

JSS Academy of Higher Education & Research

(Deemed to be University) Accredited "A" Grade by NAAC Sri Shivarathreeshwara Nagar, Mysuru - 570 015

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POST GRADUATE **DEGREE PROGRAMMES-2018**



Regulation & Syllabus

POST GRADUATE DEGREE PROGRAMMES

2018



JSS Academy of Higher Education & Research (Deemed to be University) Accredited "A" Grade by NAAC Sri Shivarathreeshwara Nagar, Mysuru – 570 015

Preamble

The Department of Water and Health under Faculty of Life Sciences offers undergraduate and postgraduate programs and one postgraduate diploma program under the UGC-CBCS pattern. The CBCS pattern offers a platform for interdisciplinary learning among our students. This pattern provides choice for students to select from the prescribed courses (core, elective, soft skills). Under this CBCS, the requirement for awarding a degree or diploma is prescribed in terms of number of credits to be completed by the students. The courses offered has a mandate to coordinate the UGC regulations in a manner that uniform quality control regulations and procedures are strictly adhered to and high academic standards are maintained, in addition to providing our students with high quality academic, ICT, other support services.

The Semester Grade Point Average (SGPA) is measured as performance of work done by the student in a semester. The Cumulative Grade Point Average (CGPA) is measured as cumulative performance of a student in all semesters in the courses taken by the student.

The mission of the undergraduate and postgraduate studies offered at FLS is to promote excellence amongst our undergraduate and postgraduate staff and students through responsive teaching, research and supervision, scholarship and in-

structional pastoral support.

The main objective of the courses offered at FLS is interdisciplinary in nature that enables over all student development and enhanced learning experience. Each course paper provides hands-on-experience that translates theory to practicals. The curriculum is supported with field trips, industrial visits and other extension and extracurricular activities wherever required.

The students are encouraged to undergo and acquire scientific knowledge by frequently participating in different subject related workshops, research centers and national/international laboratories with inter and multidisciplinary collaborative research groups.

SI. No.	Name of the Program	Program Genesis
1	M. Sc. Environmental Sciences	2011-2012
2	M.Sc. Cognitive Neurosciences	2013-2014
3	M. Sc. Biochemistry	2014-2015
4	M. Sc. Cosmetic Sciences	2014-2015
5	M.Sc. GeoInformatics	2014-2015
6	M. Sc. Molecular Biology	2014-2015
7	M. Sc. Nanoscience and Technology	2014-2015
8	M.Sc. Nutrition and Dietetics	2014-2015
9	M. Sc. Medical Statistics	2015-2016
10	M. Sc. Bioinformatics	2016-2017
11	M.Sc. Microbiology	2018-2019
12	P. G. Diploma in Tissue Culture	2015-2016

POST GRADUATE PROGRAMS OFFERED

–		:	< label{eq:started_startes		-		1-	=		1				70			-	-					7		-	-	1		Semester		
			(0)		Practical 3	lective 3b	Elective 3a	Elective 3 E	Paper 12 E	Paper 11	Paper 10	Paper 9		Practical 2	Elective 2b	Elective 2a	Elective 2	Paper 8	Paper 7	Paper 6 F	Paper 5 E		Practical 1	Elective 1	Paper 4 E	Paper 3 E	Paper 2	Paper 1 F	Papers	BOM No.	Year
		ield/hdustrial Visit report and Viva OR hesis and viva voce examination	summer Project		Vater Treatment Techniques, Waterborne Disease and Chemical Agents		Vater Resource Management and sustainable Development	invironmental Nanoscience OR	invironmental Pollution and Law	Environmental Safety and Health Janagement	Vaterborne Disease and Chemical (gents	Vater and Wastewater Treatment rechniques		invironmental Toxicology, Microbiology & kotechnology		environmental Impact assessment	3lo-Energy Technologies OR	Invironmental Economics and Management	Vater Resource and Ground Water rhydrology	temote Sensing & GIS	Environmental Toxic dogy		environmental Biology, Chemistry & earth Science	statistical Methods for Biology	environmental Earth Science	Invironmental Chemistry	Environmental Microbiology and sidechnology	rinciples of Environmental Sciences	M.Sc. Environmental Sciences		2011-12
		Thesis and viva voce examination	Summer Project		Practical 3		Psychametrics	Research Methods			Cognitive Neuro psychological Rehabilitation.	Consciousness Studies		Practical 2				Philosophy of Mind	Computational Intelligence.	Neuro Basis of Cognitive Science.	Social Cognition and Culture.		Practical 1	Statistical Methods for Biology	Research Methods	Mathematical Models of Cognitive Science	Principles of Neuro Science	Developmental Cognitive Science	M.Sc. Cognitive Neuroscience		2013-14
		Thesis and viva voce examination	Summer Project		Combination of all the above (Practical 3)		Bioethics, Research Design & IPR	Proteomics or	Clinical Biochemistry	Metabdiism	Enzymology	Plant Blochemistry		Combination of all the above (Practical 2)		Cell Signaling	Cancer Nanotherapeutics	Immunology	Anatomy and Physiology	Genetics	Nutritional Biochemistry		Biochemical Techniques (Practical 1)	Statistical Methods for Biology	Biochemical Techniques	Fundamentals of Biochemistry and Biomolecules	Fundamentals of Chemistry in Biology	Fundamentals of Molecular Biology	M.Sc. Blochemistry		
		Project work – Dissertation and viva voce examination	Markeeing case studies Dissertation and Wva-Voce examination		Cosmetics - Analysis & Evaluation			Environmental Nanoscience	Industrial Cosmetics	Applied microbidlogy	Statistical method for Biology	Cosmetics - Analysis and Evaluation		Formulation Science			Genetics	Herbal Science	Cosmeceuticals	Cosmetics Formulation Science	Cosmetics Biology		Human Anatomy and Physiology	Fundamentals of Biochemistry and Bio-molecules	Analylical techniques	Fundamentals of Nanotechnology	Cosmetics - principles	Basic human Anatomy and Physiology	M.Sc. Cosmetic Science		PG Program
		Thesis and viva voce examination	Summer Project		Advance in GIS and Remote Sensing		Urban GIS	Advances in Public Health Geoinformatics	Geodatabase for GIS	Application of Gedinformatics in Natural Resources Management	Photogram metry	Advances in Geo informatics		Image Processing and Analysis in GIS		Geostatistics	Geoinformatics for Hydrology	Digital Image Processing	Digital Cartography	Introduction to Spatial Data Analysis	Principles of Geographical Information System		Techniques of Interpretation in spatial data	Statistical Methods for Bidlogy	Introduction to Remote Sensing	Introduction to Spatial Data Sources	Fundamentals of Computer Sciences and programming C	Fundamentals of Mathematics	M.Sc. Geoinformatics		n Summary 2
		Thesis and viva voce examination	Summer Project		r-DNA techniques and in silico sequence analysis		Genomics & Proteomics	Sequence Analysis & Pharmacogenomics	IPR, Bioethics & Bio-safety	Molecular and Cellular Radiobiology	Molecular Medicine	Cancer and Stem Cell Bidogy		Animal Cell Culture and Immunotechniques			Cell and Tissue Culture Technology	Genetic Engineering	Immunology & Vaccine development	Molecular Cell Signalling	Molecular Developmental Biology		Experimental Molecular Biology	Statistical Methods for Biology	Molecular Genetics and Evolution	Fundamentals of Biochemistry and Biomolecules	Advances in Molecular Bidlogy	Fundamentals of Molecular Bidlogy	M. Sc. Molecular Biology		014-15
		Thesis and viva voce examination	Summer Project		Biopharmace utics and Pharmacolontics		Nano-loxicology	Environmental Nanoscience	Biomedical Applications of nanomaterials	Advanced DrugDelivery Systems	Biopharmaceutics and Pharmacokinetics	Nandechnology Product Development		Surface modification of nanomaterials		Applications of Nanotechnology for Industry	Cancer Nano-therapeutics	Synthesis and surface modification of nanomaterials	Nano biology	Properties of Nanomaterials	Surface and Colloidal Nano chemistry		Characterization of Nanomaterials	Statistical Methods for Biology	Characterization of Nanomaterials	Fundamentals of Biochemistry and Biomolecules	Fundamentals of Nanolechnology	Basic Chemistry and Chemical Bonding	M. Sc. Nanoscience & Nanotechnology		
		Thesis and viva voce examination	Summer Project		Menu Planning and Hospital internship	Food Security	Sensory Evaluation and Culinary Science	Nutrition for Sports and Exercise	Food Safety and Food Service Management	Community Nutrition	Medical Nutrition and Management 2	Advanced Nutrition 2		Clinical Nutrition (Practical 2)	Diet for Endocrine Disorders	Food preservation and Food Microbiology	Nutraceuticals and Functional Foods	Medical Nutrition Management-1	Human Nutrition	Principals of Diet Therapy	Advanced Nutrition-1		Nutritional Biochemistry (Practical 1)	Statistical Methods for Biology	Life Cycle Nutrition	Human Physiology	Nutritional Biochemistry and Biochemical Techniques	Fundamentals of Food Science	M. Sc. Nutrition and Dietetics		
		Thesis and viva voce examination	Summer Project		Combination of all the above (Practical 3)			Bioinformatics tools in MatLab	Immunoinformatics	CADD (Drug Designing)	Structural Bioinformatics	PYTHON for Bloinformatics		Combination of all the above (Practical 2)		Object-Oriented Programming and Database Management	Molecular statistical model using 'R'	System Biology	PERL for Bidinformatics	Multivariate Techniques and Big Data Analytics	Protein structure and function		(Practical 1)	Statistical computing using Excel and SPSS	Molecular Biology for Bioinformatics	Biomolecules	Fundamentals of Computers and Programming Languages	Fundamentals of Biostatistics	M.Sc. Bioinformatics		2015-16
		Thesis and viva voce examination	Summer Project		Practical -III			Data analysis Using MATLAB	Advanced Epidemiology	Sunival Data Analysis	Multivariate Analysis	Generallized Linear Models		Practical -II			Statistical Model Using 'R'	Time Series and Spatial Statistics	Documentation and Research Methodology	Linear Regression and Robustness	Basics of Clinical Trial		Practical -I	Statistical Computing Using Excel and SPSS	Population and Health Data Management	Fundamentals of Mathematics	Statistical Epidemiology	Basic Medical Statistics	M.Sc. Medical Statistics	-	2016-17
		Thesis and viva voce examination	Summer Project	Industrial Microbiology, Hermentation Technology, Microbial Bioremediation and Technology	Medical Microbiology, Immunology, Molecular Biology and Genetic Engineering	Intellectual Property Rights, Biosafety and Bioethics	Industrial training and Entrepreneurship or	Disease Diagnostic Technology or	Microbial Bioremediation and Technology	Industrial Microbiology and Fermentation Technology	Molecular Biology and Genetic Engineering	Medical Microbiology and Immunology	Food, Daily, Soll, Agriculture and Environmental Microbiology	Microbial Physiology, Genetics, Genomics & Enzymology	Microbial Nanotechnology	Biofertilizer and Biomanure Technology or	Bioinformatics or	Soll, Agriculture and Environmenta Microbiology	Food and Dairy Microbidlogy	Microbial Physiology, Genetics and Genomics	Microbial Enzymology	Mycology & Phycology	Virology, Parasitology & Bacteriology	Statistical Methods for Bidlogy	Phycology	Mycology	Bacteriology	Virology& Parasitology	M.Sc. Microbiology		2018-19
T otal C redits														Practical -II			Parject work			Application of Animal Cell Culture	Industrial Application of Tissue Culture and Conservation of Germ plasm		Practical -I				Techniques in Plant tissue culture	Fundamentals of Plant tissue outture	PG Diploma in Tissue Culture		2015-16
92	14	12	2		6		4		4	4	4	4	26	6		4		4	4	4	4		6	4	4	4	4	4	Credits		

POSTGRADUATE PROGRAM REGULATIONS

I. Definitions

1. Program and Course:

- a. **Program:** Post-graduate Degree Program
- b. **Course:** A theory or a practical or a project work or a combination of all as said above, studied in a semester.
- **2. Dean:** The head of the Faculty nominated by the Deemed to be University among the Senior Faculty
- **3. Head of the Department:** A recognized faculty of the respective department nominated by the Dean in consultation with the Vice Chancellor.
- 4. Faculty: A teaching member as per UGC requirements.
- **5. Semesters:** There are two semesters in a year. The semester that begins in July (July to December) is known as Odd semester and the semester that begins in January (January to June) is known as Even Semester. This includes examination and vacation for both the semesters.

II. Program Study:

Curriculum: Every department has a prescribed course structure, which in general terms is known as Curriculum/Course of Study/Program. It prescribes courses to be studied in each semester. This includes all the curricula and course contents. The medium of the instruction, examination, seminar and project work should be in English.

1. **Credit System:** In general a certain quantum of work measured in terms of credit is laid down as the requirement for a particular degree. The student acquires credits by passing courses every semester. There are mainly two types of courses: i) Laboratory courses consisting of theory and practical and ii) Non-laboratory courses consisting of only theory papers. The credit (C) for a course/paper is dependent on the number of hours of instruction per week in that program. Credits are assigned to practical training, seminar, workshop and projects also. The quanta of credits for such activities are stipulated by respective program committee of the department. It is mandatory that the HOD must seek the prior approval for the number of credits by the Board of Studies prior to the CBCS meeting.

2. Duration and Structure of the Program:

The minimum and maximum semesters for completion of a program are given below:

SI. No	Programs	No. of Se- mester	Maximum No. of Semester (to complete the Program)	Remarks			
1.	Full Time						
1.a	M.Sc.	4	6	mester/year with			
2.	Part - Time	90 working days in					
2.a	M.Sc.	8	11	each semester			

Structure and Duration of the PG Courses

The minimum number of credits to be enrolled for the successful completion of the 2 years PG programs is 76 and the maximum is 92.

3. Credit Assessment:

One credit is assigned for each lecture of one-hour duration per week (A 4 credit course will need 4 one hour lecture in one week). Two hours of practical session in a week is equal to one credit (i.e. 1 credit practical course will need 2 hours of practical). The minimum and maximum numbers of credits, a candidate has to be registered in a semester are given below;

SI. No.	Semester	Minimum Credits	Max Credits
1	First	22	26
2	Second	22	26
3	Third	18	26
4	Fourth	14	14
	Total	76	92

Credits

III. Registration:

- 1. **Registration Procedure:** The student is requested to register for opted courses/papers with the respective faculty, after due announcement of the prescribed dates and at the beginning/commencement of each semester. The HOD/concerned faculty member will inform the students the list of Core, Allied and Electives courses available for the students for registration. The procedure is as follows:
 - i. The registration of courses for the semester(s) other than the first semester shall be made at least one week prior to the end-semester examination of the previous semester.
 - ii. The details of the core, Allied and elective and the project shall be intimated to the students, two weeks prior to the date of registration.
 - iii. The registration form shall be filled in and signed by the student and the concerned teacher.
 - iv. A student may be granted permission to withdraw from a course earlier registered by him/her within two weeks (or in the event of absenting him-self/herself for more than two weeks) from the date of commencement of the semester.
 - v. A student who has withdrawn his/her registration for a specific course may register for that course again when the same course is offered by the concerned department, in subsequent semester.
- **2. Temporary withdrawal of registration:** A student may be permitted by the Dean of the faculty on the recommendation of the chairperson of the Program Committee and the concerned Head of the Department to temporarily withdraw from the program up to a maximum of two semesters for valid

grounds.

IV. Program Committee:

- 1. Every post graduate program shall have a Program Committee constituted by the HOD in consultation with all the Course Teachers of the corresponding program.
- 2. The composition of the Program Committee shall be as follows: Among the faculty member one will be the Chairperson; Teacher of all courses of the corresponding program; Student Adviser and two student representative of the program (one in I year and other in II year), nominated by the Head of the Department.
- 3. Duties of the Program Committee:
- i. Reviewing periodically the progress of the classes.
- ii. Discussing the problems concerning curricula, syllabi and the conduct of classes.
- iii. Providing consultation of the Course Teachers on the nature and scope of assessment for the course, this shall be announced, to the students at the beginning of respective semesters.
- iv. Communicating its recommendation to the Head of the Department on academic matters.
- v. The Program Committee shall meet at least thrice in a semester preferably at the end of each internal continuous assessment tests and before the final end semester exam.

V. Attendance:

- i. No candidate who has put in less than 75% of the full attendance for the course shall be permitted to take the semester examination of the concerned course.
- ii. On the day on which a course is concluded, the Course Teacher of the course shall intimate the Head of the Department, the particulars of total class hours, hours attended and percentage of attendance of all students, who have shortage of attendance in the course offered by him/her.
- iii. The Head of the Department shall announce the names of all students who will not be eligible to take the end semester examination in the various courses due to shortage of attendance.
- iv. Condonation of shortage of attendance will be permitted up to 10% after paying the prescribed fee as per the Deemed to be University norms.
- v. Students having less than 65% of the attendance are directed to re-register for the respective course again to compensate for the short-fall in attendance.

VI. Examination:

A. Continuous Internal Assessment (CIA)

- i. The Continuous Internal Assessments may be in the form of a combination of periodical tests, assignments seminar and % of attendance.
- ii. The assessment procedure to be followed for each course shall be approved by the Program Committee and announced to the students at the commencement of each semester by the Course Teacher.
- iii. Such schedule for continuous assessment procedure will be displayed on the notice board in the beginning of the semester.
- iv. The course teacher shall intimate the internal marks of the candidates and their attendance detail to the student through notice board.

v. The HOD will send the internal assessment marks together with attendance secured by each candidate and forward to Controller of Examinations office. Based on this detail and CBCS regulations, the Controller of Examinations will issue hall ticket (admit cards) for end semester examination, through HOD.

Examination	Assessment	%Marks
Test	Average of best two test performance	40
Assignment	Average of the two submitted	20
Seminar	Presentation on a given topic	20
Attendance		20

DETAILS OF SESSIONAL ASSESSMENT/INTERNAL ASSESSMENT (25 MARKS)

The question paper for the test, topic of the assignments and seminar will be assigned by the respective course teacher. All tests will be conducted only on prior notice in the respective departments. The exact date and timing will be announced by the HOD at the start of the semester. The internals for attendance is as follows:

75-85% of attendance	2 marks
85-90% of attendance	3 marks
90-95% of attendance	4 marks
95-100% of attendance	5 marks

B. End Semester Examination (ESE):

- 1. There shall be one end semester examination (ESE) of three hours duration on each lecture based course.
- 2. For practical examination, the duration shall be fixed minimum 3 hours and may be extended depends on the course.
- 3. The end semester examination is compulsory for all students and evaluated by the office of the Controller of Examinations following double evaluation system.

VII. Weightages:

1.	For lecture based courses (Non-laboratory)	
	Continuous internal assessment		25 %
	End – semester examination	-	75%
2.	For laboratory based courses / Practical		
	Sessional assessment	-	25%
	End – semester examination	-	75%
ТТ	Supplementary Examination		

VIII. Supplementary Examination:

- 1. Students who have missed CIA on valid reason(s) may apply for retests to the concerned Course Teacher specifying the reason for the absence and the Course Teacher shall conduct a retest when satisfied with the validity of the reasons given for the absence with proper documentation and with the approval of the HOD.
- 2. Students who have missed the end-semester written examinations on valid reason like hospitalization or accidents may make an application for supplement examination duly recommended by the HOD within five days from the date of examination missed. The same may be communicated to

the Controller of Examinations within 7 working days and the Controller of Examinations may conduct the supplementary examination within a month after paying the prescribed fee (need more discussion on this).

3. A candidate who has failed in one or more core subjects in the previous semesters should be cleared six month before i.e. on or before the 5th Semester.

IX. Course wise Grading of Students Letter Grades:

- 1. Based on the performance, each student shall be awarded a Final Letter Grade at the end of the semester in each course.
- 2. The letter grades and their corresponding grade points are as follows:

Grade Points	Lower Limit	Upper Limit	Range for P	Grade
6	50	59	50≥P<60	D
7	60	69	61≥P<70	С
8	70	79	71≥P<80	В
9	80	89	81≥P<90	А
10	90	99	91≥P<100	0

The Semester-end Grade Point Average (SGPA) and the Course-end Cumulative Grade Point Average (CGPA) are computed as follows:

The Grade Point in a said course may be calculated by using the formula

GP=CVxG, where CV is the Credit Value of the said course and G is Grade obtained Better to provide one example

The SGPA may be calculated as follows:

SGPA = Sum of all GPs in the said semester/Sum of Credits in the said semester. **The CGPA may be calculated as follows:**

CGPA = Sum of GPs in all the semesters/credits for the said program The CGPA may be expressed to an accuracy of three decimal digits The percentage equivalence may be obtained by multiplying CGPA by 10.

- 3. The above grading is done by Controller of Examinations office after taking into account both CIA marks together with end semester marks.
- 4. No student is considered to have completed a course successfully and earned the credits when he / she secure a Letter Grade of "NA" or "I".
- 5. A Letter Grade of "NA" in any course implies the incompletion of that course.
- 6. A course successfully completed can be repeated for the purpose of improving Cumulative Grade Point Average by re registration with prescribed fee.

