants in the field. Herbicide resistance, pest resistance, disease resistance and stress tolerant plants. Molecular pharming.

Text Books:

1. Krishna G.K.A.Elangovan S.Devika. 2016. Plant Biotechnology, New Visal Publications
2. C.B. Nirmala, G. Rajalakshmi and Chandra Karthick, 2009. 1st Edition. MJP Publishers.
3. B.D. Singh, 2007. Plant Biotechnology. 1st Edition. Kalyani Publishers
4. M. Sudhir, 2000. Applied Biotechnology and plant Genetics. 1st Edition. Dominant Publishers and Distributors.

Reference Books:

1. Adrian Slater, 2011. Plant Biotechnology: The Genetic Manipulation of Plants. 2nd Edition. Oxford University Press.
2. Sant Saran Bhojwani and Prem Kumar Dantu 2013 Plant Tissue culture: An Introductory Text, Springer publisher.
3. H.S Chawla, 2010. Introduction to Plant Biotechnology. 3rd Edition. Oxford and IBH Publishing Co. Pvt. Ltd.

Title of the paper	Core Theory 6- Environmental Biotechnology		
Category : Part III Core Theory	Year & Semester Third year, Semester 5	Credits 4	
Pre- requisites	Knowledge of biology at Higher Secondary level		
Objectives of the course	To introduce the student to basics of Environmental Biotechnology		

UNIT - I

Basic Concepts: Ecosystem dynamics and management: Stability and complexity of ecosystems; Energy flow, food chain, food web and trophic levels; Ecological pyramids and recycling, biotic community-concept, structure, dominance, fluctuation and succession; N.P.C and S cycles in nature.

Unit- II

Environmental Pollution: Water Pollution: sources of pollution and pollutants .Industrial effluents, Domestic wastes, Agrochemical. Heavy metals. Effects of Water pollution, prevention and control of water pollution. Water pollution analysis and monitoring. Soil pollution- sources, effects and its control. Air pollution- sources, air pollutants, effects, control measures. Ozone depletion, global warming.

UNIT -III

Bioremediation and Bio-leaching: Environmental impact of pollution and measurement methods, microbial bioremediation of oil spills. Concepts of bioremediation (in-situ and ex-situ), Bioleaching.

UNIT -IV

Biofertilizers and Biopesticides: Biofertilizers and their importance in crop productivity; Algal and fungal (mycorrhizae) biofertilizers Bacterial biofertilizers (rhizobial, free living N₂ fixers and phosphate solubilizing bacteria), their significance and practice; Biopesticides: Bacterial (BT pesticides), fungal (Trichoderma).

UNIT -V

Genetic Engineering in Environmental Biotechnology:
Genetically engineered microorganisms in environmental health-Genetically engineered plants and microorganisms in agriculture and productivity-Genetically engineered bacteria in bioremediation of organic pesticides, insecticides oil spills-Hazards of genetically engineered microorganisms.

Text Books:

1. Indu Shekar Thakur ,2013.Environmental Biotechnology Basic concepts and applications.2nd edition I.K.International Publishing House Pvt.Ltd
2. R.C.Dubey.2004. Text Book of Biotechnology. Schand Publishers, New Delhi.
3. Sathyanarayana. U, 2002. Biochemistry. Books and allied Pvt. Ltd.

Reference Books:

1. Bruce E. Rittmann, Perry. L. McCarty. 2012. Environmental biotechnology. Tata Mcgrew Hill Publisher.
2. Technoglous, G., Burton, F.L. and Stensel, H.D. 2004. Wastewater Engineering – Treatment, Disposal and Reuse. Metcalf and Eddy, Inc., Tata Mc Graw Hill, New Delhi.

Title of the paper	Core Theory 7- Bioinformatics
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Category : Part III Core Theory	Year & Semester Third year, Semester 5	Credits 4	
Pre- requisites	Knowledge of biology at Higher Secondary level		
Objectives of the course	To introduce the student to basics of bioinformatics		

UNIT I

Biological Databases: Sequence databases – Nucleic Acid sequence Databases: Genbank; Protein Sequence Databases: Swiss Prot, gene prediction rules and software – Human Genome Project

UNIT II

Sequence alignment methods: Pair wise alignment
Alignment Algorithms: Needleman – Wunsch Global Alignment Algorithm; Smith – Waterman Local Alignment Algorithm. Drug design / discovery synthesis.

UNIT III

Genes: Oncogenes – proto-oncogene's – Classification of Cancer types: DNA microarrays – Structural genomics - Functional Genomics – Proteomics Comparative Genomics - Phylogeny

UNIT IV

Pair wise Sequence Analysis Tools: BLAST– Steps involved in using BLAST – Interpreting BLAST results; FASTA – Alignment Scores -Multiple Alignment — ClustalW – Phylogenetic Tree

UNIT V

Sequence analysis: (Proteins and Nucleic acids)
Proteomics: Proteins analysis – structural comparisons – 2D gel, Mass spec. Genome application – Drug design, Management of diverse chemical libraries.

Text books:

1. Dassanayake S.Ranil, Silva Gunawardene, Y.I.N., 2011, Genomic and Proteomic Techniques. 1st edition, Narosa Publishing House Pvt. Ltd., New Delhi.
2. Thiagarajan, B., Rajalakshmi, .P.A., 2009, Computational Biology. 1st edition, MJP Publishers, Chennai.
3. Lohar S. Prakash, 2009, Bioinformatics. 1st edition, MJP Publishers, Chennai.
4. Bosu Orpita, Simminder Kaur Thukral, 2007, Bioinformatics Databases, Tools and Algorithms. 1st edition, Oxford University Press, New Delhi.
5. Rastogi, S.C., Mendiratta, N., Rastogi, P., 2004, Bioinformatics Methods and Protocols. 1st edition, Prentice-Hall of India Pvt. Ltd. New Delhi.

Reference Books:

1. Mairan Walhout, Marc Vidal, Job Dekker, 2012, Handbook of Systems Biology-Concepts and Insights. 1st Edition, Elsevier publications.

2. Chris Eaton, 2012, Understanding Big Data. 1st edition, Mc-Graw Hill.
3. James A. Marcum, 2009, The conceptual foundations of systems biology- An introduction. 1st edition, Nova Science publishers.
4. David Posada, 2009, Bioinformatics for DNA Sequence Analysis (Methods in Molecular Biology). 1st edition, Humana Press.

Title of the paper	Core Practical 5- PLANT BIOTECHNOLOGY & ENVIRONMENTAL BIOTECHNOLOGY		
Category : Part III Core Practical	Year & Semester Third year, Semester 4	Credits 4	
Pre- requisites	Knowledge of biology at Higher Secondary level		
Objectives of the course	To introduce the student to basics of plant biotechnology and industrial biotechnology		

PLANT BIOTECHNOLOGY - Practical

1 Organizing Plant tissue culture Laboratory

2 Preparations of Tissue Culture Media

3 Callus Inductions

4 Shoot tip culture

5 Embryos / Endosperm Culture

- 6 Somatic Embryogenesis
- 7 Hardening and Planting in field
- 8 Isolation of protoplasts
- 9 Cell suspension culture
10. Micropropagation of Tobacco plant by leaf disc culture
11. Agarose Electrophoresis
15. *Agrobacterium tumefaciens*-mediated plant transformation
16. Direct DNA delivery to plant by Particle Bombardment Demo
17. Isolation of plant genomic DNA

ENVIRONMENTAL BIOTECHNOLOGY - PRACTICAL

1. Detection of coliforms for determination of purity of fresh water.
2. Determination of total dissolved solids of water.
3. Determination of BOD of sewage samples.
4. Determination of COD of sewage samples.
5. Vermicomposting making
6. Microorganisms form polluted environment /Water resources.
7. Microorganisms form polluted environment /Air

8. Estimation of Dissolved Oxygen by Winkler's method
9. Identification of zooplankton and phytoplankton in water sample.

Title of the paper	Elective Theory 1- Methods in Biology		
Category : Part III Elective	Year & Semester Third year, Semester 5	Credits 5	
Pre- requisites	Knowledge of biology at Higher Secondary level		
Objectives of the course	To introduce the student to basic methods applied in the field of biology		

UNIT 1

Separation of Biomolecules: Isolation and purification of RNA, DNA (genomic and plasmid) and proteins, different separation methods for proteins; analysis of RNA, DNA and proteins by one and two dimensional gel electrophoresis, isoelectric focusing gels.

UNIT 2

Histochemical and immunotechniques: Detection of molecules using ELISA, RIA, western blot,

immunoprecipitation, flow cytometry and immunofluorescence microscopy.

UNIT 3

Biophysical methods: Analysis of biomolecules using UV/visible, fluorescence, circular dichroism, NMR and ESR spectroscopy, protein structure determination using X-ray diffraction.

UNIT 4

Microscopic techniques: Light microscopy, resolving powers of different microscopes, Phase contrast, inverted microscopy, scanning and transmission microscopes. Different fixation and staining techniques for light microscopy and electron microscopy, freeze-etch and freeze-fracture methods for EM. Radiolabelling and detection.

UNIT 5

Research Design -Basic principles, Meaning, Need and features of good design, important concepts. Types of research designs. Development of a research plan - Exploration, Description, Diagnosis, Experimentation. Hypothesis -Null and alternate hypothesis and testing of hypothesis. Writing Skills; Selection of topic, thesis statement, developing the thesis.

Text Books:

1. Ekwali Imam. 2015. Basics of Research Methodology. New India Publishing Agency, New Delhi.

2. K. Wilson, J. Walker. 2010. Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press, London.
3. R. K. Sharma, S.P.S. Sangha. 2008. Basic Techniques in Biochemistry and Molecular Biology. I K International Publishing House Pvt. Ltd, New Delhi.

Reference Books:

1. Lehninger, A.L., Nelson, D.L and Cox, M.M. 2017. Principles of Biochemistry, 7th edition. WH Freeman Publishers.
2. Stryer, L. 1999. Biochemistry, 4th edition. W.H.Freeman & Company, New York.
3. Zubey, G.L. 1998. Biochemistry, 4th edition. McGraw-Hill.
4. Voet, D.and Voet, J.G.1995. Biochemistry, 2nd edition. John Willey and Sons, Inc.

SEMESTER - VI

Title of the paper	Core Theory 9- Genetic Engineering
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Category : Part III Core Theory	Year & Semester Third year, Semester 6	Credits 4	
Pre- requisites	Knowledge of biology at Higher Secondary level		
Objectives of the course	To introduce the student to basics of genetic engineering		

UNIT - I

Introduction to Genetic Engineering, Restriction enzymes. Cloning vector, Plasmids & Phage Vectors, Cosmids, Phasmids, advanced vectors, artificial chromosomes BACs, YACs and PACs.

UNIT - II

Recombinant technology: gene cloning – Selection and screening for recombinants RFLP, AFLP, RAPD, DNA finger printing, Microarray and DNA sequencing.

UNIT - III

Polymerase chain reaction, DNA sequencing, Antisense technology, Whole genome sequencing, Chromosome walking, jumping. Human genetic disease, Ligase chain reaction, Site directed mutagenesis, Principles of Electrophoresis and blotting techniques.

UNIT - IV

Expression systems -Inducible expression system, Prokaryotic expression systems, Eukaryotic expression systems- applications: Production of protein from cloned genes.