X. Method of awarding letter grades:

- 1. In a reasonable time frame, the Controller of Examinations office will scrutinize the answer books by following "double valuation". Then the finalized marks (CIA+) are converted to the Letter Grades to be awarded to the students for different courses.
- 2. Three copies of the Grade Sheets containing the marks awarded with Letter Grades and the results in terms of pass or incompletion for each course shall be forwarded to the concerned department.

XI. Grade Card:

The grade card issued at the end of each semester to each student by the Control-

ler of Examinations Office shall contain the following:

- 1. The credits for each course registered for that semester.
- 2. The performance in each course shown by the letter grade obtained.
- 3. The Grade Point Average (GPA) of all the courses registered for the semester.
- 4. The Cumulative Grade Point Average (CGPA) of all the courses studied from the first to final semesters.
- 5. The maximum marks that can be obtained will be in direct proportion to the credit in the ratio of 25:1.
- 6. The total marks secured by the candidate for each of the courses in which the candidate appeared for the end semester examinations.
- 7. For the computation of cumulative grade point average (CGPA) a similar formula is used in which the sum is obtained by adding over all the courses taken in all the semesters completed up to the point in time and substituted in the formula used in the case of CGPA.
- 8. For both GPA and CGPA calculation, NA-Grade is also included but not I-Grade.

XII. Eligibility for the award of the Postgraduate Degree:

A student shall be declared to be eligible for the award of the Postgraduate Degree, when he/she has fulfilled the following conditions.

- 1. Registered for and undergone all the core and elective courses and completed the Project Work or Field Trip, if any as prescribed by the Scheme of Examinations. A student should enroll in a minimum of 76 credits and also attain the minimum pass parks in each of the enrolled subjects to be eligible for award of degree.
- 2. Successfully acquired the required credits under elective courses as specified in the curriculum of the Program within the stipulated time.
- 3. Has a CGPA of 5.0 or higher.
- 4. Have no dues to the Deemed to be University, Hostel and Library.
- 5. Has no disciplinary action pending against him/her.
- 6. Classification of the student for awarding the degree will be as follows:

SI. No.	CGPA	Grade Point	Classification
1	$8 \leq CGPA \geq 10$	10	First class with distinc- tion
2	6 ≤ CGPA < 8	8	First class
3	5 ≤ CGPA < 6	6	Second class

XIII. A. Procedure for award of mark:

The Controller of Examinations office is involved in valuation of answer scripts of various courses conducted as the end semester examination (75 marks). The answer scripts of different courses are subjected to double valuations. They are called as first and second valuation. Whenever the difference in marks between first and second valuation is within 20% marks, the average of the two marks will be taken as the mark secured and the results are **declared by the COE**. If the difference in mark is 20% and above, it will be referred to a third examiner and the third valuation will be compared with the nearest two other marks in arriving at the average mark.

B. Redressal on the award of the mark

- When a student is aggrieved with regard to the award of mark to course(s), he/she shall make a formal representation on the matter to the Controller of Examinations through the HOD in the prescribed form and fees within the stipulated time (7 working days after receiving the Marks Card).
- 2. The marks awarded for each answer will be re-totaled by a competent authority by the Controller of Examination office. The result of the re-totaled will be intimated to the candidate and HOD within 15 days.

XIV. Details of Sessional Assessment / Internal Assessment for Core, Allied, and Elective papers (For 25 Marks)

Examinations	Assessment				
Test	Average of best two test performance				
Assignment	Average of the two submitted				
Seminar	Average of best two presentation of a given topic				
Attendance	65-75% of attendance / semester 74-85% of attendance 86-90% of attendance 91-95% of attendance 96-100% of attendance	1 mark 2 marks 3 marks 4 marks 5 marks	05		

The question paper for the test, topic of the assignments and seminar will be assigned by the respective course teacher. All tests will be conducted only on prior notice in the respective departments. The exact date and timing will be announced by the HOD at the start of the semester.

XV. Question Paper Pattern (Core, Allied and Elective)

-		
Time: 3 Ho	urs	Maximum Marks: 75

PART A : (3 X 15 =45 Marks) Answer any THREE questions All questions carry equal marks	Brief note 1. Unit I 2. Unit II 3. Unit III 4. Unit IV 5. Unit V
PART B: (5 X 4 = 20 Marks) Answer ALL questions choosing either a or b All questions carry equal mark	Short answers 6. a or b Unit I 7. a or b Unit II 8. a or b Unit III 9. a or b Unit IV 10. a or b Unit V
PART C : (2 X 5 = 10 Marks) Answer ALL questions All questions carry equal marks	Long Answer 11.Unit I 12.Unit II 13.Unit III 14.Unit IV 15. Unit V

Department of Water and Health Faculty of Life Sciences

SEMESTER I							
	Heure (Deemed to be University Examination					
Paper	week	CIA	Theory/ Practical Exam	Max. Marks	Total Credit		
Core Paper 1	4	25	75	100	4		
Core Paper 2	4	25	75	100	4		
Core Paper 3	4	25	75	100	4		
Core Paper 4	4	25	75	100	4		
Elective Paper 1	4	25	75	100	4		
Practical 1	6	25	75	100	6		
Total Credits for I Semester					26		
SEMESTER II							
	Hours	Deemed to be University Examination					
Paper	week	CIA	Theory/ Practical Exam	Max. Marks	Total Credit		
Core Paper 5	4	25	75	100	4		
Core Paper 6	4	25	75	100	4		
Core Paper 7	4	25	75	100	4		

Postgraduate Examination Scheme (For all PG Courses)

Core Paper 8	4	25	75	100	4			
Elective Paper 2a OR Elective Paper 2b	4	25	75	100	4			
Practical 2	6	25	75	100	6			
Total	26							
SEMESTER III								
	Hours/ week	Deemed to be University Examination						
Paper		CIA	Theory/ Practical Exam	Max. Marks	Total Credit			
Core Paper 9	4	25	75	100	4			
Core Paper 10	4	25	75	100	4			
Core Paper 11	4	25	75	100	4			
Core Paper 12	4	25	75	100	4			
Elective Paper 3a OR Elective Paper 3b	4	25	75	100	4			
Practical 3	6	25	75	100	6			
Total Credits for III Semester					26			
SEMESTER IV								
Summer Internship * 2								
Thesis and viva voce examination12								
Total credits for IV semester14								
TOTAL SEMESTER CREDITS					92			

* Students participated in summer internship will be awarded 2 credits

MSC ENVIRONMENTAL SCIENCE

Overview of the course

Today best practice procedures in environment management are rapidly becoming international rather than national. Building on an unparalleled history of excellence in academic JSS AHER looks to provide in depth learning in environmental education, which will serve as a focus for research into local, regional and global environmental issues, management and policies in response to the urgent and increasingly complex challenges of the new century.

THE SIGNIFICANCE OF THE COURSE

The prudent management of our precious water resources, environment conservation, and sustainable development are high on the agenda of global concerns. Addressing these challenges requires professionals with a high degree of specialization and interdisciplinary approach. In order to develop improved systems and practices to preserve the most precious resource of our planet, there are a great demand fort rained people. In view of the huge focus and investment made by all nations on the water sector, there is a tremendous need for specially trained manpower for supporting the institution involved in the development and management of water, at both the grass roots levels and at the institutional level. Applying knowledge gained through environmental science is the only way to solve these problems so that the environment can be preserved. The rapid urbanization of the environment needs to be studied constantly in order to avoid altering and damaging the environment significantly. Ultimately, environmental science is necessary to save the environment from destruction and all of its dependents from extinction. M.Sc., environmental science at JSS AHER is intended for professional's practitioners, researchers and students from wide range of backgrounds who aim to develop their knowledge and insights pertaining to the environment. The course in designed to provide critical and practical skills to analyses, evaluate, design and implement solution and strategies with regards to water and health issues.

CAREER PROSPECTS

With increasing public concern about the environment, worlds of possibilities are available for graduates in terms of employment and research opportunities. Coupled with the growth of the global economy, the need for competent graduates with knowledge in environmental science is tremendous in the international arena as well. Careers in Environmental Science are so varied it is difficult to consider them as one category. Graduates of this program can gain employment with consulting firms, research bodies, government and non-government organizations as Environmental consultant, Environmental education officer. Environmental manager, Nature conservation officer, Recycling officer, Sustainability consultant, Waste management officer, Water quality scientist. As private companies and industries are emphasizing more on the science of sustainability, they are looking for a wide range of professionals to manage the process related to environment.

Curriculum Structure

	Semester I	Total Credits
Paper 1	Principles of Environmental Sciences	4
Paper 2	Environmental Microbiology and Biotechnology	4
Paper 3	Environmental Chemistry	4
Paper 4	Environmental Earth Science	4
Elective 1	Statistical Methods for Biology	4
Practical I	Environmental Biology, Chemistry & Earth Science	6
		26
	Semester II	
Paper 5	Environmental Toxicology	4
Paper 6	Remote Sensing & GIS	4
Paper 7	Water Resource and Ground Water Hydrology	4
Paper 8	Environmental Economics and Management	4
Elective 2	Bio-Energy Technologies OR Environmental Impact assessment	4
Practical II	Environmental Toxicology, Microbiology & Biotech- nology	6
		26
	Semester III	
Paper 9	Water and Wastewater Treatment Techniques	4
Paper 10	Waterborne Disease and Chemical Agents	4
Paper 11	Environmental Safety and Health Management	4
Paper 12	Environmental Pollution and Law	4
Elective 3	Environmental Nanoscience OR Water Resource Management and Sustainable Development	4
Practical III	Water Treatment Techniques, Waterborne Disease and Chemical Agents	6
		26
	Semester IV	
	Summer Project	2
	Field/Industrial Visit report and Viva	2
	Thesis and viva voce examination	10
		14
	Total Credits	92

PAPER 1: PRINCIPLES OF ENVIRONMENTAL SCIENCES 4 Credits

Course Objectives: This course introduces the students to the interdisciplinary nature of environmental studies. The students learn about biogeochemical cycles, ecology, biomes and habitat, and conversation biology.

Course Outcomes: At the end of the course, the students are able to appreciate the intricate nature of ecosystem and its role in maintenance of health earth.

Unit I: Definition, scope and interdisciplinary nature of environmental science, environmental factors: structure, composition of Atmosphere, Lithosphere, Biosphere and Hydrosphere.

Unit II: Biogeochemical Cycles of major environmental elements and significance: Carbon, Nitrogen, Phosphate, Sulphate, Hydrogen, Oxygen, Mode of energy transmission.

Unit III: Ecology: Definition, subdivision, ecosystem- Terrestrial, Aquatic, Grass, flow of energy, food chain, food web, tropic level, ecological pyramid, eco-tone, edge effect

Unit IV: Biomes and Habitat: Classification of biomes – Tundra, Taiga, Grassland, Desert, Evergreen and deciduous forests, Tropical rain forests and their characteristics, flora and fauna; Classification of Aquatic Habitats – Fresh water pond, Wetlands, Beels, Rivers – their characteristics, flora and fauna; Marine Habitats – Pelagic, Benthic, Inter-tidal Estuarine; Mangroves – their characteristics, flora and fauna

Unit V: Conservative biology: Biodiversity conservation, Wildlife management, Ex-situ and in-situ Conservation, Protected area networks in India, important projects, Role of local community in conservation, national conservation policies: National Forest policy, biodiversity Act, Wildlife protection Act. Concept of Endangered, endemic and extinct species, Red data Book.

- 1. Environmental Science The natural environment and human impact (2nd Edition) (2011): A. R. W. Jackson and J. M. Jackson, Longman
- 2. Environmental Science (2012): S. C. Santra, New Central Book Agency (P) Ltd
- Introduction to Environmental Science and Engineering (2nd Ed.) (2011):
 G. M. Masters, Pearson Education Pvt. Ltd.
- 4. Environmental Science (6th Edition) (2011): Jr. G. T. Miller, Wadsworth Pub. Co.
- 5. Fundamentals of Environmental Science (2004): G. S. Dhaliwal, G. S. Sangha and P. K. Raina, Kalyani Publication
- 6. General Climatology (4th Edition) (2010): Critichfield H. J.
- 7. Microbial Ecology (4th Edition) (2000): Atlast. R.M and Bartha, R., Addison Wesley Longman Inc.
- 8. Ecology Principles & Applications (2nd Edition) (2008): J. L. Chapman & M. J. Resis, Cambridge University Press.
- 9. Dimensions of Environmental and Ecological Economics (2009): N. C. Sahu & A. K. Choudhury (Ed), Universities Press

- 10.Fundamentals of Ecology (2009): Odum Eugene, Cengage Learning.
- 11.Cell Biology (2010) by Verma, P. S., Agarwal, V. K. S Chand and Company Ltd, New Delhi, India.
- 12. Evolution and Ecology (2010) by Verma. P. S., Agarwal V. K., S Chand and Company Ltd, New Delhi, India
- 13.A text book of Environmental Science (2012) by Vidya Thakur, Scientific publisher, India.
- 14. Aquatic Ecosystems (2009): Kumar, A P H Publishing Corporation, India
- 15. Microbiology Fundamentals and Application by Purohit, (6th Edition) (2010)

PAPER 2: ENVIRONMENTAL MICROBIOLOGY & BIOTECHNOLOGY 4 Credits

Course Objectives: This is an interdisciplinary course that focuses on the application of microbiology and biotechnology in environmental remediation. The student in the course study microorganisms, their classification, their interaction, significance.

Course Outcomes: Through this course, the students will have the basic knowledge in understanding the role of microbes in waste water treatment

Unit I: General Microbiology: Definition, history, scope of microbiology, and classification. Ultra-structure of prokaryotic and eukaryotic cell. Sterilization techniques used in microbiology, Preparation of media for isolation and culture of microorganisms. - Bacterial growth and multiplication of virus and fungi, MPN test, toxins, Role of microbes in nutrient cycles, microbial fuel cells, Pre-biotics and Pro-biotics.

Unit II: Microbial Interactions: Interactions among microorganisms: parasitism, predation, amensalism, competition, commensalism, and mutualism. Microbial interactions with plant, animal and human being. Microbial interaction in soil: Symbiotic N_2 fixation, De-nitrification, Mycorrhiza and its types.

Unit III: Applied microbiology: Control of pests and diseases by microorganisms, concept of bio-fertilizers, microbial degradation of pesticides, microbial enhanced oil recovery, microorganisms as bio-indicators (lichens as air pollution indictors), bio-mining (copper extraction) and bio-surfactants.

Unit IV: Environmental biotechnology: Biotechnology and environmental management, Bioremediation, types(in situ and ex-situ),advantages and disadvantages. Bioremediation of contaminated ground water. Phyto-remediation of soil metals and degradation of xenobiotics by microbes. Biotechnology and biodiversity conservation (gene banks and DNA banks etc,).

Unit V: Treatment of waste: Role of bio-filters in waste water treatment; role of plants (Phytotechnology) in waste water treatment; biological measure of water pollution; biotechnological approaches for solid waste management (composting process and techniques, vermin-composting).

- 1. Microbiology Fundamentals & Application (6th edition) (2010): S. S. Purohit, Student Edition.
- 2. Fermentation Microbiology and Biotechnology (3rd Edition) (2012). E . M. T. El. Mansi, C.F. A. Bryce, B. Dahhou, S. Sanchez, A. L. Demain, A. R. Allman, C R C press.

- 3. Environmental Microbiology (2014): P D Sharma.
- 4. Biology of Microorganisms (7th Ed.) (1994): Brock TD, Madigan MT, Martinko JM and Parker J Prentice Hall, New Jercy, USA.
- 5. Manual of Industrial Microbiology & Biotechnology (3rd Edition) (2010): Richard H. Baltz et al.,ASM press.
- 6. Microalgae: Biotechnology and Microbiology (1995), Cambridge University Press.
- 7. Text Book of Microbiology (7th Edition) (2005): Ananthanarayan and Paniker.
- 8. Raina M. Maier, Ian L. Pepper, Charles P. Gerba Science. Environmental Microbiology
- 9. Ehrlich HL (1996) Geomicrobiology, Marcel Dekker Inc., New York.
- 10.Eweis JB, Ergas SJ, Change DPY and Schroeder ED (1998) Bioremediation Principles, McGraw-Hill Inc., New York.
- 11.Joseph C Daniel (1999) Environment Aspects of Microbiology. 1st Edition, Bright Sun Publications, Chennai.
- 12.Pelczar MJ Jr., Chan ECS and Kreig NR (1993) Microbiology, Tata McGraw Hill, Delhi.
- 13.Reed G, Prescott and Dunn's (1987) Industrial Microbiology, 4th Edition, CBS Publishers.
- 14. Subba Rao N S (2004) Soil Microbiology. 4th Edition, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
- 15.A text book of Biotechnology (Revised edition) (1993): R.C Dubey, Chand Publication.

PAPER 3: ENVIRONMENTAL CHEMISTRY 4 Credits

Course Objectives: This course describes the chemistry of atmosphere, water bodies, soil, oxidation and reduction, fates of organic compounds in the environment. The student learns about the role of chemistry in understanding the atmosphere, water bodies and soil.

Course Outcomes: At the end of the course, the students will have an understanding on the chemistry of water bodies, greenhouse effects and soil chemistry

Unit I: Concept and scope of Environmental Chemistry, Basic Chemistry: organic compounds (Alkanes, Alkenes, Alkynes, Aldehydes, alcohols, Ketones), carboxylic acids, esters, Amines, aromatic carbons, Stoichiometry, Chemical Thermodynamics: Gibb's energy; chemical potential; Gibb's phase equilibria; equilibrium of chemical reactions; Chemical Kinetics: Simple reaction mechanisms; order of chemical reactions; law of mass action. **Unit II:** Atmospheric chemistry, Chemical composition of Air: Classification of elements, chemical speciation, Particles, ions and radicals in the atmosphere, Chemical processes for formation of inorganic and organic particulate matter, Thermochemical and photochemical reactions in the atmosphere, CFC's, Oxygen and Ozone chemistry, chemistry of air pollutants, photochemical smog.

Unit III: Water chemistry: properties of water, unusual physical properties, hydrogen bonding in biological systems, unusual solvent properties, changes in water properties by addition of solute, role of water in the environment, Acid-base reactions, solubility of gases in water, the carbonate system, radionuclides, concept of DO, BOD, COD, TOC in water, redox potential, Marine water systems.

Unit IV: Soil Chemistry: Formation, constituents and properties of soils, Sorption processes in the soil, ion exchange, and adsorption of contaminants in soil: Adsorption isotherms, Buffering capacity, Cation exchange, pH measurement, acidity and alkalinity, Redox properties of soil, Transport processes in the soil and importance.

Unit V: Instrumentation: Principle, merits and demerits of analytical techniques: Neutron activation analysis, Isotope dilution analysis, Calorimetric, Colorimetry, Atomic Absorption Spectroscopy, Gas Chromatography, HPLC, Ion Chromatography, XRF, XRD etc.,

- 1. Environmental Chemistry (5th Edition) (2003): A. K. De, New Age International
- 2. Environmental Chemistry (11th Edition) (2007): B K Sharma, Krishna Prakshan media
- 3. Environmental Chemistry (3rd Edition) (2011): Gay W Vanlon & Stephen J duffy. Oxford Publication.
- 4. Environmental Chemistry (5rd Edition) (2012): Colin & Michael Cann, W.H Freeman Publication.
- 5. Principles of Environmental Chemistry (2005): James Girard, John and Bratlett Learning.
- 6. Chemistry of the Environment (2002): Ronald Albert bailey, Academic Press
- 7. Industrial Chemistry (1991): B K Sharma, Krishna Prakshan media
- 8. A text book of Environmental Chemistry & Pollution Control (2006): S. S. Dara, S. Chand Limited.
- 9. Introduction to Instrumentation in Life Sciences (2013): Prakash Bisen & Anjana Sharma, CRC press.
- 10.A text book of Organic Chemistry (2008): P.S. Kalsi, Macmillan India limited.
- 11.A text book of Physical Chemistry (2nd Edition) (2007): A.S. Negi, New Age International.
- 12.Instrumentation (1st Edition) (2009): U. A. Bakshi & A.V. Bakshi, Technical Publications, Pune.

- 13.Environmental Soil Chemistry (2013): Donald L Sparks, Academic Press.
- 14.Environmental Chemistry A global perspective (3rd Edition) (2000): G. W. Vantoon & S. J. Duffy; Oxford university Press.
- 15.Soil and Water Chemistry. An Integrative Approach (2nd Edition) (2004): Michael. E. Essington, CRC press.

PAPER 4: ENVIRONMENTAL EARTH SCIENCE 4 Credits

Course Objectives: This introductory course exposes the students to geographical features of the earth. Through this course the students learn about the earth

materials, surface features, interior of earth, natural hazards, oceans and atmosphere.

Course Outcomes: The students inculcate sufficient knowledge in the student on role of environmental earth science.

Unit I: Earth Materials: Concept Mineral, Mineral reserves composition and physical properties of important minerals; properties and processes responsible for mineral concentrations. Distribution and exploration of minerals in different parts of India.

Unit II: Surface features and Processes: Physiography of the Earth; energy balance of the Earth's surface. Concept of Rock, Rock cycle and types of rocks. Process of soil formation. Weathering, erosion, transportation and deposition of Earth's material;

Unit III: Interior of the Earth, Origin of the earth and formation of core, mantle, crust, atmosphere and hydrosphere. Basic concepts of seismology. Earthquakes: causes and measurement, Interplate and intraplate seismicity, seismic properties of Earth's interior, Concepts of stress and strain, Behavior of rocks under stress; Folds, joints and faults, Paleomagnetism, sea floor spreading and plate tectonics.

Unit IV: Natural hazardous: Introduction to air pollutions. Global warming, climate change, Earth's processes: concepts of residence time and rate of natural cycles (elements in sea water). Catastrophic geological hazards, Study of floods, landslides, earthquakes, volcanism and avalanche, Perception of the hazards and adjustments to hazardous activities.

Unit V: Oceans and Atmosphere: Climate of India. Indian Monsoon, Tropical cyclones. Hypsography of the continents and ocean floor: continental shelf, slope, rise and abyssal plains, Physical and chemical properties of sea water and their spatial variations, Ocean currents, waves and tides, important current systems. Major water masses of the world's oceans.

- 1. Earth Science & the Environment (4th Edition) (2007): Thomson & Truck, Thomson Learning Inc.
- 2. Boundary layer climates (1978): T. R. Oke; Methuen & Co. Ltd
- 3. Introduction to Micrometeorology (1988): S. Pal Arya; Academic Press
- 4. General Meteorology (1974): H. R. Byers; McGraw-Hill
- 5. An Introduction to Climate (1968): G. T. Trewartha; McGraw-Hill
- 6. Environmental Geology (1987): K. S. Valdiya; Tata McGraw-Hill
- Atmospheric Science An introductory survey (1977): J. M. Wallace and P. V. Hobbs; Academic Press
- 8. Let's Review earth Science: The physical setting (3rd Edition) (2007): Edward J Denecke Jr., Barron's Educational Series, Inc.
- 9. Earth Science (Revised Edition) (2005): Maria Chona Sulti- Branganza, Phillipine copyright, Rex Book Store, Inc.
- 10. The Basics of Earth Sciences (2003): Robert E. Krebs, Greenwood Press.
- 11.Occean Acidification (Reprinted) (2012): Jean –Pierre Gattuso and Lina Hansoon, Oxford University press.
- 12.A text book of Geology (Reprint)(2004): P. C. Sanjeeva Rao & D. Bhaskar

Rao, Discovery Publishing House. Elective 1: Statistical Methods for Biology (Common paper) 4 Credits

(Biochemistry/ Molecular Biology/ Nanoscience & Technology/ Nutrition& Dietetics/ Geo- informatics/ Environmental Sciences/ Cognitive Neurosciences/Cosmetic Science)

Course Objectives: To train the students intensively in both theoretical and practical aspects of statistics, to bring them in contact with basic concepts and methods and to create a problem-solving attitude with the aid of statistical methodology.

Course Outcomes: It provides an introduction to selected important topics in Biostatistical concepts and reasoning. This course represents an introduction to the field of data and data types. The students learn specific topics including tools for describing central tendency and variability in data; methods for performing inference on population means and proportions via sample data; statistical hypothesis testing and its application to group comparisons; issues of power and sample size in study designs; random sample and other study types.

Unit I. Numerical Methods to Represent Variation:

Importance and Scope of Statistics, Data Types, Frequency Distribution, Graphical Representation Methods (Histogram, Bar Charts, Pie Charts), Measures of Center Tendency (Mean, Median, Mode,) and Dispersion (Standard Deviation, Variance) Advantages and Disadvantages, Co-Efficient of Variance.

Unit II. Probability:

Basic Terminology, Definition of Probability, Basic Laws of Probability, Types of Probability,

Additional Rule of Probability and Multiplication Rule of Probability, Probability Distribution-Bernoulli Distribution, Binomial Distribution, Poisson distribution and Normal Distribution-Simple Problems.

Unit III. Sampling Methods:

Collection of Data, Census Method, Concept of Population, Sample, Sampling, Sample Size, Sampling Error, Advantages and Disadvantages of Sampling Method, Necessity of Sampling, Types of Sampling Methods, Types of Random Sampling Methods – SRS, Stratified Random Sampling, Systematic Random Sampling and Cluster Sampling.

Unit IV. Testing of Hypotheses:

Statistical Hypotheses-Null and Alternative, Level of Significance, Type I and Type

II Error, Critical Region, Power of the Test, P Value, Degrees of Freedom, Chi-Square Test for Independence of Attributes and Goodness of Fit, Student's t Test: One Sample t Test and Paired t Test, F Test.

Unit V. Regression and Analysis Of Variance:

Simple Linear Regression, Multiple Linear Regression (Definition, Assumptions, Applications, and Examples), Analysis of Variance –Introduction, Definition of ANOVA, Assumption, Test of ANOVA, Types of ANOVA, Construction of One Way Analysis of Variance.

- 1. 1. Fundamentals of Biostatistics. Veer Bala Rastogi. Publisher: ANE Books. 2nd Edition, 2009.
- 2. 2. Fundamentals of Mathematical Statistics, S.C. Gupta and V. K. Kapoor, Publisher: Sultan Chand & Sons (2014).
- 3. 3. Fundamentals of Statistics. S.C. Gupta. Publisher: Himalaya Publishing House Pvt. Ltd.Edition.7th Edition, 2012
- 4. 4. Introductory Statistics for Biology. R. E. Parker. Publisher: Cambridge University Press 2nd Edition, 1991.
- 5. 5. Statistics for behavioural science. Chintamani Kar. Publisher: Dominant Publishers & Distributors (P) Ltd. (2015).

PRACTICAL I: ENVIRONMENTAL MICROBIOLOGY& BIOTECHNOLOGY, CHEMISTRY and EARTH SCIENCE 6 Credits

Environmental Microbiology

Apparatus used for a microbiological laboratory; Sterilization and Disinfections; Media preparation: semi-synthetic, synthetic media and semisolid; culture media – Nutrient agar; Enrichment media preparation; Gram staining. Safety in microbiological laboratory. Bacteriology of drinking water and domestic sewage -MPN techniques for total coliform; fecal coliform (thermos-tolerant coliform) MPN test; Fecal Streptococci (FS) MPN test; Membrane filtration techniques for fecal coliform and total coliform; P-A coliform test; Seven hour – coliform test.

Environmental Biotechnology

Plasmid DNA isolation and DNA quantitation: Plasmid mini preparations Agarose gel Electrophoresis - Microorganisms from polluted environment/Soil /Water/Air -Microbial degradation of textile dyes/pesticides/hydrocarbons and oils. Techniques for collection, Cultivation and analysis of protein present in Azolla and Spirulina -Vermicomposting: Collection, preparation and analysis of composted material for NPK, moisture holding and microbial load

Environmental Chemistry: The experiments are related to -

- 1. Analysis of water and effluent Physical parameters, Chemical parameters, Nutrient parameters and Bacterial parameters.
- 2. Volumetric analysis of water and soil samples by EDTA titration.
- 3. Turbidimetric experiment Estimation of sulphates
- 4. Potentiometric experiments Estimation of halides in water samples
- 5. Colorimetric experiments Estimation of Fe2+, Fe3+ and Ni2+
- 6. Estimation of alkali metals in various samples by flame-photometry
- 7. Analysis of soils for NPK, Na, Ca.

Environmental Earth Science: The experiments are be related to -

- 1. Familiarization with meteorological instruments and their use
- 2. Studies related to upper air and surface weather including coding and decoding of Meteorological parameters
- 3. Presentation and interpretation of wind data (wind rose)
- 4. Studies of thin sections of selective igneous, metamorphic and igneous rocks
- 5. Study of geological maps and drawing of sections across geological structures
- 6. Determination of Soil Texture
- 7. Use of survey instruments theodolite, dumpy level and plane table
- 8. Field study to a local environmentally important area

II SEMESTER

PAPER 5: ENVIRONMENTAL TOXICOLOGY 4 Credits

Course Objectives: This course is designed to impart the basics in toxicological aspects that effect the environment. The students learn about toxicology, chemical carcinogenesis, epidemiology and environmental health.

Course Outcomes: The outcome of this course is to provide the necessary knowl-

edge to the students to understand the basic toxicological aspects.

Unit I: Introduction to toxicology, scope of toxicology subspecialties of toxicology, description and terminology, factors influencing toxicity, drug toxicity, Biochemical basis of toxicity: mechanism of toxicity and receptor mediated events, acute and chronic toxicity, Selective toxicity, Dose response curves, threshold limit value, LC50 & LD50, Margin of safety and toxicity curves.

Unit II: Bioaccumulation and Bio-magnifications of toxic materials in food chain, Toxicology of major pesticides-Environmental impacts of pesticides, biotransformation, biomonitoring, programs and parameters of biomonitoring, concept of bio-indictor, bio-indicator groups and examples, Basic concepts of environmental forensics.

Unit III: Concepts of Bioassay: types, characteristics, importance and significance of bioassay, field based microbial bioassay for toxicity testing, Bioassay test models and classification. Immunotoxicity, histotoxicity, cell toxicity, Bio-sensors and Bio-markers: Concept and approach, advantages and disadvantages,

Unit IV: Toxicity Testing and Indicators: Principles of toxicity testing, Methods of toxicity evaluation at cellular and molecular level by in-vitro and in-vivo methods, Lacustrine communities as indicators of ecosystem stress, Bacterial, algal and in-vertebrate micro bio tests, Model ecosystems- microcosms and macrocosms.

Unit V: Occupational Hazards and Safety: Environmental and occupational safety: definitions, concept and scope, Occupational exposure, Occupational hazards and diseases, Control of toxic materials and protection measures, Toxicity of biohazards, Toxicity of air, water and soil.

- 1. Environmental biology and Toxicology, by Sharma P.D. Rastogi and Lamprey. 1994.
- 2. Environmental pollution and Toxicology by Meera Asthana and Astana D.K., Alka printers, 1990.
- 3. Toxicology, by A.Sood, Sarup and sons New Delhi, 1999
- 4. Text book of Preventive and Social Medicine, by Park J.E. and Park K., Banosidas Bharat Publishers, Jabalpur, 1985
- 5. Environmental Epidemiology, by Anisa Basheer, Rawat Publication Jaipur, New Delhi 1995.
- 6. Toxicology, Biochemistry and Pathology of Mycotoxins, by Kenji Uroguchi a mikio, Yamazadi Kodanshoa Ltd., Tokyo, 1978.
- 7. Environmental Toxicology Current Developments (2005): J. Rose, Taylor & Francis library.
- 8. Principles of Environmental Toxicology (2002): Ian. C. Shaw and John Chadwick, Taylor & Francis library.
- 9. Introduction to Environmental Toxicology- Wayne .G. Landis, Ming Ho Yu, 3rd Ed. (2002) Lewis Publishers, CRC press , NY
- 10.Ecotoxicology, Schuurmann, G., and Market, G., (1998), A. John Wiley & Sons, In.
- 11.Hand book of Environmental Risk Assessment and Management, Peter Callow (1998), Blackwell Science, London.
- 12.Information Resources in Toxicology: Wexler, Philip et al, 2000. 3rd ed. Academic press, 2000.

- 13.Environmental Toxicology-Biological and Health effects of Pollutants. Ming Ho Yu, Humio Tsunado and Masashi Tsunoda. CRC press. 3rd Edn. (2011).
- 14.Essentials of Toxicology Klassen CD, Watkn J.B (2003) 3rd Ed., Mc Grew Hill, New York
- 15.Environmental Toxicology and Chemistry. Crosby, Donald. G. 1998. Oxford University Press.

PAPER 6: REMOTE SENSING & GIS 4 Credits

Course Objectives: This fundamental course gives the foundation and application for remote sensing. Students are taught about history of remote sensing, the systems, the technical aspects involved in the use of satellite data, its storage, editing, data analyzing and applications.

Course Outcomes: By the end of this course, the student is able to infer satellite related data, and would be well versed in the technical aspect behind GIS and its application through GPS.

Unit I: Principles of Remote Sensing: Concepts of Remote Sensing, Physics of remote sensing, effects of atmosphere, Principle of scanner and CCD array, Spectral reflectance of earth's surface features in different wavelength region of electromagnetic spectrum: spectral characteristics of surface features (rocks, soils, vegetation's, water).

Unit II: Space Imaging: Landsat, SPOT, IRS, NOAA, RADARSAT, INSAT satellites and their sensors, Orbital characteristics, Data products. Thermal remote sensing: Basic principles, characteristics of image and their uses. Applications of Remote Sensing in environmental monitoring: Land use mapping, forest survey in environment.

Unit III: Microwave remote sensing: Basic definitions and principles, RADAR, SLAR, SAR; General characteristics, spectral resolution and interpretation. Digital Image Processing: Principles, Image Rectification, Image enhancement and Mosaicking. Image classification, Supervised, Unsupervised, Ground truth data and training set manipulation.

Unit IV: Aerial Photography: Fundamentals of photogrammetry, areal cameras, planning of aerial photography, principle of stereo photography, parallax and measurement of height & slope Elements of image interpretation, convergence and evidence, interpretation keys; Interpretation of photographs and images for environmental analysis **Unit V:** Geographical Information System (GIS): Basic principles, Raster and vector data, Map projection, Topology creation, Overlay analysis, Data structure and Digital cartography

Global Positioning System (GPS): Basic principles, Applications to environmental studies

- 1. Basics of Remote Sensing & GIS (2005): Dr. S. Kumar
- 2. Essentials of GPS (2004): N. K. Agarwal; Spatial Networks Pvt. Ltd., Hyderabad

- 3. Environmental Modelling with GIS and Remote Sensing (2002): Andrew K Skidmore, Taylor & Francis.
- 4. GIS and Remote Sensing Techniques (2009): Manishika Jain, Himansu Publications.
- 5. GIS A visual Approach (2nd Edition) (2001): Brus E Davis, Onword Press.
- 6. Arc Hydro GIS for Water resources (2002): David R Maidment, ESRI press.
- 7. Remote Sensing of the Environment An earth resource perspective: J. R. Jensen; Pearson Education
- 8. Geographic Information Systems: Martin, Routledge
- 9. An Introduction to GIS: Heywood, Pearson
- 10.Remote S sensing in Land Evaluation: Yadav; Rajesh Pub

PAPER 7: WATER RESOURCE & GROUND WATER HYDROLOGY 4 Credits

Course Objectives: The objective of the course is to introduce water resources, the concept of hydrology and its role in environment. The students learn about precipitation, ground water hydrology, water resource management and rain harvesting techniques.

Course Outcomes: By the end of the course, the student is well versed in the understanding of ground water resources and its management.

Unit I: Water Resources: Introduction of water resources, Water resource type: surface water, ground water, hydrological cycle; Causes of water resource depletion, Water Resource Management: Watershed management: Concept, and objectives, flood control; Wetlands: definition, importance and classification.

Unit II: Reservoir Capacity & Yield, Flow-Duration Curve, Reservoir Operation, Reservoir Planning, Reservoir Sediment Distribution, Flood Routing, Inter-Basin River Water, Transfers and interlinking rivers, Conjunctive Water-Use Planning.

Unit III: Groundwater Hydrology, Occurrence of groundwater, Ground water zones, The Water Table, ground water flow, Topography, Ground water depletion, Ground water Quality, Ground water pollution, Saltwater Intrusion,

Unit IV: Water bearing materials, aquifer types & Hydraulic properties of aquifers, Laws of groundwater movement & well hydraulics, Use of tracer techniques in groundwater hydrology: types of tracers

Unit V: Analysis of Test pumping data, well drilling, development & design, Methods of groundwater recharge, Groundwater Assessment & Balancing, Planning for regional groundwater development and case study.

- 1. Water Resource Engineering (2nd Edition) (2011): Larry W.Mays, John Wiley and Sons, Inc.
- 2. Water Resources (2010): Shimon C Anisfeld, Island Press.
- 3. Water resource engineering: Principle & Practice (2009): Satya N Challa Murthy, New Age International Publisher.
- 4. Principles of Water Resources: History, Development, Management, and Policy (3rd Edition) (2010): Thomas V Cech, John Wiley and Sons, Inc.
- 5. Hydrology & Water Resource Engineering (2014): S. K. Garg, Khanna Publishers, Delhi

- 6. Water Supply Engineering, Vol.1 (25th Edition) (2014): S. K. Garg, Khanna Publishers, Delhi
- 7. Engineering Hydrology (2nd Edition) (2008): Jayaram Reddy, Laxmi publications Pvt. Ltd., New Delhi
- 8. Hydrology and Water Resource Engineering (5th Edition) (2000): R.K.Sharma & T.K. Sharma, Dhanapati Rai Publications.
- 9. Engineering Hydrology (3rd Edition) (2008): K Subramanya, Tata Mc GrawHill Publishing Company Ltd., New Delhi.
- 10.Physico Chemical Process for Water quality (1st Edition) (1974): Weber. W.J, Ann Arbor, John Wiley and Sons, Inc.
- 11.Applied Ground Water Hydrology and Well Hydraullics (2nd Edition) (2001): Michael Kasenow, Water Resource Publication, and LLC.
- 12.Groundwater (1979): Freeze, R.A. & Cherry, J., Prentice Hall Inc.
- 13. Analysis & Evaluation of Pumping Test Data (1991): Kruseman, G.P. and Deridder, N.A., ILRI Publication No. 47. The Netherlands.
- 14.Groundwater Hydrology (1980): Todd, D.K, John Wiley and Sons, Inc.
- 15. Water resource System (1st Edition) (2013): Sanjay Gupta, Vayu Education of India.

PAPER 8: ENVIRONMENTAL ECONOMICS AND MANAGEMENT 4 Credits

Course Objectives: This interdisciplinary course brings together environmental science, economics and management aspects. The students learn about environmental economics, resource management, and environment management.

Course Outcomes: By the end of the course, the student is able to appreciate the value of economics and management In understanding the environment.

Unit I: Environmental Economics: Concept of ecological economics; environmental economics and principles; cost-benefits analysis; instrument for Environmental Control: Marginal Costs and Benefits (waste disposal cost), Regulatory Policy, Economic Incentives (price rationing, quality rationing, liability rule), the economics of environmental quality; economic valuation of environmental services; trade and environment; externalities, Biophysical limits to economic growth: the Malthusian, neoclassical, ecological economic perspectives

Unit II: Resource Conservation and Management: Ecosystem structure, Materials recycling, Succession, equilibrium, stability, resilience and complexity, Concept of resources; resource taxonomy; exhaustive resources and renewable and recyclable resources; resource management, conservation principle, The laws of matter and energy (laws of thermodynamics), and ways; conservation strategies, The Law of diminishing returns, Carrying capacity, Net present Value, Trade-offs **Unit III:** Environmental management fundamentals and goals: Approaches to environmental management; Sustainable development, Environmental management challenges, Environmentalism, ecologist and the Green Movement, Social aspects of resource use and total economic value, environmental ethics, Global environmental problems and economics, Environmental accounts, environmental trade and importance

Unit IV: Environmental management systems: Environmental system principles: Polluter pays principle, User pays principle (or resource pricing principle), Precautionary principle, Subsidiary principle, Intergenerational equity principle; Tools:

Standards, monitoring, modeling, eco-auditing and management strategies; different Environmental management systems; perspectives of environmental management policy in India, ISO Systems & certification procedure

Unit V: Approaches adopted to promote environmental management in business: Industrial ecology, Ecological engineering, Pigouvian taxes, Green marketing, Consumer protection bodies, Eco-labelling, Total quality management, Covenants, Life-cycle assessment, Greenwashing, Green energy and technology, International law and sovereignty issues, International conferences (Stockholm) and agreements; Participatory environmental management: education and awareness, Facilitators, International bodies and NGOs

Reference Books:

- 1. Environmental Economics (2nd edition) (2010) : Charles D Kolstad, Oxford Press.
- Natural Resources & Environmental Economics (4th Edition) (2011): Roger Perman, Yue Ma, and Michael Common, David Maddison, James Mcgilvray, Addison Wiley & Sons.
- 3. Uberoi, N K 1999 Environmental Management, New Delhi Publ. Excel Books
- 4. Modern Urban and Regional Economics (2013): Phillip Mc Cann, Oxford Publisher.
- 5. The Earthscan reader in Environmental economics, Markandya, A. 1992
- 6. Intermediate Environmental Economics (2nd Edition) (2012): Charles D Kolstad, Oxford Press.
- Environmental Economics: An Indian Perspective (Illustrated Edition) (2001): Rabindra N Bhattacharya, New Delhi, and New York Oxford University Press.
- 8. Environmental Management (2009): T.V Ramchandra & Vijay Kulkarni, Energy & resource Institute.
- 9. Environmental Management for Sustainable Development (2nd Edition) (2006): C. J Barrow, Taylor & Francis group.
- 10.Environmental Management Systems and Certification (2006): Phillip Weib & Jorg Bentlage, Batlic University Press.
- 11.Sustainable Development & Environmental Management Experiences and Case studies (2008): Corrado Clini, Ignazio Musu, Maria Lodovica Gullino, Springer.
- 12.Environmental Economics Theory & Applications (2007): Kathar Singh, Sage India.
- 13. A Text Book of Environmental Economics (2008): K.V Pavithran, New Age International limited Publisher.
- 14.Environmental Economics: Theory, Management & Policy (2009) (2nd Edition): M. L. Jingan and C.K Sharma.