UNIT - V

Gene transfer in bacteria, plant and animal cells, Electroporation, particle bombardment and Lipofection, Gene cloning and manipulations.

Text Books:

1. T.A. Brown, 2010. Gene cloning and DNA analysis: An introduction, 6th edition, Wiley-Blackwell.
2. Sandy B. Primrose and Richard Twyman, 2006. Principles of Gene Manipulation and genomics, 7th edition, Wiley-Blackwell.
3. Bernard R. Glick and Jack J. 2003. Molecular Biotechnology: Principles and Applications of recombinant DNA, Pesternak 3rd Edition, American Society for Microbiology.
4. Brown, T.A, 2002. Genomes, 2nd Edition, Wiley-Liss.
5. Old RW and Primrose SB, 2001. Principles of gene manipulation, 6th Edition, Blackwell Scientific Publications.
6. Kreuzee and Massey, 2001. Recombinant DNA & Biotechnology, A, 1st Edition, ASM Press.

Reference Books:

1. Thiel, 2002. Biotechnology DNA to Protein: A laboratory Project, 1st Edition, and Tata McGraw-Hill.
2. Ring, C.J.A. and Blair, E.D, 2001. Genetically Engineered viruses: Development and application, 1st Edition, and Bios Scientific publishers.
3. Davidson, E.H, 2001. Genomic regulatory systems: Development and evaluation, 1st Edition, 2001 and Academic press.
4. Jognand, S.N, 2000. Gene Biotechnology, Edition1 Himalaya publishers.
5. Lewin, 2009. Genes X, 10th edition, Jones & Barlett Publishers

Title of the paper	Core Theory 10- Industrial Biotechnology		
Category : Part III Core Theory	Year & Semester Third year, Semester 6	Credits 4	
Pre- requisites	Knowledge of Biology at Higher Secondary level		
Objectives of the course	To introduce the student to basics of fermentation technology		

UNIT-I

Media for Industrial Fermentation: Types of media, composition of media – carbon sources, nitrogen sources, vitamins and growth factors, mineral, inducers, precursors and inhibitors. Aerobic and anaerobic fermentation processes and their application in the field of biotechnology industry.

UNIT-II

Bioreactors: Introduction to bioreactors, Batch and Fed-batch bioreactors, Continuous bioreactors; solid state and submerged; photo bioreactors Sterilization of bioreactors; Design of Bioreactors.

UNIT-III

Industrial Production: Alcohol (Ethanol, Beer, Wine) Acids (citric), Solvents-(glycerol) Antibiotics (penicillin, tetracycline), Aminoacids (lysine, glutamic acid), Single Cell Protein (algae/fungi). Use of microbes in mineral beneficiation and oil recovery.

UNIT-IV

Introduction to bioseparation: Primary recovery process: Cell disruption methods. Cell lysis and Flocculation: Osmotic and mechanical methods of lysis. Filtration and sedimentation.

UNIT-V

Extraction Principles: Liquid-liquid extraction, aqueous two phase extraction, drying. Principles and operation of vacuum

dryer, shelf dryer, rotary dryer, freezer and spray dryer, formulation methods.

Text Book:

1. Puvanakrishnan, R, Sivasubramanian, S and Hemalatha, T. 2015. Microbes and enzymes basics and applied: 1st edition MJP Publishers, India.
2. Mathuriya S. Abhilasha. 2009. Industrial Biotechnology, 1st edition ANE Books publisher.

Reference Books:

1. Min-tze Liong, 2011. Bioprocess Sciences and Technology. Nova Science Pub Inc.
2. L.Shuler, Fikret Kargi. 2003. Bioprocess Engineering: Michael and PHI publishers.
3. R.G. Harrison, P.Todd, SR.Rudge and D.P. Petrides. 2003. Bioseparation science and engineering: John Wiley and sons.

Title of the paper	Core Practical 7- Genetic Engineering & Industrial Biotechnology		
Category : Part III Core Theory	Year & Semester Third year,	Credits 4	

	Semester 6		
Pre- requisites	Knowledge of biology at Higher Secondary level		
Objectives of the course	To introduce the student to basics of fermentation technology		

GENETIC ENGINEERING

Extraction and estimation of intracellular proteins from E. Coli – Lowry’s Method – Production of competent cells for transformation – Bacterial transformation – Isolation of genomic DNA – Extraction and estimation of RNA – Restriction Digestion of DNA – Absorption spectra of Nucleic acid – Estimation of DNA by Diphenyl amine method – Melting temperature of DNA, Agarose gel electrophoresis – SDS – PAGE – Agrobacterium mediated gene transfer – Isolation of plasmid DNA – Screening of Recombinants- Southern hybridization (DEMO) – Western Blotting (DEMO) – DNA amplification – PCR (DEMO).

INDUSTRIAL BIOTECHNOLOGY

1. Production, recovery and assay of citric acid by *Aspergillus niger*.
2. Biological assay of antibiotic.
3. Screening of Antibiotic producing microorganisms from soil by crowded plate
Technique.
4. Production, recovery of Amylase.
5. Assay of amylase.
6. Production of Bio insecticides by using *B.thuringensis*.
7. Estimation of milk sugar by Benedict's method.
8. Qualitative analysis of milk sample by Methylene Blue Reduction Time Test.
9. Enumeration of bacteria in milk by Standard Plate Count.
10. Determination of efficiency of pasteurization of milk by alkaline phosphatase test.
11. Isolation of lactic acid bacteria from the curd sample.
12. Isolation of lipolytic microorganisms from butter.
13. Isolation of spoilage microorganisms from spoiled vegetables/fruits.

Title of the paper	Elective Theory 2 - Microbial
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	Biotechnology		
Category : Part III Elective	Year & Semester Third year, Semester 5	Credits 5	
Pre- requisites	Knowledge of biology at Higher Secondary level		
Objectives of the course	To introduce the student to basic methods applied in the field of biology		

UNIT I

History and scope of microbial biotechnology, microbial diversity and its use, cultivation and preservation of microorganisms in small scale in Fermentor, bioreactors, immobilized cells and microbial polysaccharides- Microbial Biomass.

UNIT II

Production of microbial enzymes and applications, production of organic solvents- single cell proteins.

UNIT III

Production of beverages, beer, wine, microbes in banking- production of baker yeast and milk products.

UNIT IV

Biofertilizers and Biopesticides: Biomass from carbohydrates, higher alkanes, methanol. Biofertilizers – manufacture, formulation and utilization. Biopesticides – Bacteria, virus and fungi.

UNIT V

Bioremediation: Microbes in mining, ore leaching, oil recovery, waste water treatment, biodegradation of non cellulose and cellulosic wastes for environmental conservation.

Text Books:

1. L.E.J.R.Casida.2016.Industrial Microbiology. New age international publishers.
2. Puvanakrishnan.R, Sivasubramaniam.S and Hemalatha.T.2015. Microbes and enzymes basics and applied, 1st edition MJP Publishers, India.
3. A.H.Patel.2005Industrial Microbiology. Mac Millan India Ltd NewDelhi.

Reference Books:

1. W.Clarke.2016.Biotechnology: Industrial Microbiology A text book.CBS Publisher.
2. Principles of Fermentation technology by P.F. Stanbury, and A.Whitakor (2013). Pergamum Press Elsevier science Ltd.

3. M.S.Abhilasha.2009.Industrial Biotechnology. ANE books publisher.

Title of the paper	Elective Theory 3 - Environmental Biotechnology		
Category : Part III Elective	Year & Semester Third year, Semester 5	Credits 5	
Pre- requisites	Knowledge of biology at Higher Secondary level		
Objectives of the course	To introduce the student to basic methods applied in the field of biology		

UNIT I

Biofilm Kinetics: Soluble microbial products and inert biomass. Reactors: Reactors types – A batch reactor – A continuous- flow stirred- tank reactor with effluent recycle

– A plug – flow reactor – A Plug flow reactor with effluent recycles – Reactors with recycle of settled cells.

UNIT II

Linking stoichiometric equations to mass balance equations – Engineering design of reactors – Reactors in series. Reactor configurations – Special factors for the design of anaerobic sludge digesters.

UNIT III

Denitrification: Physiology of denitrifying bacteria – Tertiary denitrification – One – sludge denitrification – Drinking water treatment: Anaerobic treatment by methanogenesis – Uses for methanogenic treatment.

UNIT IV

Detoxification of Hazardous chemicals: Factors causing molecular recalcitrance – Biodegradations of problem environmental contaminants – Bioremediation of problem environmental contaminants – Bioremediation: Engineering strategies for Evaluating bioremediation.

UNIT V

Sewage and waste treatment: Pollution monitoring, control and remediation (petroleum industry, paper industry, chemical industry etc).

Text books:

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

Reference books:

1. K.Allen, 2016. Environmental Biotechnology, CBS; 1st Edition. CBS Publishers.
2. Moo-Young, M., Anderson, W.A., Chakrabarty, A.M., 2010. Environmental Biotechnology: Principles and applications. 1st Edition, Springer.
3. Gareth M. Evans, Judith C. Furlong, 2003. Environmental Biotechnology: Theory and Application.

Title of the paper	Project Instead of Elective 1-3 in V and VI Semesters		
Category : Part III Project	Year & Semester Third year, Semester 6	Credits 15	
Pre- requisites	Knowledge of biology at UG LEVEL		
Objectives of the course	To introduce research concept and execute their ideas through project.		

APPENDIX – 32 (R&S)
UNIVERSITY OF MADRAS

SRI SANKARA ARTS AND SCIENCE COLLEGE
(AUTONOMOUS)

M.Sc., BIOTECHNOLOGY
(effective from the academic year 2018 – 2019)

REGULATIONS
Choice based credit system.

1. CONDITIONS FOR ADMISSION:

A Candidate with a Bachelor's Degree in Science in the disciplines of Biotechnology,, Biology, Botany, Zoology, Microbiology, Genetics, Chemistry, Biochemistry, Physics, Agriculture from this University or B.E/B.TECH (Biotech), B.V.Sc, MBBS, BDS or an examination of some other University accepted by the Syndicate as equivalent thereto shall be permitted to appear and qualify for the M.Sc., Degree Examination.

2. DURATION OF THE COURSE:

The duration of the course is for two academic years consisting of four semesters. In order to be eligible for the award of the degree, the candidate should have successfully completed the course within THREE years reckoned from the date of enrolment for the first semester of the course.

3. STRUCTURE OF THE COURSE

The course is organized on semester basis with a total of four semesters. In first, second and third semesters, there are three (**core**) theory papers (9 hrs per week), one Core Practical (15hrs per week) and **Two elective/ optional papers**(4hrs per week), per semester and in the fourth semester, there is one core theory paper (4hrs per week), a core project/ dissertation work constituting a total of 20 hrs per week, one elective (2hrs per week), and a Soft skill program (2hrs per week).

Elective paper: Each student will opt for a comprehensive, interactive course with one of the faculty member. The topic of specialization and course content will be determined by the dept/ course advisor.

Core Practical Laboratory: Independent practical shall be held under each component. It is recommended that the practical training be organized as an exercise rather than simple demonstration. The students must actually perform the experiments.