ELECTIVE 2.1- ENVIRONMENTAL IMPACT ASSESSMENT 4 Credits

Course Objectives: The students learn the components of EIA, Legal and regulatory aspects in India, Trends in Quality Control practices.

Course Outcomes: At the end of the course, through case studies, the students are trained in the EIA for various development projects.

Unit I: Introduction: Environmental Impact Assessment (EIA) - Environmental

Impact Statement (EIS)-Environmental Risk Assessment (ERA) - Legal and Regulatory aspects in India - Types and limitations of EIA - Terms of Reference in EIA-Issues in EIA - national - cross sectoral – social and cultural.

Unit II: Components and Methods: Components - screening - setting - analysis -prediction of impacts - mitigation. Matrices - Networks - Checklists. Importance assessment techniques - cost benefit analysis - analysis of alternatives - methods for Prediction and assessment of impacts - air - water - soil - noise - biological - cultural - social - economic environments. Standards and guidelines for evaluation. Public Participation in environmental decision making.

Unit III: Quality Control: Trends in EIA practice and evaluation criteria - capacity building for quality assurance. Expert System in EIA -use of regulations and AQM

Unit IV: Documentation and Monitoring: Document planning - collection and organization of relevant information - use of visual display materials – team writing - reminder checklists. Environmental monitoring - guidelines - policies - planning of monitoring programs. Environmental Management Plan. Post project audit.

Unit V: Case Studies: Any Case studies of EIA of developmental projects.

- 1. Canter, L.W., "Environmental Impact Assessment", McGraw Hill, New York, 1996.
- 2. Environmental Impact Statements, Bregman, J. I., (1999) Lewis Publishers, London.
- 3. Environmental Assessment, Singleton R, Castle, P and Sort, D (1999), Thomas Telford Publishing, London.
- 4. Effective Environmental Assessment, Eccleston, C. H., (2000) Lewis Publishers, London.
- 5. Environmental Impact Assessment- A Comprehensive Guide to Project and Strategic Planning, Eccleston, C.H., (2000) John Wiley and Sons.
- 6. Environmental Management, N.K. Uberoi (2009), Excel Books, New Delhi, India.
- 7. ISO 14000 Environmental Management, David L Goetsch and Stanley B David (2001), Prentice hall Inc., New Jersey, USA.
- 8. Terms of Reference for EIA report for activities/ Projects requiring Environmental Clearance (2009), Administrative Staff College of India, Hyderabad.
- 9. Environmental Impact Assessment for Science, Art, Management and other Post graduate courses(2007), Manual Published by Indian Institute of Technology, Rookie, India
- 10. Guidelines to project proponents for preparation of EIA report (2010), Manual Published by State Level Expert Appraisal Committee, Gujarat, India.
- 11.Environmental Life Cycle Analysis, David F Camborne (1997), Lewis Publishers, New York, USA.
- 12.Environmental Management an Indian Perspective, S.N. Chary and Vinod Vyasulu (2000), Macmillan India Limited, New Delhi, India.
- 13. Energy technology and Directions for the Future, John R Fanchi (2004), Elsevier Academic Press, Burlington, MA, USA.
- 14.Environmental Politics and Policy, Walter A Rosenbaum (1991), Affiliated East West Press Pvt. Ltd., New Delhi, India.

15.Environmental Impact Assessment for Science, Art, Management and other Post graduate Courses (2007), Manual Published by Indian Institute of Technology, Rookie, India

ELECTIVE 2.2- BIO-ENERGY TECHNOLOGIES 4 Credits

Course Objectives: This course highlights biomass, biogas, pyrolysis, and waste characteristics.

Course Outcomes: By the end of the course the student understands biogas production from waste, characteristics of biomass fuel and importance of biodiesel.

Unit I. Energy resources, renewable energy (solar, wind, water, tidal, geothermal, ocean thermal etc.,); nonrenewable (coal, petroleum, natural gas and nuclear energy). Energy issues and problems.

Unit II. Biomass definition, photosynthesis and biomass, biomass types, composition and analysis of biomass (heating value, ultimate and proximate analyses). Modes of biomass utilization for energy, biomass conversion processes, sewage sludge and its utilization.

Unit III. Biogas, biogas production, types of substrates, operational Problems, biogas process, types of biogas plants, use of biogas and dig estate, advantages and limitations of biogas. Ethanol production processes, biodiesel Preparation and its applications.

Unit IV. Biomass combustion systems and wood stoves, Densification and its techniques, Pyrolysis, Slow and fast pyrolysis, Biomass gasification, Type of Gasifiers, fluidized bed combustion systems, , application of biomass combustion system.

Unit V. Waste and its characteristics, waste generation, composition, collection, separation, treatment and storage, Environmental and health impacts of waste, solid waste management, waste disposal methods: sanitary landfill, incineration, composting, policy and economics of waste. Energy from sewage treatment.

Reference Books

1. Charles.Y. Wereko-Brobby and Essel B. Hagan (1996), Biomass Conversion

and Technology, JohnWiley & Sons.

- 2. T.B. Reed (1988), Biomass Gasification, Noyes Data Corporation.
- 3. D.D. Hall and R.P. Grover (1987), Biomass Renewable Energy, John Wiley, New York.
- 4. Gerhard Knothe, Jon Van Gerpen and Jurgen Krahl (2005). The Biodiesel Handbook.
- 5. Bioenergy Options for a Cleaner Environment: in Developed and Developing (2004) Ralph E.H. Sims, Elsevier.
- 6. Sustainable Bioenergy Production An Integrated Approach (2013). Hans Ruppert, Martin Kappas, Jens, Springer.
- 7. Anaerobic Biotechnology for Bioenergy Production Principles and Applications (2011): Samir Khanal, Wiley Publishing.
- 8. Bioenergy Economy: A Methodological Study on Bioenergy-Based Therapies (2010): Farzad Goli, Xilbris Corporation.
- 9. Bioenergy: Opportunities and Challenges (2015): R. Navanietha Krishnaraj, Jong-Sung Yu, CRC Press
- 10.Bio-energy for Rural Energisation (1997): R. C. Maheshwari, Pradeep Chaturvedi, Concept Publishing Company.
- 11.Bioenergy and Biofuel from Biowastes and Biomass (2010): Samir K. Khanal, Rao Y. Surampalli, Tian C. Zhang, Buddhi P. Lamsal, R. D. Tyagi, C. M. Kao American Society of Civil Engineers, Technology & Engineering .
- 12.Energy Security and Development: The Global Context and Indian Perspectives (2015): B. Sudhakara Reddy, Sergio Ulgiati, And Springer.
- 13.Green Technology: Earth-friendly Innovations (2008): Geeta Sobha, read how you want.
- 14.Green Technology: An A-to-Z Guide (2011): Dustin Mulvaney, Sage Publication
- 15.Green Investing: The Case of India (2015): Gagari Chakrabarti, Chitrakalpa Sen, And Springer.

PRACTICAL II: ENVIRONMENTAL TOXICOLOGY, REMOTE SENSING AND GIS APPLICATIONS 6 Credits

Environmental Toxicology

Plant Bioassays: Estimation of protein content of biological samples – Pesticides and Metal Tolerance- microbes and Plant Bioassays - Estimation of heavy metals in soil, plant and animal materials, Animal Bioassays: *In-vitro* and *In-vivo* Cell toxicity Assays- Cell viability and Cytotoxicity - Toxicity assays – Nematodes / Earthworms - Animal Bioassays – Fish LC50, Micronucleus assay, Comet assay, Melanophore Index - Determination of Animal LD50, Probit Analysis and Graphical method.

SEMESTER III PAPER 9: WATER AND WASTE WATER TREATMENT TECHNIQUES 4 Credits

Course Objectives: The purpose of this course is to introduce the concept of water and waste water treatment techniques. The students learn about water resources, water treatment methods, waste water treatment and techniques for water treatment.

Course Outcomes: At the end of the course, the student is well aware on the principles involved in proper treatment of both water and waste water.

Unit I: Physico-chemical Treatment: Methods of water treatment, Optimized design, plant control and operational variables, Flow measurement and significance, Principles of preliminary treatment process of water & wastewater: Physical treatments-screening, grit removal; Chemical treatments- coagulation, flocculation, and sedimentation.

Unit II: Biological Treatment: Principle of biological treatment, microbial growth and their kinetics for substrate removal, Aerobic Process: Activated sludge, Oxidation ponds, Trickling filter, Towers, Rotating discs and Rotating drums, Oxidation ditch; Anaerobic Process: Anaerobic digestion, Anaerobic filters, Up flow anaerobic sludge blanket reactors (UASB), Bioreactors for wastewater treatments: Reactor types and design

Unit III: Advance Treatment: ultra-filtration, Disinfections (UV, Ozonization), water softening, Demineralization, Reverse osmosis, Color & odor removal by activated carbon, Dissolved air flotation (DAF), Iron removal.

Unit IV: Application of Nanotechnology: Applications and emerging opportunities, Nanofibers and Nanobiocides, Nanozymes for Biofilm Removal, Nanofiltration and nanomembranes, Nanomaterials and nanocatalyst in water and waste water treatment applications, Potential Risks of using nanotechnology in water treatment.

Unit V: Industrial waste water treatment: Selection of appropriate unit operations for the treatment and flow chart of wastewater treatment plant for Dairy and food, Pulp & Paper, Electroplating, Textile, Distillery

- 1. Water and waste Engineering, Vol. I and II, Fair, G.M. Geyer T.C. and Okun. D.A. (1984): John Wiley and Sons.
- 2. Waste water treatment processes, Metcalf and Eddy Inc. Academic Press, New York. (2003 & 1979)
- 3. Standard Methods for Examination of Water and Waste Water American Public Health Association (5th Ed) (1980)
- 4. Water and waste water Engineering, Vol. I and II, Fair, G.M. Geyer T.C. and Okun. D.A. (1984): John Wiley and Sons.
- 5. WastewaterTreatment Plants: Planning, Design & Operation (2nd Edition) (1999): Syed R Qasim, CRC Press.
- 6. Wastewater Treatment (3rd Edition) (2002): M Henze, Springer.
- 7. Water & Wastewater Treatment- A guide for non eng. Professional (2001): Jonnae E Drinan, CRC Press.
- Wastewater Treatment- Advanced Processesd & Technologies (2013): D.G. Rao, R. Senthil Kumar, J Anthony Byrne, S. Feroz, IWA Publishing, CRC Press.
- 9. Industrial Wastewater Treatment (Eastern Economy Edition) (2008): A.D Patwardhan, Prentice hall of India Private Limited.
- 10. Wastewater Microbiology (3rd Edition) (2005): Cabriel Bitton, John Wiley & Sons.
- 11.Physical Chemical Treatment of Water & Wastewater (2003): Arcadio P Sincero & Gregoria A Sincero, IWA Publishing, CRC Press.
- 12.Waste water Engineering (2 Edition) (2005): B.C. Punmia, Ashok Jain, Laxmi publications Ltd.

- 13.Advances in Membrane Technology for Water Treatment (2015): Angelo Basile, Alfredo Cassano, Navin K Rastog, Elsevier Limited.
- 14.Nanotechnology for Water Treatment & Purification (2014): Anming Hu & allen Apblett, Springer International Publishing.
- 15. Green Nanotechnology (2011) : Geoffrey B. Smith, Claes-Goran S. Granqvis, CRC Press.

PAPER 10: WATER BORNE DISEASES AND CHEMICAL AGENTS 4 Credits

Course Objectives: This course introduces the students to the effect of microbes and chemical agents in spread of disease through water bodies.

Course Outcomes: At the end of the course, the students have a clear understanding on the role of water bodies in spreading diseases through microorganisms and chemical agents.

Unit I: Introduction, Waterborne diseases caused by pathogenic microorganisms, Epidemiology: Amoebiasis, Cryptosporidiosis, Giardiasis, Microsporidiosis, Schistosomiasis, Dracunculiasis, Fasciolopsiasis, Ascariasis, Botulism, Cholera, *E. coli* Infection, *M. marinum*infection, Salmonellosis, Typhoid fever, SARS, Hepatitis A, Poliomyelitis, Polyomavirus infection, Desmodesmus infection.

Unit II: Human health impact of chemical agents: trace metals (fluoride, lead, cadmium and mercury), Acrylamide, Benzene, dichloroethane, vinyl chloride, Pesticides (Organophosphates, Carbamates, Paraquat and Endosulfan) and disease Epidemiology.

Unit III: Fate, Transport and effects of Contaminants: physical transport of chemical agents in surface and ground water, chemical concentration, Air-water exchange, contaminants in sediments.

Unit IV: Water Safety in Distribution Systems: Types of Water Transmission, Components of Water Transmission, Identify hazards and hazardous events and assess the risks, Microbial hazards, Chemical hazards (Disinfection by-products, Chemicals from pipe materials and fittings, Water treatment chemicals), Physical hazards, Water quality integrity.

Unit V: Risk assessment in water distribution systems (Semi-quantitative risk assessment, Quantitative microbial risk assessment) Validate control measures, Drinking-water Quality standards and Guidelines, Standard operating and management procedures, surveillance, audits and inspections, Capacity building. **Reference Books:**

1. Waterborne disease: Epidemiology and ecology: Paul R. Hunter 1997. Chichester John Wiley and Sons Ltd.

- 2. Water Safety in Distribution Systems, WHO, Geneva, Switzerland.
- 3. WHO (2001) Sustainable Development and Healthy Environments. Sanitation on Ships. Compendium of outbreaks of foodborne and waterborne disease and Legionnaires' disease associated with ships, 1970-2000.
- 4. Water borne Diseases- Epiddemiology & Ecology (1997): Paul R Hunter, Wiley and Sons Ltd.
- 5. Microbiology of Water Borne Diseases Microbiological aspects and risks

(2014): Steven L. Percival, Marylynn V. Yates, David Williams, Rachel Chalmers, Nicholas Gray, Elsevier Ltd.

- 6. Water Borne Pathogens (2Edition) AWWA Manual 2006.
- 7. Microbial Water Pathogens (2004): T. E. Cloete, J Rose, N, H. Neil, T Ford, IWA Publishing.
- 8. Water Borne diseases in India (2007): Atanu Sarkar, Srikanth K Panigrahi, Manak Publications.
- 9. Perspectives in Environmental Health (2005): Vector & Water borne Diseases: Amit Krishna De, Aniruddha Mukhopadhyay.
- 10.Water & Human Health (1983):Frederick Eugene McJunkin, Development Information Center.
- 11.Water no longer taken for granted (2007): Sandra M Alters, Thomson/ Gale.
- 12.Reviews of Environmental Contamination & Toxicology (2013): David M. Whitacre, Springer.
- 13.Water & Sanitation Related Diseases and the Environment (2011): Janine M. H. Selendy, Wiley and Sons Ltd.
- 14.Vector Borne Diseases in India: Environmental Health & Policy perspectives (2007) : Atanu Sarkar, Srikanth K Panigrahi, Manak Publications.
- 15. Flood Hazards & Health (2006): Roger Few, Franziska Matthies, Earthscan.

PAPER 11: ENVIRONMENTAL SAFETY AND HEALTH MANAGEMENT 4 Credits

Course Objectives: This interdisciplinary course highlights the importance of safety and management of environment and health. The students learn about OSHA, safe working environment, Govt. regulations required in workplace.

Course Outcomes: At the end of the course, the students can demonstrate an understanding on the importance, management of safety aspects in work environment.

Unit I: Introduction, importance of environmental safety in industry, Occupational Health Hazards, Promoting Safety, Safety and Health training, role of safety department, Safety committee and Function, Concept and Significance of ISO standards and internal auditing, Industrial Pollution, Accident and Environmental Damage

Unit II: Concept of work safety and health, development and accident prevention: accident, workplace injuries and damage, work environment; Occupational: Characteristics of Occupational Illness, Human Resources Important to Occupational Health Practice, Ethical Considerations; Risk assessment: Risk Assessment Basics, Exposure Assessment, Dose–Response Assessment, Comparative Risk Analysis, Risk Communication.

Unit III: Occupational Health: The causes of work related ill health and the steps to control and prevent it, The appropriate measures to control the hazards associated with work related ill health including: (a) Noise, (b) Repetitive strain injury (RSI), (c) Display screen equipment (DSE), (d) Viral and bacterial infections, e.g. legionnaires disease, hepatitis B. (e) Stress.

Unit IV: General Working Environment: Basics of health and safety at workplace:
(a) Workstations, (b) Room dimensions and space, (c) Floors & Gangways, (d) Stairways, (e) Lighting, (f) Temperature, (g) Ventilation, (h) Housekeeping –Safe storage, Falling objects, (j) Toilets and Washing Facilities, (j) Smoking, (k) Welfare provision, (l) Personal hygiene, (m) First Aid provision, (n) Rest Areas, The importance of safety signs and their usage, Principles of accidents prevention & First aid, application of computer, multimedia, communication, Plant layout for safety,

Unit V: Bureau of Indian standards on safety and health 14489 - 1998 and 15001 - 2000 OSHA, Process Safety Management (PSM) as per OSHA, PSM principles, OHSAS – 18001, EPA Standards, Performance measurements to determine effectiveness of PSM, health, safety and environmental management system.

Reference Books:

- 1. Fundamental principles of occupational health and safety (2008) : Benjamin O. Alli, International Labor Office
- 2. Introduction to Occupational Health in Public Health Practice (2009): Bernard J. Healey, Kenneth T. Walker, Wiley & sons Ltd.
- 3. Technical & Ethical Guidelines for Worker's Health Surveillance: International Labour office, 1998.
- 4. Handbook of Occupational Safety and Health (1999): Louis J. Diberardinis, Wiley & sons Ltd.
- 5. Chemical Process Industry Safety (2014): K.S.N.Raju, Tata Mc Graw Hill Publication.
- 6. Safety & Health Essentials –OSHA Compliance for Small Businesses (2001): William Martin, James Walters, Elsevier.
- 7. Environmental Hazards: Assessing Risk and Reducing Disaster (6TH Edition) (2013): Keith Smith, David N. Petley, and Routledge.
- Physical and Biological Hazards of the work place (2 Edition Illustrated) (2002) : Peter H. Wald, Gregg M. Stave Proctor and Hughes, Wiley & Sons Ltd.
- 9. Chemical Hazards of the Workplace (5th Edition) (2004): Gloria J. Hathaway, Nick H. Proctor, James P. Hughes, Wiley & Sons Ltd.
- 10.Disaster Management future challenges and Opportunities (2007): Jagbir Sing, I.K. International.
- 11.Industrial Safety & Health (1 Edition) (2006): Amit Kumar Gupta, Laxmi Publication Ltd.
- 12.Practical Industrial Safety, Risk Assessment and Shutdown Systems (2004) : Dave Macdonald, IDC Technologies
- 13.Industrial Safety & health Management (6th Edition) (2010): C. Ray Asfahl, David W. Rieske, and Prentice Hall.
- 14. Industrial Hazards & Plant Safety (2002): Sanjoy Banerjee, CRC Press.
- 15.Industrial Safety Management (2005): L M Deshmuk, Tata Mc Graw Hill Publication.

PAPER 12: ENVIRONMENTAL POLLUTION & LAW 4 Credits

Course Objectives: The students in this course learn about the various kinds of pollution that occur in the environment and the laws associated with these. They learn about air, water and soil pollution, climate change and health and environment, government policies on minimizing pollution.

Course Outcomes: Through this course, the students learn the importance of environment and methods to minimize the pollution. This course prepares the stu-

dents to be responsible citizens.

Unit I. Pollution: Noise Pollution: Types, sources, noise exposure levels and standards, consequences, prevention and control of noise pollution. Noise Pollution (Regulation and Control) Rules, 2000.

Radio-active Pollution: Radiation, types, sources, biological effects and control measures. The atomic energy (Radiation Protection) Rules, 2004.

Thermal Pollution: Definition, sources and consequences, pollution control measurement.

Unit II. Solid-waste: Concept of waste, types, of solid waste, composition of waste, effects of solid wastes. Solid waste management: *solid waste disposal methods:* sanitary landfill, composting and incineration. Concept of reduce, reuse and recycle. The Hazardous Wastes Rules, 2008 and MSW (Management and Handling) Rules, 2000.