4. ELIGIBILITY FOR THE AWARD OF DEGREE:

A candidate shall be eligible for the award of the degree only if he/she has undergone the prescribed course of study in a college affiliated to the University for a period of not less than two academic years, passed the examination of all the four semesters prescribed earning 90 credits and fulfilled such conditions as have been prescribed therefore.

A candidate shall be eligible for the award of the degree only if he/she has undergone the prescribed courses on Soft Skills and internship in addition to the courses prescribed by the respective Board of Studies for the subject of the Masters Degree. For two years Master's Degree Programme, a candidate must undergo a minimum of 4 courses (4 x 2=8 credits) from the courses on Soft skills.

A two year Master's Degree student shall undergo 4-6 weeks (2 credits internship during the summer vacation of the First year and submit a report in the beginning of third semester. The report will be evaluated in third semester and the marks forwarded to along with third semester internal assessment (CIA) marks.

5. EXAMINATIONS:

There shall be four semester examinations: first semester examinations at the middle of the first academic year and the second semester examination at the end of the first academic year. Similarly, the third and fourth semester examinations shall be held at the middle and the end of the second

academic year, respectively. Practical examination shall be conducted independently at the end of even semesters. For practical examination, a single comprehensive (covering different courses offered during that semester) practical examination (6hrs per day) be held for each component of the core practical at the end of even semesters.

Examinations for the courses on soft skills will be held along with the semester examinations of the core and elective courses. There is no written examination for internship. A student must submit a report after completing the summer internship. The report will be evaluated by two examiners within the Department of the college.

6. COURSE OF STUDY AND SCHEME OF

EXAMINATIONS:

FIRST SEMESTER

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

.	Paper-2 *							
7	Elective Paper-3 *	Ecology & Evolution	I	2	3	3	25	75
8	Soft Skill - I		I	2	2	3	40	60
Total								
Credits : 24								

***Candidates can opt for any two Electives**

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

SECOND SEMESTER

S. No.	Course Components	Name of Course	Semester	Inst. Hours	Credits	Exam HRS	Max. Marks	
							CIA	External
9.	Core Paper-5	Microbiology & Bioprocess Technology	II	3	4	3	25	75
10.	Core Paper-6	Immunology	II	3	4	3	25	75
11.	Core Paper-7	Genetic Engineering	II	3	4	3	25	75
12.	Core Paper-8 Practical-II	Practical - II (A) Microbiology & Immunology (B) Plant Biotechnology (C) Genetic	II	15	4	6	40	60

		Engineering							
13.	Elective Paper-4*	Intellectual Property Rights & Biosafety	II	2	3	3	25	75	
14.	Elective Paper-5*	Methods in Biology	II	2	3	3	25	75	
15.	Extra disciplina ry Elective	Plant Physiology	II	2	3	3	25	75	
16.	Soft skill - II		II	2	2	3	40	60	
Total									
credits:24									

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

THIRD SEMESTER

S.No.	Course Comp	Name of Course	Semester	Inst. Hours	Credits	Exam HRS	Max. Marks	
							CIA	External
17	Core Paper-9	Plant & Animal Biotechnology	III	3	4	3	25	75
18	Core Paper-10	Bioinformatics	III	3	4	3	25	75
19	Core Paper-11	Molecular Biology	III	3	4	3	25	75
20	Core Paper-12 Practical-III	Practical - III (A) Plant & Animal Biotechnology (B) Bioinformatics (C) Bioprocess Technology	III	15	4	6	40	60
21	Elective Paper-6 *	Nano Biotechnology	III	2	3	3	25	75

22	Elective Paper-7*	Virology	III	2	3	3	25	75	
23	Extra disciplinary elective	Animal physiology	III	2	3	3	25	75	
24	Soft skill - III		III	2	2	3	40	60	
25	**Interns hip	Internship in Industries or Research Laboratories related to Biotechnology Field	III		2		-	100	
26	Elective offered to other Dept.	Principles of Gene Manipulation Technology	III	2	3	3	25	75	
Total								credits: 26	

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

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

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

FOURTH SEMESTER

S.No.	Course Components	Name of Course	Semester	Inst. Hours	Credits	Exam HRS	Max. Marks	
							CIA	External
27	Core Paper-13	Stem cell Biology	IV	4	4	3	25	75
28	Elective* Paper -9	Research Methodology	IV	2	3	3	25	75
29	Elective* Paper-10	Marine Biotechnology	IV	2	3	3	25	75
30	Core Paper-14	Dissertation	IV	20	8		60	240 (40-work book, 150-Dissertation + 50-Viva)

31	Soft skill – IV		IV	2	2	3	40	60
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Total credits: 17

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

The following procedure be followed for Internal Marks:

Theory Papers: Internal Marks : 25

Best Two tests out of 3	10 marks
Attendance	5 marks
Seminar	5 marks
Assignment	5 marks

	25 marks

Practical: Internal Marks: 40

Attendance	- 5 marks
Practical Best Test 2 out of 3	- 25 marks
Record	- 5 marks
Viva	- 5 marks

Break-up Details for Attendance

Below 60%	- No marks
60% to 75%	- 3 marks
76% to 90%	- 4 marks
91% to 100%	- 5 marks

7. PROJECT EVALUATION:

Project : Project Work should be carried out as an individual project and actual bench work. The project work will begin from IIIrd Semester, and will continue through the IVth Semester. The project report (also work book shall be presented at the time of presentation and *viva voce*) will be submitted at the end of the IVth Semester and evaluated. For the conduct of the End Semester Examination and evaluation of Project Work the COE will appoint External and Internal Examiners.

The project work dissertation carries a total of **300** marks and evaluation will be carried out by both internal and external evaluators. The average marks awarded by them will be considered. Project work book consisting of daily research activities, methods adopted, results recorded and maintained by the candidate shall also be submitted along with dissertation for evaluation. The viva-voce examination is part of dissertation which carries marks as specified below.

The assignment of marks for Project is as follows:

Continuous Internal Assessment Marks

Best 2 out of 3 presentations (Literature survey,

Methodology and Results of

the project work) - 60 marks

Project work book - 40 marks

Dissertation/ - 150 marks

Viva-voce - 50 marks

8. REQUIREMENTS FOR PROCEEDING TO SUBSEQUENT SEMESTERS:

(i) Candidates shall register their names for the First semester examination after the admission in the PG courses.

(ii) Candidates shall be permitted to proceed from the First Semester upto the Final Semester irrespective of their failure in any of the Semester Examination subject to the condition that the candidates should register for all the arrear subjects of earlier semesters along with current (subject) Semester subjects.

(iii) Candidates shall be eligible to proceed to the subsequent semester, only if they earn sufficient attendance as prescribed therefore from time to time.

Provided in case of candidate earning less than 50% of attendance in any one of the semester due to any extraordinary circumstance such as medical grounds, such candidates who shall produce Medical Certificate issued by the Authorised Medical Attendant (AMA), duly certified by the Principal of the College, shall be permitted to proceed to the next semester and to complete the course of study. Such candidate shall have to repeat the missed semester by rejoining after completion of final semester of the course, after paying the fee for the break of study as prescribed from time to time.

9. PROCEDURE IN THE EVENT OF FAILURE

1. If a candidate fails in a particular subject (other than project work) he /she may appear for the University examination in that subject in the subsequent semester(s) and obtain pass marks.
2. In the event of failure in project work, the candidates will re-register for the project work and redo the project work in the subsequent semester and resubmit the dissertation afresh for evaluation. The Continuous Internal Assessment marks will be allotted freshly in this case.

10. PASSING MINIMUM:

- a) There shall be no Passing Minimum for Internal.
- b) For External Examination, Passing Minimum shall be of 50 % (Fifty Percentage) of the maximum marks prescribed for the paper.
- c) In the aggregate (External + Internal) the passing minimum shall be of 50% for each Paper/Practical/Project and Viva-voce.
- d) Grading shall be based on overall marks obtained (internal + external).

11. CLASSIFICATION OF SUCCESSFUL CANDIDATES:

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

12. GRADING SYSTEM: As per the existing TANSICHE Grading followed by all Post-graduate degree Courses under CBCS (w.e.f.2009-10).

13. RANKING:

Candidates who pass all the examinations prescribed for the course in the first appearance itself alone are eligible for Ranking / Distinction.

Provided in the case of candidates who pass all the examinations prescribed for the course with a break in the First Appearance due to the reasons as furnished in the Regulations under “Requirements for Proceeding to subsequent Semester” are only eligible for Classification.

14. PATTERN OF QUESTION PAPER:

Question paper pattern for M.Sc Biotechnology degree course for each semester will be given as follows.

For Theory Paper subjects

Part A

10 Objective questions or definitions of 2 marks covering all units of the syllabus (No choice will be given)

$10 \times 2 = 20$ Marks

Part B

5 Paragraph questions of 5 marks to be answered choosing one each from each unit following either/ or pattern

$5 \times 5 = 25$ marks

Part C

Two Essay type questions of 15 marks to be answered choosing one from each Unit following either/ or pattern

$2 \times 15 = 30$ marks

15. APPEARANCE FOR IMPROVEMENT:

Candidates who have passed in a theory paper / papers are allowed to appear again for theory paper / papers only once in order to improve his/her marks, by paying the fee prescribed from time to time. Such candidates are allowed to improve

within a maximum period of 10 semesters counting from his/her first semester of his/her admission. If candidate improve his marks, then his improved marks will be taken into consideration for the award of Classification only. Such improved marks will not be counted for the award of Prizes / Medals, Rank and Distinction. If the candidate does not show improvement in the marks, his previous marks will be taken into consideration.

No candidate will be allowed to improve marks in the Practical, Project, Viva-voce, Field work.

16. TRANSITORY PROVISION:

Candidates who have undergone the course of study prior to the academic year 2018-2019 will be permitted to appear for the examinations under those Regulations for a period of three years i.e., up to and inclusive of April/May 2022 Examinations. Thereafter, they will be permitted to appear for the examination only under the Regulations then in force.

APPENDIX – 32 (S)
UNIVERSITY OF MADRAS

SRI SANKARA ARTS AND SCIENCE COLLEGE
(AUTONOMOUS)

M.Sc., BIOTECHNOLOGY
(effective from the academic year 2018 – 2019)

SYLLABUS

FIRST SEMESTER

Core Paper Theory– 1			
Title of the paper	Biochemistry		
Category of the course	Year	Semester	Credits
Core	I	I	4

Unit I

Structure of atoms, molecules and chemical bonds. structure and catalysis – Water - Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction. Principles of

biophysical chemistry - pH, buffer, reaction kinetics, thermodynamics, colligative properties.

Unit II

Composition, structure and function of biomolecules – carbohydrates (Monosaccharides, Disaccharides and Polysaccharides), lipids (Storage Lipids, Structural Lipids in Membranes, Lipids as Signals, Cofactors, and Pigments), proteins (amino acids, peptides), nucleic acids and vitamins.

Unit III

Principles of Bioenergetics - Glycolysis, Gluconeogenesis, Pentose Phosphate pathway, Oxidative phosphorylation, Electron Transport Chain, Citric acid cycle, Urea cycle, Metabolism of lipids – fatty acid oxidation, Ketone bodies, Biosynthesis of fatty acids, Metabolism of phospholipids, Metabolism of glycolipids, Metabolism of cholesterol, Lipoproteins. Biological energy transducers, Coupled Reaction, Photosynthesis: harvesting light energy, Nitrogen fixation. Metabolism of Amino acid, Importance of acetyl coA.