Unit III. Air Pollution: Concept of air pollution, sources, types of air pollutants, air quality standards, air pollution indices, effects of air pollution on organisms, materials and environment. Formation of smog, acid rain, ozone layer depletion and climate change. Indoor air pollution. Pollution control by technological (catalytic converters, scrubbers, electrostatic precipitators, cyclonic separators, settling chambers) and legislation aspects (The Air (Prevention and Control of Pollution) Act 1981.

Unit IV. Water Pollution: Types (ground water, surface water and marine water), sources (point and non-point source),types of water pollutants and consequences (eutrophication, bio-magnification), water quality standards, pollution control by technological approach and legislation aspects (The Water (Prevention and Control of Pollution) Act, 1974).

Soil Pollution: Sources, consequences, pollution control measures and soil reclamation and soil erosion.

Unit V. Environmental laws and policies in India: Introduction, importance, Constitutional and statutory laws in India: Environmental (protection) Act, and rules (1986), The Forest (conservation) Act, 1980, Wildlife protection Act, 1972, The National Environment Tribunal Act, 1995, The Public Liability Insurance Act, 1991, Role of CPCB and SPCB in pollution control, Ministry of environment and Forest, Environmental Clearance (EIA notification 2006), National Green Tribunal and international environmental laws.

- 1. Environmental radioactivity (1997): M. Eisendbud, Academic press.
- Energy, Waste and the Environment: A Geochemical Perspective (2004): R. Gieré, Peter Stille, Geological Society of London
- 3. Understanding Environmental Pollution(3rd Edition) (2010) : Marquita K. Hill, Cambridge University
- 4. Air Pollution: Health And Environmental Impacts (2010): Bhola R. Gurjar, Luisa T. Molina, C.S. P. Ojha, CRC Press.
- 5. Air Pollution (26th Reprint) (2007) : M N Rao & H V N Rao, Tata Mc Graw Hill Publication.
- 6. Environment Pollution & Management (2003): A. Kumar, C Bohra. L.K. Singh, APH Publishing Corporation.
- 7. Environmental Pollution Monitoring and Control (2004):S. M. Khopkar, New

Age International Publisher.

- 8. Handbook of Environmental Law (2009): P.B Sahasranaman, Oxford University Press.
- 9. Water Pollution: Causes, Effects and Control (2006): P. K. Goel, New Age International Publisher.
- 10.Water Pollution (2009): A. K. Tripathi, S. N. Pandey, APH Publishing Corporation.
- 11.Soil Pollution & Soil Organics (2008): P.C.Mishra, APH Publishing Corporation.
- 12.Soil Pollution Origin, Monitoring & Remediation (2004): Ibrahim Mirsal, Springer.
- 13.Noise Pollution (2009) : S.K Agarwal, APH Publishing Corporation.
- 14.Constitution of India [Referred articles from Part-III, Part-IV and Part-IV-A].
- 15. Ministry of Forest and Environment, Government of India.

PRACTICAL III: WATER AND WASTEWATER TREATMENT TECHNIQUES, WATERBORNE DISEASES AND CHEMICAL AGENTS 6 Credits

- Determination of Chlorine demand, free residual chlorine,
- Na and K in Sewage sample and wastewater and natural water.
- Determination of chloride, acidity and alkalinity of raw sewage, wastewater and natural water,
- Determination of Ts, TSS, TDS in water and wastewater,
- Determination of COD and BOD,
- Jar test, Estimation of Total Coliform.
- Culture techniques for the detection of microorganisms
- Molecular techniques for the detection of microorganisms
- Epidemiology water borne diseases.

ELECTIVE 3.1: ENVIRONMENTAL NANOSCIENCE 4 Credits

Course Objectives: This course describes both the advantages and disadvantages of nano products to the environment.

Course Outcomes: By the end of the course, the students have an appreciation for the benefits of nanotechnology in improving the environment. After the successful completion of this course, the student will be able to: 1. Understand the basic and essential elements of battery materials 2. Explain the mechanism of harnessing solar energy. 3. Discuss the fabrication of solar cell structures. 4. Define and design how hydrogen energy can be stored 5. Describe the working principle of various fuel cells and model it. 6. Analyze the safety and precautionary issues in handling nanomaterials

Unit I. Environmental pollution: Environmental fate and transport of Nanomaterials, physical-chemical interactions, aggregation and deposition, definition of air pollution, water pollution and ground pollution, contribution of nanoparticles in aggravating pollution.

Unit II. Nanotoxicology: Exposure and risk assessment, dose-response, mechanisms of toxicity, definition of eco-toxicity, routes of entry of nanomaterials into the environment, cytotoxicity of nanomaterials.

Unit III. Health effects of nanoparticles: Sources of nanoparticles, epidemiological evidence, entry routes into the human body – Lung, Intestinal Tract, Skin, effect of nanoparticle size and charge, effects of nanoparticles on - cardiovascular, liver and gastrointestinal and nervous system, coagulation and thrombosis, bloodbrain barrier. Impact of CNT's on respiratory systems.

Unit IV. Environmental application of nanomaterials: Environmental Remediation, nanoparticles reactivity, fate, and lifetimes in the subsurface, ground water remediation with nanoparticles, nanomaterials for water and wastewater treatment.

Unit V. Nanotechnology for controlling air pollution: Nanomaterials for sensing toxic gases. Gas sensing materials and devices. Techniques used for gas

sensing (resistance, capacitance and electrochemical), Sensor properties, advantages of nanomaterials, synthesis and characterization of nano-metal oxides (tin oxide, zinc oxide, indium oxide), mixed oxides, nanoscale materials for sensors (quantum dots, CNTs, nanotubes, wires and belts), colloidal silver and gold, magnetic nanoparticles, application of nanomaterials in sensors, CNT-based sensors, Graphene-based sensors, active devices based on Nanostructures. Remediation and monitoring.

Reference Books:

- 1. Environmental Biotechnology, Alan Scragg, Pearson Education Limited, England, 2007, ISSN: 0199228612, 9780199228614.
- 2. Environmental Biotechnology, S.N. Jogdand, Himalaya Publishing House, Bombay, 2006.
- 3. Wastewater Engineering Treatment, Disposal and Reuse, Metcalf and Eddy, Inc., Tata Mc Graw Hill, New Delhi, 2013, ISSN: 0073401188, 9780073401188.
- 4. Environmental chemistry, A.K. De, Wiley Eastern Ltd, New Delhi, 2009, ISSN: 8122426174, 9788122426175.
- 5. Introduction to Bio-deterioration, D. Allsopp, C. Gaylarde and K.J. Seal, ELBS/Edward Arnold, 2004, ISSN: 0-521-821355, 0521528879.
- 6. Biotechnology for Wastewater Treatment, P Nicholas Cheremisin, Elsevier Science, 2013, ISSN: 0080946453, 9780080946450
- 7. Biotechnological Methods of Pollution Control, SA Abbasi and E Ramaswami,Universities Press, India, 1999, ISSN: 8173710988.
- 8. Environmental Biotechnology, Concepts and Applications, Hans-Joachin Jordening and Josef Winter, Winter-VCH, 2005, ISSN: 3-527-30585-8.

Elective 3.2: WATER RESOURCE MANAGEMENT AND SUSTAINABLE DEVELOPMENT 4 Credits

Course Objectives: In this course, the students study about water as a resource and its management. The course also covers aspects of water resources, its economic view and its role in food production.

Course Outcomes: At the end of the course, the students have a clear under-

standing on the water resources and methodology in the effective management.

Unit I: Water as a global issue: key challenges and needs – concept of Integrated water resources management (IWRM) within the broader context of development – Complexity of the IWRM process – Examining the key elements of IWRM process.

Unit II: Economic view of water issues: economic characteristics of water good and services, Non-market monetary valuation methods, Water economic instruments, policy options for water conservation and sustainable use: Case studies. Pricing: distinction between values and charges – Private sector involvement in water resources management (PPP): objectives, options, processes, experiences through case studies, Links between PPP and IWRM.

Unit III: Water for food production: 'blue' versus 'green' water debate, Virtual water trade for achieving global water security, Irrigation efficiencies, irrigation methods and current water pricing. Irrigation: Water User's Association, Types and Levels of Operation and Organization in irrigation System, User roles in irrigation Management, Role of Community Organizer. The context of Participation.

Unit IV: Remote Sensing and GIS for Water Resources: Spatial data sources – 4M GIS approach water resources system – Thematic maps, Rainfall and runoff modeling, Groundwater modeling, Water quality modeling, Flood inundation mapping and Modelling, Drought monitoring, Cropping pattern change analysis, Performance evaluation of irrigation commands. Site selection for artificial recharge -Reservoir sedimentation.

Unit V: Water Legal and Regulatory Settings: Basic notion of law and governance: principles of international and national law in the area of water management. River water disputes, integrated river basin development.

Reference Books:

- Technical Advisory Committee, Integrated Water Resources management, Technical Advisory Committee Background Paper No: 4. Global water partnership, Stockholm, Sweden. 2002.
- Technical Advisory Committee, Regulation and Private Participation in Water and Sanitation section, Technical Advisory Committee Background paper No:1. Global water partnership, Stockholm, Sweden, 1998.
- Mollinga. P. et al "Integrated Water Resources Management", Water in South Asia Volume I, Sage Publications, 2006.
- Water Resource Engineering (2nd Edition) (2011): Larry W.Mays, John Wiley and Sons, Inc.
- Water Resources (2010): Shimon C Anisfeld, Island Press.

SEMESTER IV Project Work 12 Credits

Summer Internship – 2 Credits MSc dissertation – 12 Credits

MSc Cognitive Neuroscience

Overview of the Program

This course will be a broad overview of current research and methods in the field of developmental cognitive neuroscience. The course will start with a basic overview of organization of the nervous system and functional organization of brain from cognitive perspective. Also the neural mechanisms involved in the development of memory, language, spatial cognition, object perception, executive functions, and attention would be studied. The method researchers use to study developmental cognitive science, including metabolic measures, electrophysiological techniques (including biofeedback, neurofeedback, EEG and ERPS) would be discussed in detail. An emphasis is also laid on the computational intelligence and its relation to cognitive science.

The course work also focuses on the socio-cognitive components of decision-making etc. A separate paper is dedicated to consciousness studies involving the like spirituality in relation to cognition. The students are required to submit a dissertation thesis in the last semester on any of the topics related to cognitive science. The aim is to provide students experience in research design, data analysis and interpretation. Cognition is the process by which one acquires processes, stores and acts on information from the environment. Cognitive Science: It is the study of relationships among the integration of cognitive psychology, biology, anthropology, computer science, linguistics, philosophy, and mathematics.

The subject matter has its roots in different basic disciplines like: Philosophy of Mind: The subject matter that deals with the structure of mind and relationship of

mind and body. Neuroscience: A science that establishes link between brain functions and behavior. Computational Intelligence: The subject matter that aims to understanding intelligent agent in computational terms.

Language: It is the main tool through which our thoughts get expressed and modes of reasoning become manifest. Culture: A cognitive account assumes that some trends in culture results from universal properties of human mind

Eligibility: A graduate in Medicine/Ayurveda/Homeopathy/Nursing/BPT/B.Sc. Speech and Hearing Science/BCA/B.Tech/BA Psychology, from a recognized University. Students who have not studied biological sciences may take an add on course in biological science/physiological psychology/mathematics to facilitate the learning for the courses related to Neuro Sciences and students from the science stream may take an add on consciousness studies/psychology.

	Semester I	Remarks
Paper 1	Developmental Cognitive Science	4
Paper 2	Principles of Neuro Science	4
Paper 3	Mathematical Models of Cognitive Science	4
Paper 4	Research Methods	4
Elective 1	Statistical Methods for Biology	4
Practical 1	Practical 1	6
		26
	Semester II	
Paper 5	Social Cognition and Culture.	4
Paper 6	Neuro Basis of Cognitive Science.	4
Paper 7	Computational Intelligence.	4
Paper 8	Philosophy of Mind	4
Practical 2	Practical 2	6
		22
	Semester III	
Paper 9	Consciousness Studies	4
Paper 10	Cognitive Neuro psychological Rehabilitation.	4
Elective 2	Research Methods	4
Elective 3	Psychometrics	4
Practical 3	Practical 3	6
		22
	Semester IV	
	Summer Project	2
	Thesis and viva voce examination	12
		14
	Total Credits	84

Course Curriculum

SEMESTER I

PAPER 1: DEVELOPMENTAL COGNITIVE SCIENCE 4 CREDITS

Course Objectives: The course helps the students to understand the principles of cognitive neuroscience. It enables them to learn the development of perception, spatial recognition, memory, speech, decision making and reasoning. The student builds up practical knowledge on applications of cognitive psychology in improving memory processes.

Course Outcomes: On successful completion of this program, a student will gain in depth understanding of the key theoretical and practical issues about typical and atypical development in children and young people from a cognitive neuroscience perspective. The students will also gain knowledge of how questions about developmental changes in children's cognitive abilities can be addressed using scientific methods. The students will also gain knowledge in conducting high quality original research in developmental cognitive sciences.

Unit I: Introduction to Cognitive Science: Organization of Nervous system: Cognition in the Brain. Sensation & representation. Principles of Cognitive Neuroscience.

Unit II: Development of perception: Theoretical approaches to perception, Deficits in perception. Attention and consciousness. Development of Object Recognition /Understanding, Development of Face Recognition. Development of Spatial cognition and Cognitive Map.

Unit III: Memory: Models of memory, Processes, Development of Explicit Memory and Implicit memory, Practical Applications of Cognitive Psychology in improving memory processes.

Unit IV: Development of Speech and Language: Understanding spoken language: Speech perception, constituent structure, transformational grammar and factors affecting comprehension. Selecting the content of speech, speech errors, gestures, social context of speech. Nature and Acquisition of language; Bilingualism and Multilingualism, Neuropsychology of Language. Reading: Bottom -up and Top - down processes, Reading and writing skills.

Unit V: Decision-making and reasoning: Deductive reasoning and inductive reasoning. Problem-solving and Creativity.

- 1. Matlin, M. (1994). Cognition. Prism Indian Books
- Solso, R. L. (2004). Cognitive Psychology (6th ed). Delhi: Pearson Education.
- 3. Sternberg, R.J. (2007). Cognitive Psychology. Australia: Thomson Wadsworth.

PAPER 2: PRINCIPLES OF NEUROSCIENCE 4 CREDITS

Course Objectives: This paper enables the students to learn anatomical and physiological aspects of brain. The students will also appreciate the biochemical aspects of the nervous system and learn to identify the metabolic defects. At the end the students will learn to correlate all the neurological functions at molecular level.

Course Outcomes: On successful completion of Neuroscience program, students will:

- Demonstrate knowledge of, and recognize the relationships between, the structure and function of molecules and tissues involved in neurobiological systems at all levels: molecular, cellular, and organismal.
- Recognize the impact that science has on culture, and vice versa.
- Perform basic laboratory techniques used in neuroscience research and understand and apply principles of laboratory safety.
- Locate and retrieve scientific information and read, understand, and critically evaluate primary literature.
- Prepare oral and written reports in a standard scientific format.
- Apply the scientific process, including designing, conducting, and evaluating experiments and testing of hypotheses.
- Use mathematics and statistics to evaluate scientific evidence and interpret graphs and tables.
- Recognize that all areas of science are integrated and interconnected.
- Appreciate scientific knowledge as something that is not static, but constantly expanding through the ongoing work of researchers.
- Value ethical conduct in science.
- Recognize that the best decision-making and policies are based on evidence.

Unit I: Anatomy of the Brain: Major anatomical sub-divisions of the human brain, the surfaces anatomy and interior structure of cortical regions. Anatomical connectivity among the various regions. The blood supply to brain and the CSF system, cyto- architecture and modular organization in the brain. Neuronal Signaling: The membrane property and ion channels of neurons for electrical signaling, action potential, the role of synapses and neurotransmitters in inter neuronal communication. Recording the nerve action potential.

Unit II: Biochemistry of Central Nervous System: Biochemical constituents of Brain; Brain function and importance of Glucose; Metabolic aspects of Central Nervous System; Biochemical aspects of Metabolic defects. Neural Transmission: Neurotransmitters and Neuromodulators including Neuropeptides; Pharmaco-chemical aspects of Neurotransmitters; Neurotransmitter dysfunction in behavioral disorders.

Unit III: Concept of Inheritance: Structure and Function of Chromosomes; Genetics aspects of major psychoses; Genetic abnormalities in Mental Retardation; Genetic Counselling.

Unit IV: Neurobiology of Sensory and Motor Systems: The organization of sensory system in terms of receptors, relay neurons, Thalamus and cortical processing of different sensations. Principle motor mechanisms of the periphery (muscle spindle), Thalamus, basal ganglia, brain stem, cerebellum and cerebral cortex.

Neurobiology of Drives and Motivation: Mechanisms of Aggression, Hunger, Thirst and Sex

Unit V: Regulation of Internal Environment: Role of limbic, autonomic and the neuroendocrine system in regulating the internal environment. Reticular formation and other important neural substrates regulating the state of sleep/wakefulness. State of consciousness/ brain death.

Reference Books

- 1. Singh, V. (2004). Textbook of Clinical Neuroanatomy. Elsevier.
- 2. Shepherd, G.M. (1983). Neurobiology. Oxford University Press.

PAPER 3: MATHEMATICAL MODELS OF COGNITIVE SCIENCE 4 CREDITS

Course Objectives: The paper enables the students to get trained in understanding the philosophy. The student gets trained in Analogy and conceptual systems.

Course Outcomes: Students are expected to learn knowledge to a modeling theu ory of cognition in science and mathematics.

Unit I. Philosophy of Mathematics: Philosophical issues about or related to mathematics, including the existence and nature of basic mathematical objects such as numbers and sets, how we can come to have knowledge of such objects, the status of mathematical truth, the relation of mathematics to logic, and whether classical logic can be called into question.

Unit II. Cognitive Science of Mathematics: Empirical investigation of the nature of mathematics. How the human mind/brain creates abstract concepts, such as infinity, infinitesimals, imaginary numbers, or zero: embodiment, creativity, and history. Cognitive approaches that connect mathematics to human thought in general.

Unit III: Cognitive Foundations of Mathematics: Nature of mathematics as an empirical question subject to methodological investigations of an interdisciplinary nature, involving hypothesis testing and appropriate theoretical interpretations. Mathematics as a unique type of human conceptual system, which is sustained by specific neural activity and bodily functions; Cognitive mechanisms that make human imagination, abstraction, and notation-making processes possible.

Unit IV: Analogy and Conceptual Systems: Human thought and meaning are deeply tied to the capacity for mapping conceptual domains onto each other, including common schemas and performing mental simulation. The course examines major aspects of this cognitive activity including metaphor, conceptual blending and embodied cognition

Unit V: Logic: Introduction to the aims and techniques of formal logic. The logic of truth functions and quantifiers. The concepts of validity and truth and their relation to formal deduction. Applications of logic and the place of logic in philosophy. The central results of modern logic: the completeness of predicate logic, recursive functions, the incompleteness of arithmetic, the un-provability of consistency, the indefinability of truth. **Reference Books**

- 1. Russell, B. (1919). Introduction to Mathematical Philosophy. George Allen & Unwin, Ltd.
- 2. Thagard, P. (1996). Mind: An introduction to cognitive science, PHI.

PAPER 4: RESEARCH METHODS IN COGNITIVE SCIENCE 4 CREDITS

Course Objectives: This paper trains the students in designing and analyzing the experiments pertaining to human cognition with special emphasis on neuro-psychological assessment. The students also learn the Brain imaging techniques, methods of recording and analyzing human movements. They are also trained in computational models of cognitive processes.

Course Outcomes: At the end of the course the students develop skills in designing their experiments for assessing

Unit I. Design and Analysis of Experiments: Introduction to mathematical foundations of probability and statistical decision theory. Decision theory is applied to the problem of designing and analyzing experiments.

Unit II. Research Designs: Issues in design, implementation and evaluation of research in cognitive science. Surveys a variety of theoretical and methodological approaches to the study of human cognition. Topics include language structure, language processing, concepts and categories, knowledge representation, analogy and metaphor, reasoning, planning and action, problem solving, learning and expertise and emotion.

Unit III. Neurophysiology: Neuropsychological approaches to understanding human cognition neuropsychological assessment techniques; measurement and interpretation of Event Related Potentials (ERPs).

Unit IV. Brain Imaging: Brain imaging techniques such as MRI; experimental methods; methods in sleep research; methods in the recording and analysis of human movement.

Unit V: Introduction to programming: Algorithms, computational models of cognitive processes, applications of computational models, from cognitive psychology to neuropsychology. Examination of the structure and function of parallel - distributed processing models.

- 1. Kerlinger. (1964). Foundations of Behavioral Research.
- 2. Rohrbaugh, J W. (1990). Event Related brain potentials Basic issues & applications, Oxford University Press: NY.

Elective 1: Statistical Methods for Biology (Common paper) 4 Credits

(Biochemistry/ Molecular Biology/ Nanoscience & Technology/ Nutrition& Dietetics/ Geo- informatics/ Environmental Sciences/ Cognitive Neurosciences/Cosmetic Science)

Course Objectives: To train the students intensively in both theoretical and practical aspects of statistics, to bring them in contact with basic concepts and methods and to create a problem-solving attitude with the aid of statistical methodology.