Unit IV

Enzymes – Nomenclature, Classification, Enzyme Active Site, Enzyme specificity. Mechanism of enzyme action, Properties of enzymes – Reaction Kinetics, Enzyme inhibition, Control of enzyme activity. Enzyme Kinetics – Effect of substrate concentration, Effect of pH, Effect of

temperature. Enzyme Regulation - Feedback Regulation, Allosteric enzymes. Isoenzymes.

Unit V

Conformation of proteins and Nucleic acids: Protein - Ramachandran plot, secondary structure, domains, motif and folds. Nucleic acid - t-RNA, micro-RNA. Nucleic acid metabolism – Nucleotide synthesis and degradation, DNA structure (helix (A, B, Z)), DNA synthesis and Repair, RNA metabolism, The genetic code and Translation, Gene expression in Prokaryotes and Eukaryotes.

Text Books:

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

Reference Books:

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

2. Jeremy M. Berg, John L. Tymoczko, Lubert Stryer. 2010. Biochemistry. 7th Edition W.H.Freeman publishers. New York, United States.

Core Paper Theory– 2			
Title of the paper	Cell & Developmental Biology		
Category of the course	Year	Semester	Credits
Core	I	I	4

Unit I

Membrane structure and function: Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, membrane pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes). Structural organization and function of intracellular organelles: Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure & function of cytoskeleton and its role in motility. Organization of genes and chromosomes: Operon, unique and repetitive DNA, interrupted genes, gene families, structure of chromatin and chromosomes, heterochromatin, euchromatin, transposons.

Cell division and cell cycle: Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle.

Unit II

Cell signaling: Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant two-component systems, light signaling in plants, bacterial chemotaxis and quorum sensing. Cellular communication: Regulation of hematopoiesis, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation.

Unit III

Cancer: Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, apoptosis, therapeutic interventions of uncontrolled cell growth. Programmed cell death, aging and senescence.

Unit IV

Basic concepts of development : Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the

cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development. Gametogenesis, fertilization and early development: Production of gametes, cell surface molecules in sperm-egg recognition in animals; embryo sac development and double fertilization in plants; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis, establishment of symmetry in plants; seed formation and germination

Unit V

Morphogenesis and organogenesis in animals : Cell aggregation and differentiation in *Dictyostelium*; axes and pattern formation in *Drosophila*, amphibia and chick; organogenesis – vulva formation in *Caenorhabditis elegans*, eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development- larval formation, metamorphosis; environmental regulation of normal development; sex determination. Morphogenesis and organogenesis in plants: Organization of shoot and root apical meristem; shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in *Arabidopsis* and *Antirrhinum*

Text Books:

1. Harvey Lodish , A. Berk , Chris A. Kaiser , M. Krieger , A. Bretscher , H. Ploegh, A. Amon Kelsey C. Martin. 2016. Molecular Cell Biology, 8th Edition, W. H. Freeman and Company

2. Scott F. Gilbert, Michael J. F. Barresi 2016. Developmental Biology. Oxford University Press.
3. Paul, A. 2011. Text Book of Cell and Molecular Biology, Second edition, 2001. Niyogi Books.
4. David E. Sadva. 2009. Cell biology organelles structure and function, CBS publishers and distributors, New Delhi.
5. Prakash S. Lohar, 2009. Cell and Molecular Biology. John Wiley & Sons, New York.

Reference Books:

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

Core Paper Theory–3			
Title of the paper	Molecular Genetics		
Category of the course	Year	Semester	Credits
Core	I	I	4

Unit 1

Mendelian principles: Dominance, segregation, independent assortment. Concept of gene: Allele, multiple alleles, pseudoallele, complementation tests Extensions of Mendelian principles: Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters.

Unit 2

Gene mapping methods: Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants. Extra chromosomal inheritance: Inheritance of Mitochondrial and chloroplast genes, maternal inheritance.

Unit 3

Microbial genetics: Methods of genetic transfers – transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes. Human genetics: Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.

Unit 4

Quantitative genetics: Polygenic inheritance, heritability and its measurements, QTL mapping. Mutation: Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis. Structural

and numerical alterations of chromosomes: Deletion, duplication, inversion, translocation, ploidy and their genetic implications. Recombination : Homologous and non-homologous recombination including transposition.

Unit 5

Gene Regulation- Principles of gene regulation- Transcriptional and post transcriptional gene regulation- activators, co-activators, suppressors, co-suppressors, moderators, silencers, insulators, enhancers. Operon-lac operon, trp operon, ara operon and gal operon.

Text Books:

1. Daniel L. Hartl, Elizabeth W. Jones, 2013. Genetics: Analysis of Genes and Genomes, Jones & Bartlett Learning.
2. Karvita B. Ahluwalia., 2010. Genetics. New Age International Pvt Ltd and Publishers, New Delhi.
3. Robert brooker, 2011. Genetics: Analysis and principles. 4th Edition. McGraw-Hill.
4. Gardner, M. J. Simmons, D. P. Snustad, 2006. Principles of Genetics, 8th Ed, John Wiley & Sons.

Reference Books:

1. Anthony J F Griffiths, Susan R. Wessler , Sean B. Carroll , John Doebley, An Introduction to Genetic Analysis Solutions Manual, 2015.

2. Leland Hartwell, Leroy Hood, Michael Goldberg, Ann Reynolds, Lee Silver, 2010. Genetics: From Genes to Genomes. 4th edition, McGraw-Hill.
3. Monroe W. Strickberger, 2008. Genetics, PHI Learning.

Core Practical – 1			
Title of the paper	Biochemistry, Cell & Developmental Biology, Molecular Genetics		
Category of the course	Year	Semester	Credits
Core	I	II	4

Biochemistry

1. Basic calculations in Biochemistry - Normality, Molarity, Molality percent solutions (v/v, w/v).
2. Calibration of pH meter
3. Transition interval of commonly used pH indicators
4. Preparation of biological buffer - phosphate buffer
5. Extraction of Proteins from biological materials
6. Protein separation methods:-Ammonium sulphate Precipitation
7. Membrane Dialysis
8. SDS PAGE

9. Estimation of Proteins by Lowry's method
10. Estimation of Proteins by Biuret method
11. Estimation of Proteins by Bradford method
12. Estimation of RNA by orcinol method
13. Estimation of DNA by diphenylamine method
14. Estimation of Carbohydrate by Anthrone method
15. Purity check of DNA & RNA by UV Spectrophotometry - A₂₆₀/A₂₈₀
16. Separation of amino acids by Paper Chromatography
17. Separation of sugars by Paper Chromatography
18. Separation of amino acids by Thin layer chromatography
19. Separation of sugars by Thin layer chromatography

Demo Experiments

1. Gel permeation chromatography,
2. Affinity chromatography,
3. Ion exchange chromatography
4. Western blotting

Cell & Developmental Biology

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

5. Preparation of buccal smear.
6. Red blood cell as osmometer.
7. Subcellular fractionation and biochemical/enzymological analysis.
8. Cytochemical study of cells/cell types using specific dyes/reagents.
9. Immunocytochemical analysis for specific cellular constituents.
10. Meiotic study in flower buds and cockroach or grasshopper.
- 11 . Preparation of tissue culture medium and membrane filtration;
12. preparation of single cell suspension from spleen and thymus;
13. Cell counting and cell viability;
14. Macrophage monolayer from PEC and measurement of phagocytic activity;
15. Trypsinization of monolayer and subculturing; Cryopreservation and thawing;
16. MTT assay for cell viability and growth
17. Demo experiment - Embryonic development and stem cells (serpulid polychaete Hydroides elegans/ chick/ frog)

Molecular Genetics

1. Isolation of DNA from bacteria
2. Isolation of DNA from plants
3. Isolation of DNA from animal tissue
4. Isolation of DNA from blood
5. Plasmid DNA isolation.
7. Transfer of DNA from gel . Southern Blotting
8. Isolation of RNA
9. Glyoxal denatured Agarose gel electrophoresis of RNA
10. Formaldehyde denatured Agarose gel electrophoresis of RNA
11. Urea denatured Agarose gel electrophoresis of RNA
12. Transfer of RNA from gel . Northern Blotting
13. Restriction digestion of DNA
14. Blue white screening of recombinants
15. Amplification of DNA using PCR

Elective Paper – 1			
Title of the paper	Environmental Biotechnology		
Category of the course	Year	Semester	Credits
Elective	I	I	3

Unit I

Introduction to Biotechnology: The Role of Environmental Biotechnology, The Scope for Use, The Market for Environmental Biotechnology, Integrated Approach, Microbes and Metabolism: The Immobilisation, Degradation or Monitoring of Pollutants from a Biological Origin, Microbes, Plants, Metabolism, Microbial diversity, Metabolic Pathways of Particular Relevance to Environmental Biotechnology(Glycolysis, TCA cycle), Production of cellular energy.

Unit II

Fundamentals of Biological Intervention: Using Biological Systems- Extremophiles, thermophiles, Diverse degradative abilities, Pollution and Pollution Control: Classification of Pollution- toxicity, persistence and mobility, Ease of control, Pollution Control Strategies- Dilution and dispersal, Concentration and containment, Practical Applications to Pollution Control- Biofilters, biotrecking filters,

Bioscrubbers, Biological control- Whole-organism approaches, Semiochemical agents, Biosubstitutions

Unit III

Bioremediation: Methods in bioremediation, *In Situ* and *Ex Situ* Techniques, Intensive and Extensive Technologies, Process Integration, The Suitability of Bioremediation, Factors Affecting the use of Bioremediation and use of bio diversity

Unit IV

Aerobes and Effluents: Sewage Treatment, Nitrogenous Wastes, Aeration, Diffused air systems, Mechanical aeration systems, Trickling systems, Activated Sludge Systems, Process disruption, Organic loadings, Deep Shaft Process, Pure Oxygen Systems, The Oxidation Ditch, The Rotating Biological Contactor, Membrane Bioreactors, Sludge Disposal. Phytoremediation and photosynthesis: Terrestrial Phyto-Systems (TPS), Metal Phytoremediation, Phytoextraction, Hyperaccumulation, Rhizofiltration, Phytostabilisation, Organic Phytoremediation- Phytodegradation, Rhizodegradation, Phytovolatilisation, Hydraulic Containment.

Unit V

Biotechnology and Waste: The Nature of Biowaste, Composition of biowaste, Biological Waste Treatment, Composting, The composting process, Applying Composting to Waste Management- Home composting, Centralised

composting, Process parameters, Anaerobic Digestion process, Applying AD to Waste Management, Genetic Manipulation- Manipulation of Bacteria Without Genetic Engineering, Manipulation of Bacteria by Genetic Engineering, Basic Principles of Genetic Engineering, Analysis of Recombinants, Examples of developments in plant GE, Integrated Environmental Biotechnology: Bioenergy, Derived Biofuels, Ethanol fermentation, Biodiesel, Integrated Agricultural Applications, Plant disease suppression, Microbial pesticides, Plant/microbe interactions.

Text books :

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

Reference books:

1. Allen K., 2016. Environmental Biotechnology, CBS; 1st Edition.
2. Moo-Young, M., Anderson, W.A., Chakrabarty, A.M., 2010. Environmental Biotechnology: Principles and applications. 1st Edition, Springer.
3. Gareth M. Evans, Judith C. Furlong, 2010. Environmental Biotechnology: Theory and Application. 2nd Edition. Wiley Blackwell Publisher.

Elective Paper – 2			
Title of the paper	Biostatistics		
Category of the course	Year	Semester	Credits
Elective	I	I	3

Unit-I:

Collection of data- census method, sampling method; Classification and tabulation of data – Class intervals, Tally marks, Frequency distribution; Presentation of biometric data- Line diagrams, frequency polygon, scatter or dot diagrams, bar diagrams, pareto charts, map diagrams; Types of graphs-histogram, frequency curve, pie chart, pictograms

Unit-II:

Measures of central tendency (mean, median, mode) and dispersal; probability distributions (Binomial, Poisson and normal); Sampling distribution; Difference between parametric and non-parametric statistics; Confidence Interval; Errors; Hypothesis testing, Levels of significance.

Unit-III:

Correlation- Types of correlations, Linear and non-linear correlations, measures of correlations, Bivariate and Multivariate distributions, positive and negative correlation. Regression- Regression coefficient, objectives of regression analysis, differences between regression analysis and correlation analysis.

Unit-IV:

t-test- degrees of freedom.t-test for single mean,t test for group data,parametric and non parametric tests,assumptions for t test,types of t tests,t test for two sample means. Chi-Square Test- Pearson's chi-squared test, Yates's correction for continuity, Tukey's test of additivity.

Unit-V:

Analysis of variance- test of ANOVA, summary of steps for calculating ANOVA, F test, assumptions of ANOVA, computation analysis of ANOVA, assumptions in F-test, Basic introduction to Muetrovariate statistics. Application of Biostatistics in life science research. Software packages used in Biostatistics.

Text Books:

1. S.Rao, 2012. Introduction to Biostatistics and Research Methods. 5th Edition. Prentice Hall India Learning Pvt Ltd.

2. Veer Bala Rastogi. 2011. Fundamentals of Biostatistics. Ane books Pvt Ltd, Chennai.
3. Banerjee Pranab Kumar, 2007. Introduction to Biostatistics. S Chand Publishing Company.
4. Rosner B. 2005. Fundamentals of Biostatistics, Duxbury Press.

References Books:

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

Elective Paper –3			
Title of the paper	Ecology & Evolution		
Category of the course	Year	Semester	Credits
Elective	I	I	3

Unit-I

The Environment- Physical environment; biotic environment; biotic and abiotic interactions.Habitat and Niche- Concept of habitat and niche; niche width and overlap; fundamental and

realized niche; resource partitioning; character displacement. Population Ecology- Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); concept of metapopulation – demes and dispersal, interdemetic extinctions, age structured populations. Species Interactions- Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.

Unit-II

Community Ecology-Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones. Ecological Succession-Types; mechanisms; changes involved in succession; concept of climax. Ecosystem Ecology-Ecosystem structure; ecosystem function; energy flow and mineral cycling (C,N,P); primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine). Biogeography: Major terrestrial biomes; theory of island biogeography; biogeographical zones of India. Applied Ecology- Environmental pollution; global environmental change; biodiversity: status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches. Conservation Biology- Principles of conservation, major approaches to management, Indian case studies on conservation/management strategy (Project Tiger, Biosphere reserves).

Unit-III

Emergence of evolutionary thoughts -Lamarck; Darwin-concepts of variation, adaptation, struggle, fitness and natural selection; Mendelism; Spontaneity of mutations; The evolutionary synthesis. Origin of cells and unicellular evolution-Origin of basic biological molecules; Abiotic synthesis of organic monomers and polymers; Concept of Oparin and Haldane; Experiment of Miller (1953); The first cell; Evolution of prokaryotes; Origin of eukaryotic cells; Evolution of unicellular eukaryotes; Anaerobic metabolism, photosynthesis and aerobic metabolism.

Paleontology and Evolutionary History-The evolutionary time scale; Eras, periods and epoch; Major events in the evolutionary time scale; Origins of unicellular and multi cellular organisms; Major groups of plants and animals; Stages in primate evolution including Homo.

Unit-IV

Molecular Evolution-Concepts of neutral evolution, molecular divergence and molecular clocks; Molecular tools in phylogeny, classification and identification; Protein and nucleotide sequence analysis; origin of new genes and proteins; Gene duplication and divergence. The Mechanisms-Population genetics – Populations, Gene pool, Gene frequency; Hardy-Weinberg Law; concepts and rate of change in gene frequency through natural selection, migration and random genetic drift; Adaptive radiation; Isolating mechanisms; Speciation; Allopatricity and Sympatricity; Convergent evolution; Sexual selection; Co-evolution.

Unit-V

Brain, Behaviour and Evolution-Approaches and methods in study of behaviour; Proximate and ultimate causation; Altruism and evolution-Group selection, Kin selection, Reciprocal altruism; Neural basis of learning, memory, cognition, sleep and arousal; Biological clocks; Development of behaviour; Social communication; Social dominance; Use of space and territoriality; Mating systems, Parental investment and Reproductive success; Parental care; Aggressive behaviour; Habitat selection and optimality in foraging; Migration, orientation and navigation; Domestication and behavioural changes.

Text Books:

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

Reference Books:

1. A.Manning and M.S. Dawkins, 2016. An Introduction to Animal Behaviour, Sixth Edition, Cambridge University Press, India.
2. Jones & Bartlett, 2013. Strickberger's Evolution. Jones & Bartlett Learning.
3. Carl T.Berstrom and Lee Alan Dugatkin, 2012. Evolution. International Student Edition, W.W.Norton & Company
4. Peter Stilling, 2011. Ecology – Global Insights & Investigations, Ecology. McGraw-Hill Education

SECOND SEMESTER

Core Paper Theory– 4			
Title of the paper	Microbiology & Bioprocess Technology		
Category of the course	Year	Semester	Credits
Core	I	II	4

Unit-I

Important criteria used for classification in each taxon:
Classification microorganisms - Evolutionary relationships among taxa - Host parasite interaction - Recognition and

entry processes of different pathogens like bacteria, viruses into host cells - Alteration of host cell behavior by pathogens, virus-induced cell transformation, pathogen-induced diseases in animals and plants, cell-cell fusion in both normal and abnormal cells - Microbial Physiology (Growth yield and characteristics, strategies of cell division, stress response).

Unit- II

Morphology, culture, biochemical, pathogenicity, laboratory diagnosis and prevention of bacterial diseases - *Salmonella typhi*, *Vibrio cholerae*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Yersinia pestis* and *Borrelia type* – Common parasites and pathogens of humans. Antimicrobial activity - antimicrobial resistance-tests for sensitivity to antimicrobial agents - antibiotics and its mode of actions.

Unit- III

Role of microorganisms in food production (SCP) dairy and non-dairy products - Fuel (ethanol), pharmaceuticals (antibiotics), biofertilizers (BGA), biopesticides (*Bacillus thuringensis*), biopolymers (CBB), biosurfactants (BS), vitamin B12, protease, glutamic acid. Secondary metabolites. Biogas production, biocomposting and biotransformation.

Unit- IV

Basic principles and Advantages of bioprocess technology. Isolation and screening of industrially important microbes- Primary screening and Secondary. Detection and assay of fermentation products. Improvement of the strains for

increased yield and other desirable characteristics. Design and construction of fermenter -Types of fermenter: CSTR, bubble column, airlift, fluidized bed, packed bed bioreactors. Media formulation-substrates for industrial fermentation. Media sterilization and contamination. Principles of microbial growth in batch and continuous fermentation. Scale up.

Unit – V

Fermentations – Submerged, solid state, anaerobic fermentation processes and their applications. Production of beer, wine, vinegar, citric acid, enzymes, penicillin and insulin. Primary recovery process: Cell disruption -physical, chemical, enzymatic methods. Solid liquid separation-flootation, flocculation, filtration, centrifugation. Product formulation- Drying, freeze drying and crystallization.

Text Books:

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

Reference Books:

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

Core Paper Theory– 5			
Title of the paper	Immunology		
Category of the course	Year	Semester	Credits
Core	I	II	4

Unit-1

History and scope of immunology- Innate and adaptive immune system - Cells and molecules involved in Innate and Adaptive immunity – Mechanism of phagocytosis process – Hematopoiesis – Programmed cell death (PCD) – Cells and Organs of the immune system, myeloid stem cells and Lymphatic system, Maturation of B cell and CALT.

Unit- 2

Immune Responses- Humoral Immune Response (HMI), CMI and Antigen Dependent Cell Mediated Cytotoxicity (ADDC); Antigens – antigenicity, immunogenicity and biological classes of antigen (Haptens, Mitogens and Adjuvant), B and T cell epitopes, activation and differentiation of B and T cells, B and T cell receptors; Immunoglobulins – Structure and classes of immunoglobulins, structure and function of antibody molecules, generation of antibody diversity, Monoclonal antibodies, production and applications of Mabs and Abzymes.

Unit- 3

Antigen – Antibody interactions, opsonization and western blotting; Primary and Secondary immune modulation - complement system- Lectin pathway, classical pathway and alternative pathway; Cytokines- properties and functions of cytokines, cytokines receptors; MHC molecules; Toll-like receptors, cell-mediated effector functions, inflammation.

Unit- 4

Antigen processing and presentation-Immunological Tolerance-Transplantation, classification, Graft rejection and tissue typing MLR; hypersensitivity and autoimmunity, immune response during bacterial (tuberculosis), parasitic (malaria) and viral (HIV) infections, congenital and acquired immunodeficiencies – Application of immunological

principles –vaccines, diagnostics. Tumor Immunology; Host parasite relationship.

Unit – 5

Immunotechnology- Purification of Immunoglobins - Ion Exchange Chromatography, Gel filtration Chromatography; Nephelometry; FACS; Immunological screening of Recombinant Library; ELISA; Western Blotting; RIA; *In vitro* and *In vivo* Immuno histochemical Techniques; Laboratory animals.

Text Books:

1. Abul K. Abbas & Andrew H. H. Lichtman & Shiv Pillai. 2015. Basic Immunology, 5th Edition, Elsevier Publications.
2. Seemi Garhat Bashir. 2009. Text Book of Immunology, PHI Learning Pvt. Ltd. New Delhi.
3. Rajasekara Pandian, M and Senthil Kumar, B. 2007. Immunology & Immunotechnology, panima publishing corporation, New Delhi.

Reference Books:

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

Core Paper Theory– 6			
Title of the paper	Genetic Engineering		
Category of the course	Year	Semester	Credits
Core	I	II	4

Unit I

Isolation and purification of RNA, DNA (genomic and plasmid) and proteins, different separation methods. Analysis of RNA, DNA and proteins by one and two dimensional gel electrophoresis, Isoelectric focusing gels.

Unit II

Expression of recombinant proteins using bacterial, animal and plant vectors. Isolation of specific nucleic acid sequences Generation of genomic and cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors. In vitro mutagenesis and deletion techniques, gene knock out in bacterial and eukaryotic organisms.