Course Outcomes: It provides an introduction to selected important topics in Biostatistical concepts and reasoning. This course represents an introduction to the field of data and data types. The students learn specific topics including tools for describing central tendency and variability in data; methods for performing inference on population means and proportions via sample data; statistical hypothesis testing and its application to group comparisons; issues of power and sample size in study designs; random sample and other study types

Unit I. Numerical Methods to Represent Variation:

Importance and Scope of Statistics, Data Types, Frequency Distribution, Graphical Representation Methods (Histogram, Bar Charts, Pie Charts), Measures of Center Tendency (Mean, Median, Mode,) and Dispersion (Standard Deviation, Variance) Advantages and Disadvantages, Co-Efficient of Variance.

Unit II. Probability:

Basic Terminology, Definition of Probability, Basic Laws of Probability, Types of Probability,

Additional Rule of Probability and Multiplication Rule of Probability, Probability Distribution-Bernoulli Distribution, Binomial Distribution, Poisson distribution and Normal Distribution-Simple Problems.

Unit III. Sampling Methods:

Collection of Data, Census Method, Concept of Population, Sample, Sampling, Sample Size, Sampling Error, Advantages and Disadvantages of Sampling Method, Necessity of Sampling, Types of Sampling Methods, Types of Random Sampling Methods – SRS, Stratified Random Sampling, Systematic Random Sampling and Cluster Sampling.

Unit IV. Testing of Hypotheses:

Statistical Hypotheses-Null and Alternative, Level of Significance, Type I and Type II Error, Critical Region, Power of the Test, P Value, Degrees of Freedom, Chi-Square Test for Independence of Attributes and Goodness of Fit, Student's t Test: One Sample t Test and Paired t Test, F Test.

Unit V. Regression and Analysis Of Variance:

Simple Linear Regression, Multiple Linear Regression (Definition, Assumptions, Applications, and Examples), Analysis of Variance –Introduction, Definition of ANOVA, Assumption, Test of ANOVA, Types of ANOVA, Construction of One Way Analysis of Variance.

- 1. Fundamentals of Biostatistics. Veer Bala Rastogi. Publisher: ANE Books. 2nd Edition, 2009.
- 2. Fundamentals of Mathematical Statistics, S.C. Gupta and V. K. Kapoor, Publisher: Sultan Chand & Sons (2014).
- 3. Fundamentals of Statistics. S.C. Gupta. Publisher: Himalaya Publishing House Pvt. Ltd. 7th Edition, 2012
- 4. Introductory Statistics for Biology. R. E. Parker. Publisher: Cambridge University Press 2nd Edition, 1991.
- 5. Statistics for behavioral science. Chintamani Kar. Publisher: Dominant Publishers & Distributors (P) Ltd. (2015).

SEMESTER II PAPER 5: SOCIAL COGNITION 4 CREDITS

Course Objectives: The students in this course understand the concepts of social reality and social cognition across the cultures. The students are trained to design experiments in attitude research, models of social cognition, judgment, and decision making.

Course Outcomes: At the end, the student will appreciate the science and research methodology behind studying the importance of social cognition and the factors influencing it.

Unit I: Understanding Individuals and Groups: Construction of social reality: sense of self, others and groups. Attention, encoding, memory organization and retrieval of social information. Social categorization: Activation and application of social cognition. Person identification, trait inferences, stereotyping, prejudice, social projection. Social cognition across cultures

Unit II: Current Issues in Attitude Research: Attitude formation. Experimental designs in attitude research. Techniques to measure explicit and implicit attitude. Theoretical controversies in attitude research. Attitude change

Unit III: Social Cognition: Affect and Motivation-current states and goals affect the construction of social reality - experiments designs in social cognition, affect and motivation-theoretical issues in motivation and social cognition, affect and motivation - theoretical issues in motivation and social cognition how the social reality impacts basic processes

Unit IV. Judgment and Decision: Judgment and decision making. Normative and descriptive models of judgments and choice. the axioms of probability, Bayesian networks, decision theory and game theory. probability biases and choice anomalies. Current psychological models of judgment and choice including heuristics and biases; prospect theory; decision field theory; sampling approaches and rational analysis models. The implications of this research for practical decision making, and the use of decision aids.

Unit V. Culture and Cognition: Evolutionary and cognitive perspective of culture. Culture, symbols, and social interaction. Identity construction: individual and collective; class, gender, race, and religion; object, place, and event. Ancestry and descent; marked and unmarked identities; lifestyles, commuters, and integrators;

the cognitive politics of identity. Belief systems: ideology, religion, science; interaction between believing and belonging.

Reference Books:

- 1. Augoustinos, M. (1996). Social Cognition. Sage Publication.
- 2. Myers, D. (2010). Social Psychology. McGraw-Hill.
- 3. Hewstone, M. (1989). Causal attribution: From cognitive processes to collective beliefs.
- 4. Oxford: Blackwell.
- 5. Fiske, S.T. & Taylor, S.E. (1991). Social cognition. New York: McGraw-Hill.

PAPER 6: NEUROPSYCHOLOGICAL BASIS OF COGNITIVE SCIENCE 4 CREDITS

Course Objectives: This paper enables thestudents to learn the syndromes, disorders, and diseases of nervous system.

Course Outcomes: The students will learn to appreciate the importance of normal neuronal physiology while understanding the abnormal physiology.

Unit I. Frontal lobe syndrome: Disturbances of regulatory functions. Attentional processes, Emotions, Memory and Intellectual activity; Language and Motor functions.

Unit II. Temporal lobe syndrome: Special senses, hearing, Vestibular functions and integrative functions; Disturbances in learning and memory functions, language emotions, time perception and consciousness.

Unit III. Parietal and Occipital lobe syndromes: Disturbances in sensory functions and body schema perception, Agnosias and Apraxias; Disturbances in visual space perception; color perception, writing and reading ability.

Unit IV. Neuropsychological: Profile of various Neurological Conditions: Huntington's disease, Parkinson's disease, Progressive Supra-nuclear Palsy, Thalamic degenerative disease, Multiple sclerosis, cortical and subcortical dementias, Alzheimer's dementia, AIDS dementia complex etc.

Unit V: Cognitive aberrations: Neural basis of conditions such as Parkinson's and disorders, and the neurobiology of sensory systems.

- 1. Eberhard, J.P. (2009). Brain Landscape. Oxford University Press.
- 2. Sigh, V. (2004). Textbook of Clinical Neuroanatomy. Elsevier.
- 3. Jaaskelainen, L.P & ventus. (2002). Introduction to Cognitive Neuroscience. Publishing APS

PAPER 7: COMPUTATIONAL INTELLIGENCE AND NEUROSCIENCE 4 CREDITS

Course Objectives: This course will enable the students with the most upcoming field of science i.e., artificial intelligence. It makes the students to have a computational approach with multidisciplinary view in linking neuroscience with artificial intelligence.

Course Outcomes: After completion, the students will learn the design and role of cognition and computation in development of technologies in aviation, air traffic control, diagnostic and robotics.

Unit I. Human and artificial intelligence: Information possessing theories, alternative approaches to intelligence. Concepts of artificial intelligence.

Unit II. Multidisciplinary computational approaches: Study of creativity, learning. Learning theory (supervised/ unsupervised/ reinforcement learning. Learning Classifiers, Knowledge and inference, emotion and motivation.

Unit III. Computational aspects of perceptual systems: Perception of different (visual, auditory and tactile) modalities. Multi-level (neural, psychological, computational) analysis of cognitive phenomena. Integrated theories of natural and artificial cognitive systems. Information - theoretical, control - theoretic and decision - theoretic approaches to neuroscience. Computer simulation.

Unit IV: Introduction to Programming for Cognitive Science: Fundamentals of Computer programming are introduced. Topics will include fundamentals of computer architecture, variables, functions, and control structures; writing, testing and debugging programs; programming style and basic software design.

Unit V: Cognitive consequences of technology: The role of cognition and computation in the development of state-of-the art technologies such as human computational interaction in aviation, air traffic control, medical diagnosis, robotics and tele robotics and the design and engineering of cognitive artifacts.

- 1. Russel and Norvig. (2012). Artificial Intelligence- A modern approach. TMH.
- 2. Poole, D.L. & Mack worth, A.K. (2010). Artificial Intelligence: Foundations of Computational Agents. Cambridge University Press.
- 3. Ethem Alpaydin. (2010) Introduction to Machine learning. The MIT Press.
- 4. Laurene Fausett, (2004). Fundamentals of Neural Networks. Person.

PAPER 8: PHILOSOPHY OF MIND 4 CREDITS

Course Objectives: This course enables the students to understand the theories proposed by Indian and Western philosophers. It provides an understanding of moral problems and psychology by spanning over the concepts of ethics, sympathy, empathy, will, weakness, guilt, shame, and regrets to enable good life.

Course Outcomes: At the end, the students will appreciate the genesis and implementation of various philosophies in real life.

Unit I. Classics of Western Philosophy: Introduction to Western philosophical tradition through the study of selected major thinkers such as Plato, Aristotle, Lucretius, Descartes, Hobbes, Leibniz, Locke, Berkeley, Hume, Kant, Nietzsche and Marx. Emphasis on changes of intellectual outlook over time, and the complex interplay of scientific, religious and political concerns that influence the development of philosophical ideas.

Unit II. Schools of Indian Philosophy: An overview- Different school of thought, upanishadic concepts, Buddhist concepts, Jain school of thought, Yoga school of thought, Nyaya and Vaiseshika, Charka - Materialism,

Unit III: Moral Problems and Good Life: Introduction to important philosophical debates about moral issues and what constituents a good life: what is right, what is wrong, and why? How important are personal happiness, longevity, and success if one is to live a good life? When is it good for you to get what you want? To what extent are we morally obliged to respect the rights and needs of others? What do we owe the poor, the discriminated, our loved ones, animals and fetuses?

Unit IV: Bioethics: Ethical questions that have arisen from the growth of biomedical research and the health- care industry since World War II. Should doctors be allowed to help patients end their lives? If so, when and how? Should embryos be cloned for research and / or reproduction? Should parents be given control over the genetic make - up of their children? What types of living things are appropriate to use as research subjects? How should we distribute scarce and expensive medical resources? Draws on philosophy, history, and anthropology to show how problems in bioethics can be approached from a variety of perspectives.

Unit V: Moral Psychology: An examination of philosophical theories of action and motivation in the light of empirical findings from social psychology, sociology and neuroscience. Topics include belief, desire, and moral motivation; sympathy and empathy; intentions and other committing states; strength of will and weakness of will; free will; addiction and compulsion; guilt, shame and regret; evil; self- knowledge and self- deception; virtues and character traits.

Reference Books

- 1. Dutta, D. & Chatteree, S. (2007). An Introduction to Indian Philosophy. Rupa Publications.
- 2. Billington, R. (2009). Living Philosophy, An Introduction to Moral Thought, 3rd Edition.

ELECTIVE 2

RESEARCH METHODS

4 CREDITS

Course Objectives: This course provides students with modeling of memory, concepts of intelligence and memory retrieval of memory. It also helps the students to represent knowledge using imaging and mapping techniques.

Course Outcomes: On completion, the students will learn the principles involved in evaluating and manipulating the mental representation of knowledge.

Unit I: Tasks used for measuring memory: Recall versus recognition task, intelligence and importance of culture in testing, sensory stores, short term store and long term store

Unit II: Memory models: Atkinson & Shiffrin's memory model with experimental methods, levels of processing model, integrative model, neuroscience & integrative model with working memory

Unit III: The concept of intelligence and memory, multiple memory system, exceptional memory and neuropsychology, outstanding memory, deficient memory – Amnesia – Alzheimer's disease

Unit IV: Memory retrieval – short term memory – long term memory, serial processing, exhaustive and self-terminating processing, intelligence and retrieval Processes of forgetting and memory distortion, interference theory and decay theory Constructive nature of theory, autobiographical memory, effect of context on memory

Unit V: Memory landscape: Mental images, maps and propositions Mental representation of knowledge, communicating knowledge, pictures versus words, dual code theory, images and symbol, limitations of mental images Mental manipulations of images-principles of visual advertising, neuroscience and functional equivalence

- 1. H, Eichenbaum. (2002). The Cognitive Neuroscience of Memory. Oxford University.
- 2. Sternberg, R.J. (2007). Cognitive Psychology. Australia: Thomson Wadsworth.

SEMESTER III

PAPER 9: CONSCIOUSNESS STUDIES 4 CREDITS

Course Objectives: This paper provides a detailed view on history, evolution, and evaluation of consciousness by making the students to have assertive approach in the philosophies of consciousness. The students will learn the concepts of quantum mechanics at philosophical level.

Course Outcomes: On completion, the students will be able to appreciate the concept of consciousness, status and traits of consciousness and spiritual basis of cognition.

Unit I. Minds and Machines: Introduction Consciousness Studies. Can computers think? Is the mind an immaterial thing? Alternatively, is the mind the brain? How can creatures like us think thoughts that are about things? Can I know whether your experiences are the same as mine when we both look at raspberries, fire trucks, and stoplights? Can consciousness be given a scientific explanation?

Unit II. Philosophy of Quantum Mechanics: Quantum mechanics is said to describe a world in which physical objects often lack "definite" properties, indeterminism creeps in at the point of "observation", ordinary logic does not apply, and distant events are perfectly yet inexplicably correlated. Examination of these and other issues central to the philosophical foundations of quantum mechanics, with special attention to the measurement problem, no- hidden – variables proofs and Bell's with special attention to the measurement problem, no – hidden- variables proofs, and Bell's Inequalities. Rigorous approach to the subject matter nevertheless neither presupposes nor requires the development of detailed technical knowledge of the quantum theory.

Unit III. History and evolution of Consciousness: Views by different philosophers definition of consciousness, functions of consciousness, Pharmacology of the brain, Review of standard drugs, their effect on the brain and consciousness, Mental lesions and their effect on consciousness (phantom limbs, commissurotomy, hemineglect, anosgnosia)

Unit IV. Concept of Consciousness- Status and traits of consciousness, the persistent paradox of psychic phenomena, Computational models of consciousness, Quantum mechanics theories of consciousness, functions of consciousness, Pharmacology of the brain, Review of standard drugs, their effect on the brain and consciousness, Mental lesions and their effect on consciousness (phantom limbs, commissurotomy, hemineglect, anosgnosia)

Unit V. Spiritual Cognition: Concept of spiritually, spiritual intelligence, Intuition, Spiritual and cognitive development, Spiritual cognitive therapy and its process, Cognitive deficits and spirituality. Buddhist Psychology.

- 1. Dehaene, S. (2014). Consciousness and the brain Deciphering how the brain codes our thoughts .Viking Penguin, USA.
- 2. Bransden & Joachain. (2000). Quantum Mechanics, second edition, Prentice Hall.
- 3. Gallagher, S & Zahavi, D. (2008). The Phenomenological mind- An Intro-

duction to Philosophy of mind and Cognitive Science. Roultedge.

PAPER 10: COGNITIVE NEUROPSYCHOLOGICAL REHABILITATION 4 CREDITS

Course Objectives: It enables the students to learn the processes involved in cognitive rehabilitation and remediation. It provides the students with concepts of, and protocols in assessment of injury to brain.

Course Outcomes: At the end, the student learns to diagnose, treat neuropsychological conditions by standardizing the methodology involved in cognitive neuropsychological rehabilitation

Unit I: Cognitive Remediation in Learning Disability and Neuropsychological Rehabilitation in Brain Dysfunction and Epilepsy

Unit II: Neuropsychological assessment and syndrome analysis and Rehabilitation in Minimal brain Dysfunction. Epilepsy, Mental Retardation and Learning Disabilities, Aphasias, Apraxia and Agnosias.

Unit III: Neuropsychological Rehabilitation in Brain Injured and Spinal Cord injured patients

Unit IV: Plasticity and Restoration of Brain Function, Computer assisted neuropsychological rehabilitation and training.

Unit V: Functional Human Brain Mapping: QEEG, ERP, PET, SPECT, And FMRI in Neuropsychological Rehabilitation

- 1. Principles of Neuropsychological Rehabilitation, Prigatano, G.P. (1999). Oxford University Press: NY
- 2. Neuropsychology, a clinical approach, Walsh K. (1994), Churchill Livingstone: Edinburgh.
- 3. Developmental Psychopathology, 2nd Edition, Volume Two: Developmental Neuroscience, Edited by Dante Cicchetti & Donald J. Cohen, © 2006 by John Wiley & Sons, Inc.

ELECTIVE 3

PAPER: PSYCHOMETRICS- 4 CREDITS

Course Objectives: This paper enables the students to learn the generation of construction, uses, limitations of psychological testing and scaling methods. It trains the students for classifying, analyzing, and testing the items.

Course Outcomes: At the end, students will learn to check the reliability, validity and normality for assessment in their cognitive research

Unit I: Test construction: Measurement scales, Classification of tests, General steps in test construction, uses and limitations of psychological tests and testing, Ethical issues in psychological testing. Scaling techniques: psychophysical and psychological scaling methods. Rating scales.

Unit II: Item Analysis: Types of item, Guidelines for item writing, meaning and purpose of item analysis, Power and speed tests, Item difficulty, index of discrimination, Item characteristic curve, Item response theory.

Unit III: Reliability: Meaning of reliability, Index of reliability. Test-retest reliability, Internal consistency reliability, Alternate-form reliability, scorer reliability, Reliability of speed tests, Factors influencing reliability of test scores

Unit IV: Validity: Meaning of Validity, Construct validity, Content validity, Criterion validity. Factors influencing test validity, Relationship between validity and reliability

Unit V: Normality: Norm-referenced and criterion referenced tests, Age-equivalent norms, Percentile norms, Standard score norms. Steps in developing norms-Defining target population, selecting sample from target population, standardizing conditions.

Reference Books

- 1. Anastasi, A. & Urbina, S. (1997). Psychological testing. N.D.: Pearson Education.
- 2. Kaplan, R.M. & Saccuzzo, D.P. (2007). Psychological Testing: Principles, Applications, and Issues. Australia: Thomson Wadsworth
- 3. Gregory, R.J. (2005). Psychological testing: History, principles and applications. New Delhi: Pearson Education.
- 4. Singh, A.K. (2006). Tests, Measurements and Research Methods in Behavioural Sciences. Patna: Bharati Bhavan.

SEMESTER IV

Summer Project-2 Credits Thesis and viva voce examination-12 Credits M.Sc. Biochemistry

Course overview

Postgraduate degree in Biochemistry, offered by JSS Academy of Higher Education & Research, is a well-designed program, which provides in depth knowledge in basic and advanced biochemistry. The course begins with fundamentals of biochemistry, which introduces various physico chemical properties of biomolecules, their organization and function. Next, the student is exposed to various theoretical and practical aspects of biochemical techniques, which will help in any area of life science research. The course continues with the basic aspects of molecular biology that encompassing the structural organization of DNA, RNA and protein, central dogma of life, transcription and translation mechanisms.

In addition, in the first semester the student will also study statistical models of biology as an elective, which are very much essential in the modern science. Keeping in mind the demands of modern research in life science, in the second semester, the student is exposed to the basics of cell and tissue culture, genetics, immunology and nanotherapeutics. Knowledge in the gene regulation and expression is very much essential for advancing the career in biochemical research. In addition, the student performs experiments covering all the above subjects. In the Semester-III, the student studies both clinical and plant biochemistry subjects to acquire the knowledge beginning from the synthesis of food all the way to its metabolism in human systems and its impact on human health and disease management.

Additionally, the student also studies the fundamentals of enzymes, enzyme inhibitors their role in disease management. Along with these, the student also studies the basics of proteomics, one of the most important areas of research in modern life science. The student is also exposed to various biochemical techniques used in clinical biochemistry laboratory. The fourth semester provides an opportunity to student to get exposed to modern research labs. The student performs experiments under the supervision of an expert research guide and submits his report as dissertation thesis.

In addition, the student can also present his/her research findings in national/international seminars; publish work in high impact peer reviewed journals. In total, the students get a chance to shape his/her career in modern life science research. In conclusion, the M.Sc. in Biochemistry course offered under Faculty of Life Sciences, JSS Academy of Higher Education & Research is a well-designed master's program for shaping a student's career in modern research and teaching.