Unit III

Protein sequencing methods, detection of post translation modification of proteins. DNA sequencing methods, strategies for genome sequencing. Methods for analysis of gene expression at RNA and protein level, large scale

expression, such as micro array based techniques Isolation, separation and analysis of carbohydrate and lipid molecules. RFLP, RAPD and AFLP techniques

Unit IV

Probes. Heterologous probes. Homologous probes. Complementary DNA (cDNA) synthesis. Polymerase chain reaction (PCR). Radioactive and nonradioactive labeling methods. Nucleic acid labeling, Electrophoresis, Southern blot. Antisense RNA Technology and Ribozyme

Unit IV

Molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems. DNA in disease diagnosis and medical forensics. Pharmaceutical products of DNA technology. Recombinant and DNA Vaccine. Gene therapy.

Text Books:

1. Somnath De. 2016. Basic concepts of Recombinant DNA Technology, 1st edition, DuPedia Publications (P) Ltd. Delhi.
2. T.A.Brown, 2010. Gene cloning and DNA analysis: An introduction, 6th edition, Wiley- Blackwell.
3. Sardul Singh Sandhu, 2010. Recombinant DNA Technology, IK International House Pvt. Ltd.

4. Sandy B.Primrose and Richard Twyman, 2006. Principles of Gene Manipulation and genomics, 7th edition, Wiley-Blackwell.
5. Bernard R. Glick and Jack J. 2003. Molecular Biotechnology, American Society for Microbiology.

Reference Books:

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

Core Practical – 2			
Title of the paper	Microbiology & Bioprocess Technology, Immunology, Genetic Engineering		
Category of the course	Year	Semester	Credits
Core	I	II	4

Microbiology & Bioprocess Technology

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

Immunology

1. Identification of various immune cells from human peripheral blood.
2. Lymphocyte separation and identification
3. Determination of lymphocyte viability by trypan blue method
4. WBC counting
5. Preparation of serum and plasma
6. Electrophoretic profile of human serum in native PAGE
7. Preparation of cellular antigen – human RBC
8. Preparation of antigen-adjuvant mixture for production of polyclonal antibody
9. Isolation of IgG molecule from serum
10. Immunodiagnosics: CRP
11. Immunodiagnosics: ASO
12. Immunodiagnosics: Widal
13. Immunodiagnosics: RF
14. Immunodiagnosics: Blood grouping and typing
15. Immunodiagnosics: hCG

16. ELISA
17. Radial Immunodiffusion
18. Ouchterlony Immunodiffusion
19. Immunelectrophoresis
20. Rocket electrophoresis
21. Counter current immunelectrophoresis.

Genetic Engineering

1. Preparation of plasmid DNA by alkaline lysis method.
2. Agarose gel electrophoresis
3. Silver staining of gels
4. Methylene blue DNA staining
5. Elution of DNA from agarose gel.
6. Restriction enzyme digestion.
7. Restriction mapping of plasmid DNA.
8. Ligation.
9. Transformation and selection of recombinants (Blue white screening).
10. RAPD
11. RFLP
12. Amplification of DNA - PCR
13. Determination of molecular weight of DNA.

Elective Paper –4			
Title of the paper	Intellectual Property Rights & Biosafety		
Category of the course	Year	Semester	Credits
Elective	I	II	3

Unit I

Introduction to Intellectual Property Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of New GMOs; International framework for the protection of IP, IP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies; Introduction to History of GATT, WTO, WIPO and TRIPS.

Unit II

Concept of ‘prior art’ Invention in context of “prior art”; Patent databases; Searching International Databases; Country-wise patent searches (USPTO, EPO, India etc.); Analysis and report formation.

Unit III

Basics of Patents Types of patents; Indian Patent Act 1970; Recent Amendments; Filing of a patent application; Precautions before patenting-disclosure/non-disclosure;

WIPO Treaties; Budapest Treaty; PCT and Implications; Role of a Country Patent Office; Procedure for filing a PCT application.

Unit IV

Patent filing and Infringement Patent application- forms and guidelines, fee structure, time frames; Types of patent applications: provisional and complete specifications; PCT and convention patent applications; International patenting-requirement, procedures and costs; Financial assistance for patenting-introduction to existing schemes; Publication of patents-gazette of India, status in Europe and US Patenting by research students, lecturers and scientists-University/organizational rules in India and abroad, credit sharing by workers, financial incentives Patent infringement-meaning, scope, litigation, case studies and examples.

Unit V

Biosafety Introduction; Historical Background; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety guidelines - Government of India; Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements including Cartagena Protocol.

Text Books:

1. Deepa Goel and Shomini Parashar, 2013. IPR, Biosafety and Bioethics, Pearson Education India.
2. Sree Krishna, V., 2007. Bioethics and Biosafety in Biotechnology, 1st Ed. New Age International Publishers, New Delhi.
3. Traynor, P.C., Frederic.R. and Koch, M. 2002. Biosafety. Board of Trustees, Michigan State University, USA.
4. Benjamin Lewin, 2000, Genes VII, First edition, Oxford, New York.

Reference Books:

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

Elective Paper – 5			
Title of the paper	Methods in Biology		
Category of the course	Year	Semester	Credits
Elective	I	II	3

Unit I

Methods of estimating population density of animals and plants, ranging patterns through direct, indirect and remote observations, sampling methods in the study of behavior, habitat characterization: ground and remote sensing methods.

Unit II

Antibody generation, Detection of molecules using ELISA, RIA, western blot, immunoprecipitation, fluocytometry and immunofluorescence microscopy, detection of molecules in living cells, in situ localization by techniques such as FISH and GISH.

Unit III

Molecular analysis using UV/visible, fluorescence, circular dichroism, NMR and ESR spectroscopy Molecular structure determination using X-ray diffraction and NMR, Molecular analysis using light scattering, different types of mass spectrometry and surface plasma resonance methods.

Unit IV

Detection and measurement of different types of radioisotopes normally used in biology, incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, safety guidelines. Single neuron recording, patch-clamp recording, ECG, Brain activity recording, lesion and stimulation of brain, pharmacological testing, PET, MRI, fMRI, CAT.

Unit V

Visualization of cells and subcellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells, scanning and transmission microscopes, different fixation and staining techniques for EM, freeze-etch and freeze fracture methods for EM, image processing methods in microscopy.

Text Books:

1. Khandpur, R.S. 2014. Handbook of Biomedical instrumentation, 3rd Edition. McGraw Hill Education.
2. Dinesh Kumar Chatanta, Prahlad Singh Mehra. 2012. Instrumental Methods of Analysis in Biotechnology. First Edition edition. I K International Publishing House Pvt. Ltd.
3. Ghatak K. L. 2011. Techniques and Methods in Biology. Prentice Hall India Learning Private Limited.

4. Bajpai P.K. 2010. Biological Instrumentation & Methodology. S Chand & Company.
5. Keith Wilson, John Walker. 2010. Principles and Techniques of Biochemistry and Molecular Biology (7th Edition) Cambridge University Press.

Reference Books:

1. David L. Nelson, Michael M. Cox. Lehninger. 2008. Principles of Biochemistry, Fifth edition and W. H. Freeman, New York.
2. Shawn O. Farrell, Ryan T. Ranallo. 2007. Experiments in Biochemistry: A Hands-On Approach. Brooks Cole Publisher.

Elective Disciplinary Elective 1			
Title of the paper	Plant Physiology		
Category of the course	Year	Semester	Credits
Elective Disciplinary Elective	I	II	3

Unit 1

Plant Physiology- Photosynthesis - Light harvesting complexes; mechanisms of electron transport;

photoprotective mechanisms; CO₂ fixation-C₃, C₄ and CAM pathways.

Unit 2

Respiration and photorespiration – Citric acid cycle; plant mitochondrial electron transport and ATP synthesis; alternate oxidase; photorespiratory pathway. Nitrogen metabolism - Nitrate and ammonium assimilation; amino acid biosynthesis.

Unit 3

Plant hormones – Biosynthesis, storage, breakdown and transport; physiological effects and mechanisms of action. Sensory photobiology - Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins.

Unit 4

Stomatal movement; photoperiodism and biological clocks. Solute transport and photoassimilate translocation – uptake, transport and translocation of water, ions, solutes and macromolecules from soil, through cells, across membranes, through xylem and phloem; transpiration; mechanisms of loading and unloading of photoassimilates.

Unit 5

Secondary metabolites - Biosynthesis of terpenes, phenols and nitrogenous compounds and their roles. Stress physiology – Responses of plants to biotic (pathogen and insects) and abiotic (water, temperature and salt) stresses. Common parasites and pathogens of crops.

Text Books:

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

Reference Books:

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

THIRD SEMESTER

Core Paper Theory– 7			
Title of the paper	Plant & Animal Biotechnology		
Category of the course	Year	Semester	Credits
Core	II	III	4

Unit-I

Introduction of plant tissue culture, Composition of media, tissue and cell culture methods for plants, micropropagation, organogenesis, somatic embryogenesis, haploid and triploid production, protoplast isolation and fusion, hybrid and cybrid, Artificial seeds , production of secondary metabolites - Biosynthesis of terpenes, phenols and nitrogenous compounds and their roles. Organisms of conservation concern: Rare, endangered species. Conservation strategies.

Unit-II

Plant Transformation- Methods of gene transformation in plants - agro bacterium and crown gall tumour-mechanism of t-DNA transfer to plants. Breeding in plants, Marker – assisted selection, Transgenic plants-transgenic Responses of plants and conferring resistance to biotic (pathogen and insects) and abiotic (water, temperature and salt) stresses.

Unit-III

Introduction to animal cell culture -Laboratory establishment- Culture medium: natural media, synthetic media, sera, balanced salt solutions and simple growth medium. Role of carbon di oxide. Behavior of cells in culture, properties, utility. Disaggregation of tissue and primary culture; cell separation, Slide and coverslip cultures, flask culture, test tube culture techniques.

Unit-IV

Definition of cell lines, maintenance and management; cell adaptation. Measurement of viability and cytotoxicity. Cell cloning, cell synchronization and cell manipulation. Various methods of separation of cell types, advantages and limitations; flow cytometry. Use of cryoprotectants, Methods of cryopreservation of cells and retrieval.

Unit-V

Ovary stimulation. Oocytes recovery and uptake. Sperm preparation IVF and embryo transfer, Assisted Reproduction technology (ART). Transgenic animals in livestock improvement, transgenic animals as model for human diseases. Molecular approaches to diagnosis and strains identification. Breeding in animals, including marker-assisted selection. Common parasites and pathogens of animals.

Text Books:

1. Vinay Sharma and Afroz Alam. 2015. Plant tissue culture. IK International publishing house Pvt limited.
2. C.B. Nirmala, G. Rajalakshmi and Chandra Karthick. 2009. Plant Biotechnology, 1st Edition, MJP Publishers.
3. H. S. Chawla 2009. Introduction to Plant Biotechnology. 3rd edition. Oxford & IBH Publishers, New Delhi.

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

Reference Books:

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

Core Paper Theory– 8			
Title of the paper	Bioinformatics		
Category of the course	Year	Semester	Credits
Core	II	III	4

Unit-I

Introduction to Bioinformatics –Historical overview and definitions-Bioinformatics databases – definitions-types of databases-nucleic acids and protein databases-considerations for biological databases-information search and data retrieval-electronic libraries-data retrieval tools-downloadable and web-based tools-tools for sequence searches, motif analysis and presentation-data mining of biological databases-data mining for sequence analysis.