	Semester I	Remarks
Paper 1	Fundamentals of Molecular Biology	4
Paper 2	Fundamentals of Chemistry in Biology	4
Paper 3	Fundamentals of Biochemistry and Biomolecules	4
Paper 4	Biochemical Techniques	4
Elective 1	Statistical Methods for Biology	4
Practical 1	Biochemical Techniques (Practical 1)	6
		26
	Semester II	
Paper 5	Nutritional Biochemistry	4
Paper 6	Genetics	4
Paper 7	Anatomy & Physiology	4
Paper 8	Immunology	4
	Cell signaling	
Elective 2	Or	4
	Cancer Nanotherapeutics	
Practical 2	Combination of all the above (Practical 2)	6
		26
	Semester III	
Paper 9	Plant Biochemistry	4
Paper 10	Enzymology	4
Paper 11	Metabolism	4
Paper 12	Clinical Biochemistry	4
Elective 3	Proteomics	
	Or Righthics Decearch Decian and IDD	4
Dractical 2	Combination of all the above (Practical 2)	6
Practical 3		0
	Correctory TV/	20
	Semester IV	2
	Summer Project	2
	I nesis and viva voce examination	12
		14
	Total Credits	92

Course Curriculum

SEMESTER I

PAPER 1: FUNDAMENTALS OF MOLECULAR BIOLOGY 4 CREDITS

Objective: This paper focuses on the objective of introducing to basic principles of biochemistry, genetics, molecular biology, and recombinant DNA technologies with the material being presented introduces modern biology at the molecular level.

Outcome: At the successful completion of the course, the students will be able to understand the core biology concepts at molecular level where they can apply in teaching as well as molecular research jobs.

Unit I. The Central dogma - flow of information in biological system; Evidences of DNA as genetic material - historical perspectives – experiments of Hammerling, Griffith, Avery - MacLeod & McCarty, Hershey & Chase; Structure of DNA - Watson & Crick model – different forms of DNA (A,B,Z) - nearest base frequency (anti parallel nature) analysis. RNA – structure and functions; mRNA, rRNA & tRNA – structures and functions.

Unit II. DNA replication- Semiconservative model of DNA replication (Meselson and Stahl's experiment); Prokaryotic DNA replication – different models – rolling circle model - bacterial DNA polymerases – characteristics & functions; Viral DNA replication. Eukaryotic DNA replication – Okazaki fragments - role of helicases, topoisomerases, DNA polymerases and DNA ligases - formation of replication fork; Telomere synthesis and functions of telomerase.

Unit III. Transcription – Prokaryotic gene transcription – bacterial RNA polymerases – mechanism and regulation of bacterial transcription; Eukaryotic gene transcription – eukaryotic RNA polymerases – transcription factors – mechanism (initiation & elongation) and regulation of eukaryotic transcription; Post transcriptional modification – 5'CAP formation, polyadenylation, splicosome assembly, splicing & editing. Ribozymes – mechanism of action and applications.

Unit IV. RNA Translation- Genetic code, experiments of Khorana and Nirenberg, feature of genetic code triplet codon, degeneracy, wobble hypothesis, variation in codon usage, structure of ribosome - A, P, E sites of ribosomes, translation in prokaryotes & eukaryotes- activation of amino acids, initiation: shine dalgarno complex, initiation factors, elongation: elongation factors, peptide bond formation, termination: release factors.

Unit V. Concept of gene: Fine structure of gene, Beadle and Tatum's One gene one enzyme concept, One gene one polypeptide concept, Complementation test, Intragenic complementation, Cistron, Recon and Muton, Split gene, Jumping gene, Overlapping gene & multiple genes. Operon concept- *lac* operon, Arabinose and tryptophan operon.

- 1. Watson, J. D., Hopkins N. H., Roberts J. W., Steitz J. A., Weiner A. M. 2014. Molecular Biology of the Gene. Benjamin/Cummings. 7th edition.
- 2. Gardner E J, Simmons M J, Snustad D P. 2006, Principles of Genetics. John Wiley & Sons, Inc., 8th edition.
- 3. Griffith A J F, Miller J H, Suzuki D T, Lewontin R C, Gelbert W M.2000. An

introduction to Genetic Analysis. W.H. Freeman and Co. New York, 7th edition.

- 4. Strickberger, M. W. Genetics. 2008, Macmillan New York:, 3rd edition.
- 5. Lewin B., Gene. 2012, Oxford University press, Oxford., 11th edition.

PAPER 2: FUNDAMENTALS OF CHEMISTRY IN BIOLOGY 4 CREDITS

Objective: This course acts as the gate-way of fundamental concepts of chemistry and biochemistry, i.e. it describes the mutual relationship between these two disciplines.

Outcome: The students will emerge with focus upon the importance of the chemical and physical perspective in all the physiological and metabolic functions of a living organism.

Unit I. Role of alkali and alkaline earth metals in Biology: - Ion transporters/ Ion pumps, ionophores. Transport and Storage of metal ions in Biology. Electron transport, oxygen transport and storage. Metal containing enzymes: - Catalase, SOD, POD, Carbonic Anhydrase. Role of hazardous materials such as nitric oxide, cyanide and methyl isocyanate in biological system.

Unit II. Chemical Bonding: Electronic theory of chemical bonding, octet rule, limitations of octet rule, Covalent bonds, Ionic or electrovalent bonds, Bond Parameters: Length, Bond angle, Bond enthalpy, Bond order, Polarity of bonds, Hybridization, sp, sp², sp³. Highlights of Valence Shell Electron Pair Repulsion (VSEPR) Theory, Valence Bond Theory (VBT) and Molecular Orbital Theory (MOT). Hydrogen Bond and its types. Weak interactions

Unit III. Basis of Organic Reactions Mechanism: Fundamental aspects: Homo and heterolytic cleavage, structure and reactivity of carbocation (C+), carbanion (C-) and carbon free radical (C.). Substitution $S_N 1$, $S_N 2$, Elimination E1 E2 and Addition reactions: Mechanisms. Isomerism: Types, isomerism in carbon compounds, chirality and stereogenic centres, Enantiomers and diastereomers, Fischer Projections. Related terms.

Unit IV. Chemical Equilibria: Colligative properties of solutions, ionic equilibria in solution, solubility product, common ion effect, hydrolysis of salts, pH, buffer, Henderson–Hasselbalch equation. Concentration units: Normality, Molarity, Molality, PPM. Physical and chemical properties of water.

Unit V. Reaction Kinetics: Rate constant, order of reaction, molecularity, activation energy, zero, first and second order kinetics, catalysis and elementary enzyme reactions. Thermodynamics: First law, reversible and irreversible process, internal energy, enthalpy, Kirchhoff's equation, heat of reaction, Hess law, heat of formation, second law, entropy, free energy, and work function. Third law of thermodynamics. Zeroth law of thermodynamics.

Reference Books:

 Miguel Valcárcel Cases, Ángela I. López-Lorente, Ma Ángeles López-Jiménez (2017) Foundations of Analytical Chemistry. Macmillan International.

- 2. Arun Bahl & B S Bahl.(2016) A TEXTBOOK OF ORGANIC CHEMISTRY. S. Chand Publishing.
- 3. Avinash Upadhyay Kakoli Upadhyay, Nirmalendu Nath (2016). Biophysical Chemistry Principles & Techniques. Himalaya Publishing House.
- 4. Wilson, K., & Walker, J. (Eds.). (2010). Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press.
- 5. Fergie Ellison (2014) Handbook of Bioinorganic Chemistry. Agrotech Press.
- 6. Irena Kostova, R. K. Soni (2012), Bioinorganic Chemistry . Shree Publishers.
- 7. David Van Vranken, Gregory A. (2012) Weiss. Introduction to Bioorganic Chemistry and Chemical Biology Paperback. Garland Science. CRC Press.
- 8. Freifelder, D. (1982). Physical Biochemistry: Applications to Biochemistry and Molecular Biology. Macmillan.

PAPER 3: FUNDAMENTALS OF BIOCHEMISTRY AND BIOMOLECULES 4 CREDITS

Objective: The course aims to highlight the role of biomolecules in structure and function of life. It spans over the significance and methodology involved in characterizing major biomolecules.

Outcome: This paper trains students to appreciate the salient features of biomolecules in the organization of life. It helps the students in understanding the classification, functions and application aspects of biomolecules.

Unit I. Classification of carbohydrates: Monosaccharides: Configuration and conformation of monosaccharides, Reducing and optical properties of sugars, Derived monosacharides: deoxyglucose, amino sugars, muramic acid, neuraminic acid. Disaccharides: Stability of glycosidic bond, Sucrose, Lactose, Maltose, Trehalose Polysaccharides: Homopolysaccharides and heteropolysaccharides, Structural polysaccharides-cellulose, hemicellulose, pectin, lignin, chitin, chitosan, Storage polysaccharides; starch, glycogen, inulin, Stearic factors in polysaccharides folding, sugar code and lectin, Glycosaminoglycans, mucopolysaccharides, hyaluronic acid, Chondriotin sulfate, keratan sulfate, dermatan sulphate, Bacterial cell wall – proteoglycans and peptidoglycans

Structural elucidation of carbohydrates: Structural Elucidation of Glucose, Carbohydrate characterization: graded acid hydrolysis, enzyme hydrolysis, periodate oxidation, methylation, acetylation, GC-MS, and NMR. Glycobiology: Glycoproteins; N- and O-glycosylation, lectins, Proteoglycans; agreecan, syndecan, and decorin. Carbohydrates in tissue engineering.

Unit II. Amino acids: Nomenclature, classification and buffering properties of amino acids, zwitterionic structure, reaction of amino acids, unusual amino acids, non-protein amino acids. Peptides: Features of the peptide bond, naturally occurring peptides; glutathione, Gramicidin, enkaphalins and endorphins. Chemical synthesis of peptides; Khorana's solution phase synthesis, Merrifield's solid phase synthesis.

Hierarchy of protein structure: Primary Structure: Determination of amino acid composition: Acid and base catalyzed hydrolysis, separation, quantification, Determination of primary structure Sequencing strategies, Determination of N and C terminal residues, Automated sequanators, determination of site of glycosylation and type of linkage (o-glycosyl and n-glycosyl). Determination of s-s-bond position

Secondary structure of protein: a, β sheet, β -bend, β -turn and super secondary structures. Secondary structure prediction methods; Ramachandran plot, Chou and Fasman algorithm.

Tertiary and quaternary structures: Protein folding and conformation: Anfinsen's experiment. Bonds in protein folding: Weak forces of interaction; hydrogen bonding, Vander Waal's forces, London force, ionic interactions, hydrophobic interactions, S-S bridges, peptide bond, glycosidic bond, phospodiester bond, and allolysine. Chaperones in protein folding and Levinthal paradox. Denaturation (pH, temperature, chaotropic agents) and renaturation of proteins, molten globule. Protein-protein interactions. Structures of myoglobin hemoglobin, immunoglobulin, collagen, chymotrypsin and keratin. Isolation of proteins; overview of purification and criteria of purity.

Unit III. Lipids: Classification of lipids: Simple, Compound and Derived Lipids. Fats, oils, and waxes. Occurrence and properties of fatty acids. Esters of fatty acids, Triacylglycerols. Phosopholipids, Glycolipids, Sphingolipids, Cerebrosides and Gangliosides. Steroids, Sterols, Cholesterol, Bile acid and Bile salts.

Lipid mediators: Eicosanoids, prostaglandins, leukotrienes, prostacyclins, thrombaxanes, DAG and ceramide.

Unit IV. Nucleic Acids: Nitrogenous bases: Purines, Pyrimidines; nucleosides, nucleotides, unusual bases. Physiochemical properties of nucleic acids. Difference between RNA and DNA. Chemical reactions of DNA and RNA. Secondary structure of DNA. Watson and Crick model; B and Z DNA, other models of DNA structure. Supercoiling of DNA.

Denaturation and renaturation of Nucleic acids. Melting of DNA, Tm; factors affecting Tm, Cot curve, classification of DNA based on cot curve. Nucleotides as regulatory molecules, enzyme cofactors and mediators of chemical energy in cells. Other secondary structural features in DNA, steam loop structure, palindromic sequences, cruciforms. DNA protein interaction; zinc finger leucinc zipper, helix-turn-helix, other motifs, DNA bending and kinks

Sequencing of DNA: Maxam Gilbert method, dideoxy method. Genetic Code, Chargaff's rule. Types and roles of RNA, Secondary structure of tRNA: cloverleaf model. Isolation of DNA and RNA from biological sources (microbes, plants and animals). Purification of nucleic acids.

Unit V. Porphyrins – Structure and properties of porphyrins – Heme, chlorophyll and cytochromes. Vitamins – Water soluble and insoluble vitamins, structure and function, deficiency symptoms. DRI, RDA. Reactive oxygen species and detoxification mechanisms.

- 1. Nelson, D. L. & Cox, M. M. Lehninger, 2013, Principles of Biochemistry. Freeman - 6th edition,
- 2. Berg, J. M., Tymoczko, J. L. and Stryer, L. 2011, Biochemistry. Freeman 7th edition.
- 3. Voet, D., Voet, J. G., & Pratt, C. W. 1999. Fundamentals of Biochemistry (pp. 408-409). New York: Wiley – 4th edition.
- 4. Conn, E., &Stumpf, P. 2009. Outlines of Biochemistry. John Wiley & Sons 5th edition.
- 5. West, E. S., Todd, W. R., Mascon, H. S., & Van Bruggen, J. T. 1974. Textbook of Biochemistry. Oxford and IBH Publishing - 4th Edition
- 6. Lodish, H., Berk, A., Zipursky, S. L., Matsudaira, P., Baltimore, D. and James Darnell, J.2013. Molecular Cell Biology, Freeman 7th edition.

PAPER 4: BIOCHEMICAL TECHNIQUES 4 CREDITS

Objectives: In this paper students will be able to demonstrate methods for purifying proteins, and analyzing biological molecules by electrophoresis, Western blotting, and enzyme activity assays. They will acquire the skills required to design and interpret the data from scientific experiments. Also, it will emphasize the learning of basic lab skills (including dilutions, good pipetting technique, and basic statistical analysis) and good lab practices (such as good notebook keeping).

Outcome: The units of this paper are crucial for implementation of research ideas at molecular level. It trains the students in adopting various techniques in biological research. This significantly enhances the employability of the candidates in Biotechnological, Pharmaceutical Industries and Analytical Laboratories and research institutes.

Unit I: Separation techniques: Principles, methods and applications of chromatography – Paper, thin layer, ion exchange, gel filtration and affinity chromatography, GLC, HPLC, UPLC and chromato-focussing.

Spectroscopic techniques: Principles of colorimeter, spectrophotometer, fluorimeter. Beer-Lambert's Law and its limitations. Extinction coefficient, fluorescent probes and their applications

Unit II: Cell fractionation techniques: Cell lysis, preparation of lysis buffers, pH, ionic strength, ionic and non-ionic detergents, and composition of general lysis buffers such as RIPA, homogenization, extraction, salting in, salting out, dialysis and ultra-filtration.

Centrifugation: Svedberg's constant, sedimentation velocity and sedimentation equilibrium.

Ultra-centrifugation: Differential and density gradient centrifugation, centrifugal elutriation, construction of preparative and analytical ultracentrifuge, Schleiran optics

Unit III: Electrophoretic techniques: Polyacrylamide gel electrophoresis, SDS-PAGE, 2D-electrophoresis, agarose gel electrophoresis, isoelectric focusing, pulsed field electrophoresis, high voltage electrophoresis, capillary electrophoresis, iso-tachophoresis. Separation of proteins, lipoproteins and nucleic acids. Visualizing separated components; staining, fluorescence, PAS staining, zymogram and reverse zymogram

Unit IV: Isotopic tracers: Heavy isotopes and radio-isotopes, theory and construction of mass spectrometer. Ionization, fragmentation, m/e, time of flight, MALDI and ESI.

Radioisotopes in Biology: 3H, 14C, 32P, 131I, 35S, concept of half-life, decay constant, detection and quantitation - GM counter and solid and liquid scintillation counter. Specific activity, autoradiography and their applications

Labeling: Using plant system (monosaccharides and polysaccharides), animal system, chemical (Glucose-14C) and enzymatic methods (disaccharides). Labeling of acetate (1-C14 and 2-C14), ATP (a-P32 and g-P32), proteins and nucleic acids. **Applications of radioactivity:** Dilution techniques, pulse chase method, carbon dating, substrate product relationship (cholesterol biosynthesis) and bond cleavage specificity

Unit V: Animal models, choice of animals, types of studies, xenografts, allografts, mutant organisms (auxotroph), cultured animal and plant cells as representative models.

Reference Books:

- 1. Wilson, K., & Walker, J. (Eds.). 2010. Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press.
- 2. Robyt, J. F., & White, B. J. 1990. Biochemical Techniques: Theory and Practice, Prospect Heights, IL: Waveland Press.
- 3. Pingoud, A. 2002. Biochemical Methods: A concise guide for students and researchers, Wiley-VCH Verlag GmbH & Co.
- 4. Rodney Boyer, 2003, Modern Experimental Biochemistry, 6th edition, Pearson.
- 5. Holtzhauer, M. 2006. Basic methods for the Biochemical lab, Springer.

Elective 1: Statistical Methods for Biology 4 Credits

Objectives: To train the students intensively in both theoretical and practical aspects of statistics, to bring them in contact with basic concepts and methods and to create a problem-solving attitude with the aid of statistical methodology.

Outcomes: It provides an introduction to selected important topics in Bio-statistical concepts and reasoning. This course represents an introduction to the field of data and data types. The students learn specific topics including tools for describing central tendency and variability in data; methods for performing inference on population means and proportions via sample data; statistical hypothesis testing and its application to group comparisons; issues of power and sample size in study designs; random sample and other study types.

Unit I. Numerical Methods to Represent Variation: Importance and Scope of Statistics, Data Types, Frequency Distribution, Graphical Representation Methods (Histogram, Bar Charts, Pie Charts), Measures of Center Tendency (Mean, Median, Mode,) and Dispersion (Standard Deviation, Variance) Advantages and Disadvantages, Co-Efficient of Variance.

Unit II. Probability: Basic Terminology, Definition of Probability, Basic Laws of Probability, Types of Probability,

Additional Rule of Probability and Multiplication Rule of Probability, Probability Distribution-Bernoulli Distribution, Binomial Distribution, Poisson distribution and Normal Distribution-Simple Problems.

Unit III. Sampling Methods: Collection of Data, Census Method, Concept of Population, Sample, Sampling, Sample Size, Sampling Error, Advantages and Disadvantages of Sampling Method, Necessity of Sampling, Types of Sampling Methods, Types of Random Sampling Methods – SRS, Stratified Random Sampling, Systematic Random Sampling and Cluster Sampling.

Unit IV. Testing of Hypotheses: Statistical Hypotheses-Null and Alternative, Level of Significance, Type I and Type II Error, Critical Region, Power of the Test, P Value, Degrees of Freedom, Chi-Square Test for Independence of Attributes and Goodness of Fit, Student's t Test: One Sample t Test and Paired t Test, F Test.

Unit V. Regression and Analysis Of Variance: Simple Linear Regression, Multiple Linear Regression (Definition, Assumptions, Applications, and Examples), Analysis of Variance –Introduction, Definition of ANOVA, Assumption, Test of ANOVA, Types of ANOVA, Construction of One Way Analysis of Variance.

Reference Books:

- 1. Rastogi, V. B. 2009. Fundamentals Of Biostatistics, Ane Books Pvt Ltd 2nd edition.
- 2. Gupta, S. C., & Kapoor, V. K. 1994. Fundamental of Mathematical Statistics. Sultan Chand & Sons. New Delhi-2003.
- 3. Gupta, S. C. 2016. Fundamentals of Statistics. Himalaya Publishing House.
- 4. Biostatistics, Snedger and Gohrran.
- 5. R. E. Parker, 2012. Introductory Statistics for Biology. Queen's University Belfast-2nd Edition

PRACTICAL 1: BIOCHEMICAL TECHNIQUES 6 CREDITS

Objectives: In this paper, the learning of basic lab skills including qualitative analysis, dilutions, good pipetting technique, and good lab practices.

Outcome: It trains the students in adopting various techniques in biological research. This paper significantly enhances the employability of the candidates in Biotechnological, Pharmaceutical Industries and Analytical Laboratories and research institutes.

- 1. Paper chromatography ascending and descending separation of amino acids and sugars.
- 2. Qualitative tests for the identification of amino acids and carbohydrates.
- 3. Thin layer chromatography of amino acids and lipids.
- 4. Column (GPC) chromatographic separation of proteins (albumin and trypsin).
- 5. Polyacraylamide Gel Electrophoresis and agarose gel electrophoresis of serum proteins.
- 6. Ion exchange chromatography of amino acids.
- 7. Absorption spectrum of chlorophyll extracted from green leaves.
- 8. Absorption spectrum of aromatic amino acids, purines and pyramidines.
- 9. Determination of Molar absorption coefficient of tyrosine.
- 10. Molecular weight determination of proteins by SDS-PAGE
- 11.Western blotting
- 12.Quantitative estimation of proteins and DNA by spectrophotometric method. Verification of Beer-Lambert's Law.

- 1. Wilson, K., & Walker, J. (Eds.). 2010. Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press.
- 2. Robyt, J. F., & White, B. J. 1990. Biochemical Techniques: Theory and Practice, Prospect Heights, IL: Waveland Press.
- 3. Pingoud, A. 2002. Biochemical Methods: A concise guide for students and

researchers, Wiley-VCH Verlag GmbH & Co 4. Holtzhauer, M. 2006. *Basic methods for the biochemical lab*, Springer.