Unit-II

Sequence alignment-basics of sequence alignment-alignment of pairs of sequences-methods of sequence alignments–global and local alignment algorithms using scoring matrices-Multiple sequence alignment-methods of multiple sequence alignment-progressive alignment and Iterative alignment algorithms-applications of multiple sequence alignments. Tools for similarity search and sequence alignment-Pairwise alignment based rigorous algorithm (Smith and Waterman) and Heuristic algorithms (FASTA and Blast).Markov models and Hidden Markov Models (HMM's).

Unit-III

Bioinformatics for genome analysis and mapping-linkage analysis-physical and genetic maps- genome cloning-sequence assembly tools-contigs-human genome project(HGP)-basics of gene prediction-pattern recognition-gene prediction methods and tools- Protein structure prediction and classification-Motifs, patterns, profiles and

fingerprints-Tools and databases for proteomics- -DNA microarrays-applications of Microarray technology- Bioinformatics for phylogenetic analysis-distance-based and character-based methods-phylogenetic tree evaluation-tools for phylogenetic evaluation. Genomics and its application in health and agriculture including gene therapy.

Unit-IV

Molecular visualization tools– Structure analysis tools – VAST and DALI-RNA Structure Prediction tools-Vienna RNA Package-Eddy labs RNA prediction packages: SSU Align, ERAE-analysis of metabolic pathways- KEGG Database-simulation of cellular activities-E-CELL and V-CELL-Introduction to biological markup languages- Extensible Markup Language (XML),CellML-Bioinformatics Sequence Markup Language (BSML) -Structural biology - Homology modeling-prediction of functionally important features of proteins and biomolecules-biosensors.

Unit-V

Medical application of Bioinformatics – disease genes, Drug Discovery –Introduction– Pharmacogenetics- Pharmacogenomics-Single Nucleotide Polymorphisms(SNPs)-Steps in drug discovery – Target Identification-G-protein coupled receptors-Ion channels: drug discovery and techniques-voltage-gated and non-voltage gated ion channels-Aquaporins-Biomarkers in drug development- Target Validation and druggability–cell cycle in drug discovery– cell cycle regulatory mechanisms and cancer. Lead Identification –computer-aided drug design-

Preclinical pharmacology and toxicology – ADME-Tox–
Rational drug design – Computer aided drug design – Ligand
based approach – Target based approach.

Text books:

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

Reference Books:

1. Lesk, Arthur, M.2014. Introduction to bioinformatics, Fourth edition. Oxford University Press, Oxford.
2. Singh, R. and Sharma, R.2010. Bioinformatics basics, algorithms and applications. Universities Press
3. Atwood, T.2007. Introduction to Bioinformatics. Oxford University Press, Oxford.

Core Paper Theory– 9			
Title of the paper	Molecular Biology		
Category of the course	Year	Semester	Credits
Core	II	III	4

Unit I

Basic mechanisms in the living cell-role of biomolecules in the cell-cell division-mitosis-meiosis-proteins-nucleic acids-DNA-RNA-types and functions-Genetic code-chromosome structure-DNA organization-central dogma-signal transduction-C-value paradox.

Unit II

DNA replication, repair and recombination-Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms, homologous and site-specific recombination.

Unit III

RNA synthesis and processing -transcription factors and machinery, formation of initiation complex, transcription

activator and repressor, RNA polymerases, capping, elongation, and termination, RNA processing, RNA editing, splicing, and polyadenylation, structure and function of different types of RNA, RNA transport.

Unit IV

Protein synthesis and processing -Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, and translational proof-reading, translational inhibitors, Post- translational modification of proteins.

Unit V

Control of gene expression at transcription and translation level -regulating the expression of phages, viruses, prokaryotic and eukaryotic genes, role of chromatin in gene expression and gene silencing.

Text books:

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

Reference Books:

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

Core Practical – 3			
Title of the paper	Plant & Animal Biotechnology, Bioinformatics, Molecular Biology		
Category of the course	Year	Semester	Credits
Core	II	III	4

Plant & Animal Biotechnology

1. Sterilization Techniques.
2. Preparation of MS medium.
3. Micro propagation.
4. Callus induction.

5. Induction of Suspension culture.
6. Production of secondary metabolites from callus
7. Preparation of synthetic seeds
8. Regeneration of Shoots callus culture
9. Regeneration of roots from shoots.
10. Protoplast Isolation
11. Protoplast viability
12. Protoplast fusion.
13. Induction of tumors by Agrobacterium .
14. Isolation of Ti plasmid.
15. Isolation of DNA and from plant tissue
16. Meristem culture.

17. Introduction to Animal Cell culture: Procedure for handling cells and medium.

18. Cleaning and sterilization of glassware and plastic tissue culture flasks
19. Preparation of tissue culture media
20. Preparation of sera for animal cell culture
21. Preparation of single cell suspension from chicken liver (Primary cell culture).
22. Trypsinization of established cell culture.
23. Cell counting and viability - staining of cells a) Vital Staining (Trypan blue, Erythrosin B) b) Giemsa staining.
24. MTT Assay

Bioinformatics

1. Sequence retrieval from Genbank
2. Sequence retrieval from Uniprot.
3. Sequence identity search- Sequence similarity search using BLAST
4. Sequence similarity search using FASTA
5. Sequence similarity search using PSI BLAST
6. Sequence similarity search using PHI- BLAST.
7. Prediction of signal sequence using SignalP online tool
8. Pattern Search (Domains & Motifs) using Pfam
9. ORF gene Search - Genscan
10. Sequence translation using ExPASy translate tool
11. Characterization of retrieved protein sequence by ProtParam tool.
12. Pair-wise global sequence alignment using EBI-EMBOSS Needleman-Wunsch tool
13. Pair-wise local sequence alignment using EBI-EMBOSS Smith-Waterman tool
14. Multiple sequence alignment using EBI-CLUSTALW2.

15. PHYLOGENY- Phylogenetic tree using PHYLIP.
16. Prediction of secondary protein structure using GOR (Garnier-Osguthorpe-Robson) server.
17. Prediction of tertiary protein structure using SWISS-MODEL Server
18. Validation of the predicted structure using PROCHECK server
19. Molecular visualization of proteins using RASMOL.
20. Docking of small molecule with protein structure using Hex software.
21. Docking of two proteins using PatchDock (Protein-Protein docking) tool.
22. Retrieval of *E.Coli* glycolytic pathway from KEGG.

Molecular Biology

1. Preparation of buffer stocks (TE, TBE, TAE)
2. Isolation of genomic DNA from plant and animal tissues
3. Isolation of genomic DNA from E.coli
4. Isolation of plasmid DNA from E.coli / Agrobacterium
5. Agarose gel electrophoresis
6. Molecular weight determination of isolated DNA using agarose gel electrophoresis

7. Extraction and Isolation of histone proteins from plant, animal tissues and E.coli.
8. Molecular weight determination of isolated protein using SDS-PAGE
9. Estimation of proteins by Lowry and Bradford method
10. Western blotting
11. Southern blotting
12. PCR

Elective Paper			
Title of the paper	Nanobiotechnology		
Category of the course	Year	Semester	Credits
Elective	II	III	3

UNIT I

BASICS AND SCALE OF NANOTECHNOLOGY

Introduction – Scientific revolutions – Definition of a nanosystem – Basic concepts of Nanoscience and Nanotechnology- Definition of nanoparticle and its types.

Unit II

DIFFERENT CLASSES OF NANOMATERIALS

Classification based on dimensionality - Quantum Dots, Wells and Wires – Carbon - based nano materials (buckyballs, nanotubes, graphene) – Metalbased nanomaterials (nanogold, nanosilver and metal oxides) - Nanocomposites – Nanopolymers – Nanoglasses – Nano ceramics - Biological nanomaterials.

UNIT III

SYNTHESIS OF NANOMATERIALS

Chemical Methods: Metal Nanocrystals by Reduction - Solvothermal Synthesis - Photochemical Synthesis - Sonochemical Routes - Chemical Vapor Deposition (CVD) – Metal Oxide - Chemical Vapor Deposition (MOCVD). Physical Methods: Ball Milling – Electrodeposition - Spray Pyrolysis - Flame Pyrolysis - DC/RF Magnetron Sputtering - Molecular Beam Epitaxy (MBE).

UNIT IV

MATERIALS CHARACTERIZATION

Introduction to Nanoparticle characterization: Methods and Instruments- X- ray diffraction, Neutron diffraction and Electron diffraction – X - ray fluorescence spectroscopy – Fourier transform Infrared spectroscopy (FTIR) – Ultraviolet and visible spectroscopy (UV -Vis) – Differential Scanning Calorimetry (DSC). Field Emission

Scanning Electron Microscopy (FESEM) – Environmental Scanning Electron Microscopy (ESEM) High Resolution Transmission Electron Microscope (HRTEM)

UNIT V:

APPLICATIONS

Potential application of nanomaterials in electronics, nanorobots, sensors - Applications of nanomaterials in medicine and biotechnology – Nanotoxicology challenges.

TEXT BOOKS

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

Reference Books:

1. Laurencin, Lakshmi S. Nair, 2012. Nanotechnology and tissue engineering. CRC press.
2. M.A.Shah and Tokeer Ahmad 2010 Principles of Nanoscience and Nanotechnology Alpha Science International Ltd.
3. Kurt E. Geckeler, Hiroyuki Nishide, 2010. Nanotechnology- Advanced Nanomaterials, Wiley VHC.
4. Chad A. Mirkin and Christof M. Niemeyer. 2007. Nanobiotechnology II: More Concepts and Applications, Wiley-VCH.
5. Poole, F.O.C.2007. Introduction to Nanotechnology. Wiley Publishers, USA.

Elective Paper			
Title of the paper	Virology		
Category of the course	Year	Semester	Credits
Elective	II	III	3

Unit I

Structure of animal viruses and plant viruses; Classification of animal and plant viruses; Satellite viruses; Viroids; Virusoids etc.; Diseases caused by animal viruses and plant viruses; Economic loss due to important viruses.

Unit II

Genome organization of animal viruses; Replication of RNA viruses; Replication of DNA viruses

Unit III

Genome organization of plant viruses; Replication of RNA viruses; Replication of DNA viruses

Unit IV

Methods to diagnose animal virus infections: Electron microscopy, Tissue culture growth of viruses, Virus quantitation assays, Viral serology: ELISA, neutralization assays; Molecular methods: hybridization, PCR, real time PCR, sequencing, microarray, gene silencing and antiviral assays.

Unit V

Methods to study plant viruses; Infectivity assays – Sap transmission, insect vector transmission, agroinfection (using *Agrobacterium*); Ultracentrifugation, electron microscopy, serological methods, immunoelectrophoresis in gels, direct double-antibody sandwich method, Dot ELISA, Immunosorbent electron microscopy (ISEM), Decoration

technique, Polymerase chain reaction; DNA and oligonucleotide microarray; Gene silencing, PTGS & TGS, viral suppressors of gene silencing.

Text Books:

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

Reference Books:

1. Alan J. Cann, 2015. Principles of Molecular Virology. Academic Press.
2. Bruce Alberts et al. 2014. Molecular Biology of the Cell, Sixth Edition, Garland Science.
3. J.E. Krebs, E.S. Goldstein and S.T. Kilpatrick, 2013. Lewin's Genes XI. Jones & Bartlett Learning.
4. Leonard C.Norkin, 2010. Virology: Molecular Biology and Pathogenesis. American Society for Microbiology.

Elective Disciplinary Elective			
Title of the paper	Animal Physiology		
Category of the course	Year	Semester	Credits
Elective Disciplinary Elective	I	II	3

Unit 1

Animal Physiology- Blood and circulation - Blood corpuscles, haemopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, haemoglobin, immunity, haemostasis. Cardiovascular System: Comparative anatomy of heart structure, myogenic heart, specialized tissue, ECG – its principle and significance, cardiac cycle, heart as a pump, blood pressure, neural and chemical regulation of all above.

Unit 2

Respiratory system - Comparison of respiration in different species, anatomical considerations, transport of gases, exchange of gases, waste elimination, neural and chemical regulation of respiration.

Unit 3

Nervous system - Neurons, action potential, gross neuroanatomy of the brain and spinal cord, central and peripheral nervous system, neural control of muscle tone and posture. Sense organs - Vision, hearing and tactile response.

Unit 4

Digestive system - Digestion, absorption, energy balance, BMR. Endocrinology and reproduction - Endocrine glands, basic mechanism of hormone action, hormones and diseases; reproductive processes, gametogenesis, ovulation, neuroendocrine regulation.

Unit 5

Excretory system - Comparative physiology of excretion, kidney, urine formation, urine concentration, waste elimination, micturition, regulation of water balance, blood volume, blood pressure, electrolyte balance, acid-base balance. Thermoregulation - Comfort zone, body temperature – physical, chemical, neural regulation, acclimatization. Stress and adaptation.

Text Books:

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

2. S. C. Rastogi, 2015. Essentials of Animal Physiology, ^{3rd} Edition, New Age International Pvt Ltd, New Delhi.

Reference Books:

1. C.D.Moyes and P.M.Schulte. 2016. Principles of Animal physiology. Second Edition. Pearson Education.
2. Richard Hill, Gordon A. Wyse & Margaret Anderson, 2016. Animal Physiology. Sinauer Associates Inc Publisher.

Elective offered to other Department.			
Title of the paper	Principles of Gene Manipulation Technology		
Category of the course	Year	Semester	Credits
Elective	II	III	3

UNIT I

Restriction enzymes, DNA modifying enzymes, cloning vectors, prokaryotic hosts-Creating Recombinant DNA molecules-Isolation and Cloning of genes

UNIT II

Construction of representative cDNA and genomic libraries-Polymerase Chain Reaction (PCR) and applications-Innovations in PCR -Real-time PCR-Taqman

fluorescent probes-Pfu and Tth polymerases in PCR-Southern/Northern Blotting analysis-RFLP-RAPD analysis-Applications of cloning and DNA analysis-Gene expression studies-PCR-Production of protein-Applications in Medicine and Agriculture-Protein for non-invasive imaging-near-infra-red Fluorescent Protein (iRFP)

UNIT III

Gene transfers-Introduction of foreign genes into cells:electroporation-biolistic transfer-transfection-Selectable markers-Microinjection-Embryonic stem cells-Reporter transgenes-Homologous recombination-“knock in/knock out”-Recombinant cellulose binding domains (CBD) in affinity chromatography

UNIT IV

Transgenics-approaches to transgenesis: Microinjection-Embryonic stem cells-Sperm mediated transfer-Mammalian cloning by nuclear transfer-“Dolly” the cloned sheep-“Noori”-Cloned Indian goat-Genetic mosaics-Chimeric organisms- Tender Coconut Water (TCW) as animal cell growth media

UNIT V

Edible Vaccines-Disease Resistance in transgenic organisms-Pest and herbicide resistant plants. The Mx gene system or anti-viral disease resistance in animals -Biosafety and Food safety of GMOs-Regulatory organizations in India for biologic drugs-Department of biotechnology (DBT)-Review

Committee on genetic manipulation (RCGM)- Central Drugs Standard Control Organization (CDSCO).

Text Books:

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

Reference Books:

1. Dubey R.C., 2014. A Textbook of Biotechnology. 5th Edition, S.Chand Publications.
2. Dabhole M.P. 2014. Recent Innovations in Therapeutic Recombinant Protein. Pharma Bio World.
3. Dubey, R.C. and Maheshwari D.K., 2013. A Textbook of Microbiology. 3rd Edition, S. Chand Publications.
4. Gupta, P.K., 2012. Biotechnology and Genomics. 1st Edition, Rastogi Publications.
5. Michael Zachariou, 2008. Affinity Chromatography: Methods and Protocols. 1st Edition, Humana Press.

FOURTH SEMESTER

Core Paper – 10			
Title of the paper	Stem Cell Biology		
Category of the course	Year	Semester	Credits
Core Theory	II	IV	4

Unit -1

Introduction to stem cells, classification, Sources, programming and reprogramming, tissue specific stem cells Embryonic hematopoietic and neural stem cells, Classification and Sources

Unit -2

Embryonic Stem Cells Blastocyst and inner cell mass cells; Organogenesis; Mammalian Nuclear Transfer Technology; Stem cell differentiation; Stem cells cryopreservation

Unit -3

Characteristics of stem cell- cell cycle, Ras\Raf pathway, PI3K cell signaling, p53 check points, Role of LIF pathway in cell cycle control.

Unit -4

Chromatin modification and transcriptional regulation, chromatin modifying factors, Chromosomal inactivation. Human Embryonic Stem Cells and society. Human stem cells research : Ethical considerations; Stem cell religion consideration; Stem cell based therapies: Pre clinical regulatory consideration and Patient advocacy.

Unit -5

Therapeutic applications of Embryonic stem cells, Bone marrow stem cells, Adipose derived stem cells and Hematopoietic stem cells in Heart regeneration and neural defects.

Text Books:

1. Jonathan Slack, 2012. Stem cells: A very short introduction. Oxford University Press.
2. Vemuri C. Mohan. 2010. Stem Cell assay. Humana press, New Jersey.
3. Robert Lanza: 2005. Essentials of Stem Cell Biology. Academic Press.
4. Kursad Turksen. 2004. Adult Stem Cells. Humana Press, Inc.

Reference Books:

1. Rex Turner, 2015. Stem Cells: Biology and Diseases. Hayle Medical

2. Ann A. Kiessling. 2006. Human Embryonic Stem Cells. 2nd Edition, Jones and Bartlett Publishers, Inc.

Elective Paper			
Title of the paper	Research Methodology		
Category of the course	Year	Semester	Credits
Elective	II	IV	3

Unit- I

Research Methodology - An Introduction: Meaning of Research, Objectives of Research, Types of Research, Research Approaches, Importance of knowing how research is done, Research Process, Criteria of good research. Defining the Research Problem; Research Design; Selecting the problem

Unit- II

Hypothesis What is hypothesis Research hypothesis and Null hypothesis. Research Design Meaning of research Objective of research Motivation of research Significance of research. How to prepare a research proposal Literature survey for the proposed research work. How to conduct field survey Sampling fundamentals Important sampling distributions

Unit- III

Methods of data and information collection Collection of primary data Observation method Interview method Method of data collection Collection of secondary data Selection of appropriate method for data collection. Processing and analysis of data Basic statistical techniques Analysis of variance, Chi square test, ANOVA, standard deviations, F and t test. Tubular and graphical presentation of data, Histogram, frequency polygon, pie chart. Parametric and Non parametric tests,

Unit- IV

Measurement and scaling technique Refining Skills in Regression Analysis Advanced Multivariate Analysis. Sampling errors Theory of errors Errors and residuals, precision, measure of precision, Probable error of function, rejection of observation, Experimental designs Design of experiments, completely randomized and random block design, factorial experiments, missing plot technique, Modeling and simulation.

Unit- V

Computer aided statistical analysis Electronic data processing, operating system-common software available, Internet applications, database and bioinformatics. Use of statistical software packages-SPSS. Scientific writing and publication Interpretation, technical Report writing and presentation (oral/poster), Overhead projector power point slides, Journal selection.

Text Books:

1. Kothari C.K. 2014. Research Methodology- Methods and Techniques, 3rd Edition, New Age International, New Delhi.
2. Donald H. McBurney. 2006. Research Methods, 5th Edition, Thomson Learning.

Reference books:

1. Deepak Chawla and Meena Sindhi. 2016. Research Methodology-Concepts and Cases. 2nd Edition, Vikas Publishing Company.
2. Montgomery, Douglas C. & Runger, George C. 2007. Applied Statistics & Probability for Engineers, 3rd Edition, Wiley India.
3. Krishnaswamy, K.N., Sivakumar, Appa Iyer and Mathiranjani M. 2006. Management Research Methodology; Integration of Principles, Methods and Techniques, 1st Edition, Pearson Education, New Delhi.

Elective Paper			
Title of the paper	Marine Biotechnology		
Category of the course	Year	Semester	Credits
Elective	II	IV	3

Unit 1

Principles of oceanography Marine Ecology Estuaries, coastal and deep sea. Major oceans and sea. Physico-chemical parameters-Temperature, Salinity, Oxygen, BOD,COD and Light. Marine Bioresources in India.

Unit 2

Planktonic Microorganisms Diversity-Marine Viruses, Marine Bacteria and Archaea, Eukaryotic Phytoplankton, Zooplankton.

Unit 3

Marine Microalgae-genome. Gene transfer methods in Microalgae, metabolic engineering. Photobioreactors of Microalgae. Sponges- sponges associated Bacteria's, Archaea, Eubacteria. Sponge specific microorganisms. Molecular method to elucidate the sponge symbiosis. Metagenomic screening of natural products form marine sponges.

Unit 4

Marine Enzymes-Polysaccharide degrading enzymes, proteases, Halogenating enzymes, down stream process of marine enzymes. Bioprospecting of marine environment-culturing technique and culture independent. Gene target method. Omics and meta Omics approaches. Applications of genomics and proteomics to marine biotechnology, biomaterials and bioengineering, and public policy.

Unit 5

Marine microorganisms source of valuable natural products (seaweed and microbes) and the cell factory-Biomass production and Novel Biocatalysts. Transgenic marine organisms- selection of organism's, Gene transfer method, identification of transgenic animals. Enhancing the disease resistance, somatic growth. Increase the color of ornamental fishes. Model to studying Human disease Transgenic a fish as environmental indicator, Application of Biotechnology in Aquaculture–use of antibodies, protein, antifreeze protein, antibiotics and microbes.

Text books:

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

References Books:

1. Abhijit Mitra, Sufia Zaman, 2016. Basics of Marine and Estuarine Ecology 1st Edition. Springer.

2. N.V. Prasad 2012. Ecology of Mangrove Estuarine Zooplankton: Composition, Distribution, Production, BIS
3. Yves Le Gal, Roland Ulber. 2010. Marine Biotechnology I / Edition 1. Springer Berlin Heidelberg
4. Committee on Marine Biotechnology: Biomedical Applications of Marine Natural Products, National Research Council, Division on Earth and Life Studies Staff, Ocean Studies Board Staff, National Research Council Staff. 2002. Marine Biotechnology in the Twenty-First Century: Problems, Promise, and Products. National Academies Press.