SEMESTER II

Paper 5: Nutritional Biochemistry 4 Credits

Objective: The aim of this course is to provide the students with general theoretical information on micronutrients, water and electrolytes in nutritional biochemistry and their functions in metabolism. It also explains how nutrients are delivered to the body and describes the function of various nutrients including how they are metabolized to form energy used by the human body.

Outcome: The students at the end of the course will learn the nutritional essentiality of biomolecules. The insights gained help the students to apply it into research or in their day to day life.

Unit I. Nutrition- Essential nutrients and their classification. Food groups, proximate analysis of foods. Food as source of energy, Energy content of food: Calorie value, Respiratory Quotient, methods of determining energy value of foods, calorimetry, utilization of energy by man. Basal metabolic rate (BMR) factors affecting BMR, specific dynamic action of foods. **Water Balance:** Factors and regulation. **Electrolytes** - Concept, balance and acid base balance. **Balanced diet--** Recommended dietary allowances for different categories of the human beings

Unit II. Carbohydrates - Dietary types, dietary sources, requirements, utilization and functions, nutritional importance, sources, glycemic index and its uses, essentiality and adverse effects of dietary fiber. Carbohydrate content of foods. Extrinsic sugars, Intrinsic sugars. Protein sparing action. Disorders related to carbohydrate metabolism. Carbohydrates related to dental health, obesity, CVDs, cancer and other diseases.

Unit III. Proteins – essential and non-essential amino acids- their role in growth and development. Evaluation of nutritive value of dietary protein PER, BV, NPU, Protein content of some common foods found in the diet, Mutual supplementation of proteins, nutritional classification of proteins, supplementary value of proteins, Nitrogen balance, protein calorie malnutrition Kwashiorkor and Marasmus: clinical features and biochemical changes. Protein and weight management.

Unit IV. Fats- dietary types, sources, requirements, utilization and functions, invisible fat, essential fatty acids, saturated, unsaturated, MUFA, PUFA, cis and trans fatty acids, dietary intake. Role of lipoproteins, cholesterol, triglycerides in health and disease. Lipids related to CHDs and obesity.

Unit V. Vitamins - Fat soluble and water soluble vitamins, pro-vitamins, dietary sources, daily requirements, functions, deficiency symptoms, hyper-vitaminosis, vitamin like compounds.

Minerals Macro and micronutrients, sources, requirements, functions and deficiency symptoms. RDA and factors affecting it.

Antinutritional factors: Sources and harmful effects of anti-vitamins (eg avidin, dicoumarol), Natural toxicants (eg *Lathyrus sativa*) and adulterants (eg butter yellow, lead chromate, malachite green).

Reference Books:

1. Tom Brody, 1998, Nutritional Biochemistry, Academic Press, Second Edi-

tion.

- 2. Walter Santos, Nabuco Lopes, J. J. Barbosa, Dagoberto Chaves, José Carlos Valente, 2013, Nutritional Biochemistry and Pathology. Springer
- 3. M. Swaminathan, 2015, Food & Nutrition Volume I and II, Bappco
- 4. Joan Webster-Gandy, Angela Madden, and Michelle Holdsworth, 2011; Oxford Handbook of Nutrition and Dietetics by Oxford Medical Handbooks

PAPER 6: Principles of Genetics 4 Credits

Overview: The paper aims in highlighting the scope and significance of genetics by imbibing the principles of hereditary genetic transmission and interactions of gene with environment.

Outcome: It helps students to learn the molecular aspects of genetics disorders and mutations. It helps the students to appreciate the concepts of gene and relationship between genotype and phenotype.

Unit I. Introduction to Genetics, Scope and significance of genetics: Principles of Genetic Transmission: Concept of dominance, Principle of dominance and segregation, Principle of independent assortment, Mendel's Experiments, Symbols and terminology, Mendelian inheritance and **use of** probability (Multiplication and Addition rules).

Unit II: Extension of Mendelism: Incomplete dominance, codominance, multiple allelism, Gene action (from genotype to phenotype), Gene interaction, penetrance, expressivity, epistasis, pleiotropy, interaction with environment. Allelic variation and gene function. The chromosomal basis of Mendelism: Chromosomes – chromosome number, Chromosome theory of inheritance. Experimental evidence, non disjunction as proof of chromosome theory, chromosomal basis of Mendel's principles. Linkage and crossing over, sex linkage, sex limited and sex influenced characters. Polygenic inheritance, Extra chromosomal inheritance : Inheritance of Mitochondrial and chloroplast genes, maternal inheritance.

Unit III: Sex Determination: Sex chromosomes, Chromosomal and molecular basis of sex determination in *C.elegans*, Drosophila, Man and Plants. Dosage compensation: Genic balance, Gene dose, Molecular basis of dosage compensation in Drosophila and man

Unit IV: Concept of gene: Fine structure of gene, Types of genes. Molecular anatomy of eukaryotic chromosome – Centromere, Telomere, Nucleosome, Nucleomere, Kinetochore, Chromosome banding techniques. Population genetics, Gene pool, Gene frequency Hardy Weinberg equation. Linkage, genetic drift.

Unit V: Mutations: Types, Spontaneous, Induced mutation, Conditional lethal mutations –Base substitution mutation, Missense, Nonsense and Silent mutations. Chemical, Physical and Biological mutagenesis. Quantification and Detection of mutations. Structural and numerical alterations of chromosomes: Deletion, duplication, inversion, translocation, ploidy and their genetic implications. Genetic disorder - Color blindness, Cystic fibrosis, Down syndrome, Duchenne muscular dystrophy, Hemophilia, Klinefelter syndrome, Sickle-cell disease, Turner syndrome

Reference Books:

- 1. Hartl, D. L., & Jones, E. W. (1998). Genetics: Principles and analysis. Jones and Barlett Publishers.
- 2. Simmons, M. J., &Snustad, D. P. (2006). Principles of genetics. John Wiley & Sons.
- 3. Andersen, W. R. (1999). Genetics: the continuity of life. Brooks/Cole Publishing Company.
- 4. Atherly A G, Girton, J R and Mc Donald J F, 1999. The Science of Genetics, Saunders College Publishing, Harcourt Brace College Publishers.
- 5. Brooker, R. J. (1999). Genetics: Analysis and Principles. Reading, MA: Addison-Wesley.
- 6. Gardner E J, Simmons M J, Snustad D P 1991. Analysis and Principles of Genetics. Ed. Benjamin Cummings. California.
- 7. Griffith A J F, Miller J H, Suzuki D T, Lewontin R C, Gelbert W M.1996. Principles of Genetics. John Wiley & Sons, Inc.
- 8. Griffiths, A. J. F., Miller, J. H., Suzuki, D. T., Lewontin, R. C., &Gelbart, W. M. (2000). An Introduction to Genetic Analysis, WH Freeman. New York.
- 9. Strickberger, M. W. (1976). Genetics. Macmillan, New York. Genetics. 2nd ed. Macmillan, New York.
- Watson, J. D., Baker T. A., Bell S. P., Gann A., Levine M., Losick R. 2004. Molecular Biology of the Gene. Pearson Education Pte. Ltd., New Delhi, India - 5th Edition
- 11.Klug, W S, and Cummings M. R. 1998. Essentials of Genetics. Prentice Hall, Upper Saddle River, NJ. 3rd edition.
- 12.Hartl, D L & Jones E W 2006. Essential Genetics: a genomics perspective, Jones and Bartlett Publishers, Boston 4th Edition.
- 13.Tamarin R. H. 2002. Principles of Genetics. Tata-McGraw Hill, Seventh Edition.
- 14.Lewin B., 1995. Gene IV, V, VI. Oxford University press, Oxford.

Paper 7: Anatomy and Physiology 4 Credits

Overview: The paper aims in highlighting the structural and functional aspects of the organ systems of the human body.

Outcome: The students will be able to appreciate the biochemistry behind the anatomical and physiological aspects of the human body.

Unit I. Introduction and scope of anatomy and physiology

Terminologies in anatomy and physiology, Organization of life: Hierarchy of complexity, Characteristics of Life, Major themes in anatomy and physiology: Cell theory, Homeostasis, Evolution, Hierarchy of structure, Unity of form and function. Anatomical positions, planes. Major body regions: Axial and appendicular. Body cavities and membranes: cranial, thoracic, abdominopelvic and potential spaces. Basic body plan in humans and location of organs. Organ systems.

Unit II. Blood - Composition, cells. Erythrocytes - structure and function, WBC - types and functions, differential count. Platelets and their function. Buffer systems; hemostasis. Blood clotting, digestion of clot; anticoagulants. CSF-composition and function.

Cardio vascular system: Comparative anatomy of heart structure, myogenic heart, ECG – its principle and significance, cardiac cycle, heart as a pump, blood volume, blood pressure and its regulation : neural and chemical.

Respiratory system – Anatomy of lungs, transport of gases, exchange of gases, waste elimination, neural and chemical regulation of respiration.

Oxygen binding by hemoglobin and factors affecting it. Acid-base balance and its regulation.

Unit III. Digestive system - GI tract, digestion and absorption of carbohydrates, proteins and lipids. Mechanism of HCl production in the stomach. Gastrointestinal hormones. Role of pancreas.

Excretory system - Ultra structure of the nephron, glomerular filtration, formation of urine

Hepatobiliary system - Anatomy of the liver; cells- hepatocytes, endothelial cells, Kupffer cells and paranchymal cells. Secretory and excretory function; detoxification and formation of bile.

Unit IV. Control and coordination: Nervous system: Gross neuroanatomy of the brain and spinal cord, central and peripheral nervous system. Neurons, neurotransmission, action potential, synapse and its types, neural control of muscle tone and posture.

Endocrine System - Endocrine organs. Hierarchy and regulation of hormone release. Classification of hormones. Basic mechanism of hormone action. Hypothalamus –pituitary-target organ axis and regulation by feedback mechanism. Hypothalamus: Structure, hormones and their regulation. Pituitary- anatomy and its hormones. Thyroid, parathyroid, adrenals, gonads - Testes and ovaries. Endocrine disorders.

Reproductive system: Male and female reproductive system, Gamatogenesis, Menstrual cycle.

Unit V. Thermoregulation: Body temperature – physical, chemical, neural regulation, acclimatization. **Sense organs**- Mechanism of sight, smell, taste, touch, and hearing.

Muscles: Types, Structure, Sections of muscle fiber, mechanism of contraction and relaxation, Sliding filament model of skeletal muscle contraction, factors affecting it.

Bones: Composition and structure of long bone, growth and remodeling of long bone. Factors affecting its growth.

- 1. Kenneth Saladin, 2014, Anatomy & Physiology: The Unity of Form and Function, McGraw-Hill Education, 7th Edition.
- 2. Henry Gray, 2013, Gray's Anatomy, Arcturus Publishing Ltd.
- 3. White, Handler and Smith, 1974- Reprint, Text book of Biochemistry.
- 4. Arthur C. Guyton, John E. Hall, 2005. Text book of Medical Physiology, 9th Ed. W. B. Saunders Company, Prism books (Pvt) Ltd. 11th edition.
- 5. Robin R. Preston, Thad Wilson, 2012, Lippincott's Illustrated Reviews Physiology(SAE), LWW; North American edition
- 6. Chatterjee, 2016, Text book of Physiology. CBS Publishing; 11 edition
- 7. Swaminathan M, 1974, Essentials of Food and Nutrition, Ganesh and Co; 1st edition
- 8. Goodheart, 1980, Modern Nutrition Health and Diseases. Lea &

Febiger, U.S.; 6th edition.

PAPER 8: IMMUNOLOGY 4 Credits

Objective: The students will be able to identify the cellular and molecular basis of immune responsiveness. They will also be able to describe the roles of the immune system in both maintaining health and contributing to disease.

Outcome: This course provides you with knowledge and understanding of immunology and the way it is applied in diagnostic and therapeutic techniques and research. It trains the students with essentiality of molecules, cells, tissues, and organs involved in the defense mechanism. It's a paper which accomplishes the learning of techniques involved in understanding the immunological aspects of physiology and biological samples.

Unit I: Introduction: Historical development and milestones in immunology – Contributions of Edward Jenner, Louis Pasteur, Emilvon Behring &Kitasato, Metchinkoff, Primary and secondary lymphoid organs – Lymphatic system, Reticulo-endothelial system, Types of immunity, Innate & Acquired.

Unit II: Nonspecific defenses: Barriers to infection – skin, mucous membrane, inflammation and phagocytosis. Complement system: Classical, alternate and lectin binding pathway, Generation of membrane attach complex. Anaphylo-toxins & Opsonine. Antigens: Chemical nature & properties, Epitopes, Antigenicity, Immunogenecity, Valency of antigens, Haptens. Antibodies: Structure, Classes and subclasses, Paratopes, Immunoglobulin variants – Isotypes, Allotypes & Idiotypes, Valency of antibody diversity.

Unit III: Immune responses: Primary and secondary, class switching. Structure &functions-MHC antigens in man, Vaccines: Vaccines and their preparations (traditional and recombinant vaccines) BCG, Polio, DPT, HBV, Adjuvants.

Unit IV: Cellular basis of immunity: Hematopoiesis, Biology of T-cells and B-Cells. T-cell subsets. T-cell and B-Cell receptors. Antigen presenting cells and accessory cells (macrophages & dendritic cells), T-cell and B-Cell co-operation, Antigen processing & presentation, Clonal selection, Cytokines – role in immunity. Transplantation: Tissue typing-Autograft, Isograft, Allograft &Xenograft. Graft versus host reactions (GVHI). Immune-suppression. Hypersensitivity: Types of Hypersensitivity reactions. Types I, II, III & IV Anaphylexis.

Unit V: Monoclonal antibodies – preparations & applications, Immunological techniques: Preparations, agglutinations, Complement fixation, Immunodiffusion, Immunoelectrophoresis, Immunofluroscence, RIA & ELISA, Western blotting. Disorders of immunity: Immunological tolerance, Autoimmunity. Immunodeficiency disorders, SCID, AIDS, Tumor immunology: Tumor associated antigens & Tumor specific antigens. Immune surveillance, TNF & α , β , immunotherapy.

- 1. Roitt I M, Brostoff J and Male D K, 1993. Immunology Mosby Yearbook Europe Ltd., London -3rd edition
- 2. Roitt I M Delves P J.2001. Essential Immunology, Blackwell Scientific Publi-
cations – 10th edition.

- 3. Boyd W C, 1964. Fundamentals of Immunology, Toppan Co. Ltd., Tokyo.
- 4. Kimball J W, 1983. Introduction to Immunology, Macmillan Publishing Co. Inc. New. York.
- 5. Otto S. View and others, 1986. Fundamentals of Immunology, Springer-Verlag.
- 6. Wier D M. 1978. Experimental Immunology, Blackwell Scientific Publications Oxford.
- 7. Kubay J. 2001.Immunology, W H Frecman& Company NewYork–2nd edition.
- 8. Abbas A K Lichtman A H, 2007. Cellular and Molecular Immunology. Oxford University Press, Oxford –3rd edition.

Elective 2 (a): Cell Signaling 4 Credits

Objective: To enable the students to understand the cellular networks involved in maintenance of living organism.

Outcome: The students will appreciate the role of multiple biomolecules in bringing physiological changes with a systematic approach.

Unit I. Cytoskeletal elements in Cellular dynamics: Mechanism and regulation of vesicular transport, Golgi and post Golgi sorting, receptor mediated endocytosis **Structural elements in microfilaments**: cell motility and cell shape; Actin- Ar-chitecture and assembly, myosin- muscle contraction; microtubules- structure, assembly and dynamics and microtubule associated proteins; Cilia, flagella, intermediate filaments.

Unit II. Cellular signaling: Extra cellular signaling – G Protein linked receptors ,Role of cyclic AMP, IP₃, DAG, Ca²⁺ as a second messenger, receptor tyrosine kinases , MAP kinase pathway, SAP/JNK pathway, p38 pathway, ERK pathway, NFkB pathway, Cell survival pathway, JAK/STAT pathway, TGF-b/SMAD signalling and Wnt signalling. Multiple signaling pathways- Insulin receptor (regulation of blood glucose); regulation of cell surface receptors and transcription factors in signaling pathways. Signalling defects.

Growth factor: Platelet derived growth factor, vascular endothelial growth factor and their mechanism of action.

Unit III. Multicellularity: Role of extra cellular matrix- Hyaluronan and Proteoglycan , matrix proteins and their receptors, Adhesive proteins and cell junctions in multi cellularity. Structure and function of plant cell wall. Cell communication, adhesion. Role of active oxygen species (AOS) in plant signal transduction: AOS in plants, AOS as signal molecules, AOS-part of a signaling network.

Unit IV. Cell division and cell cycle: Mitosis and meiosis. Strategies in cell cycle, Discrete cell cycle events, Early embryonic cell cycle, Yeast cell cycle, regulation of cell cycle, cyclins, cyclin dependent kinases, inhibitors, cell division control in multi cellular organism. Programmed cell death - apoptosis, factors affecting apoptosis, p53 and bcl2.

Unit V. Tumor biology: Causes of cancer, Etiology, retroviruses, retroviral trans-

formation of host, Proto-oncogene, conversion from proto-oncogene to oncogene, tumor suppresser gene, Role of p53 in cancer, Cell culture uses in research, Molecular medicine and cancer. The end point of signal transduction gene transcription, nuclear receptors and transcription factors in signaling. Signaling from single gene expression to multiple gene expression: Super array as a tool for the study of multiple gene transcription, Practical application of the signal transduction research, RNA Interference and Cell Signaling, Senescence and Its Signaling Pathways.

Reference Books:

- 1. Lodish, H, et al., 2016, Molecular Cell Biology. 5th Edn. W. H. Freeman; 8th edition.
- 2. Alberts et al. 2008, Molecular biology of the Cell –Garland Science; 5th edition.
- 3. Karp, 2013, Cell and Molecular Biology. J.JohnWiey and Sons In. Wiley; 7th edition.
- 4. Geoffrey M Cooper and Robert E Hausman, 2006, The Cell-Molecular approach. Sinauer Associates, Inc.; 4th edition.

Elective 2(b). Cancer Nanotherapeutics 4 Credits

Course Objectives: This course mainly aims on highlighting the advances in nanotherapeutics. The main *objective* of this *course* is to impart knowledge on cancer developmental stages, Drug Delivery Concepts in Nanoscience, latest advances in cancer nanotherapeutics, nanotechnology aided imaging and diagnostics.

Course Outcome: The course provides insights into the cancer development, stages in development, aberrant signaling mechanisms in cancer, angiogenesis and expression of oncogenes. The course covers topics for current therapies for cancer and their limitations. It highlights the advancements made in the field of nanotechnology for the treatment of cancer, precision tools for diagnosis of cancer. This course will largely depend on Research Papers and class room discussion for references.

Unit I: Biology of cancer development: Different forms of cancer, principles of carcinogenesis, and principles of cancer metastasis and clinical significance. Metastatic cascades, basement membrane disruption. Three step theory of invasion. Signaling mechanism and tumor microenvironment.Oncogenes and identification of oncogenes.Cell cycle and its regulation, apoptosis, DNA damage and repair mechanism, cell death, epigenetic regulation of gene expression.Types of cancer therapies, Mutations and drug resistance.

Unit II: Nanotechnology based precision tools for cancer diagnosis and imaging: Nanotechnology based biochips, nanofludics and microarrays, Mems, Bionanosensors, nanoscale single scale identification and cancer theranostics.

Unit III: Nanotechnology based therapies: Enhanced Permeation and Retention based therapies. Investigational and approved nanomedicine products.Doxil and abrexane formulation, mechanism of action, internalization and pharmacokinetics.Cancer nanotherapeutics in clinical trials. Molecular-targeted nanotherapies for cancer - Nanoparticles based siRNA therapies and Immunotherapies.

Unit IV: Nanotechnology in Hyperthermia based cancer therapy: Over view of hyperthermia, whole body hyperthermia, basics of hyperthermia cancer treatment, nanoparticle mediated hyperthermia in cancer therapy. Gold and magnetic nanoparticles for hyperthermia. Neel and Brownian relaxation in magnetic nanoparticles.

Unit V: Chemo and radio sensitization using nanotechnology: Chemo/radio-sensitive and resistant, tumors, novel approaches to sensitize tumors, thermal chemo-sensitization, chemo and radio sensitization strategies, radio-sensitizing chemotherapy. Nanoparticles in radiotherapy, nanoparticles based brachytherapy spacers, hydrogel spacers, and smart brachytherapy spacers for combined chemo-radiotherapy and drug eluting brachytherapy spacers. Animal models in cancer nanotherapeutics.

Reference Books:

- 1. Cancer Chemotherapy. Dr. Rajat Kheri. Edition 2011, VDM, Verlag Publishers.
- 2. Nanoparticle-Based Medicines: A Review of FDA-Approved Materials and Clinical Trials to Date. 2016, A review.
- 3. George C. Prendergast, 2015, Molecular Cancer Therapeutics: Strategies for Drug Discovery and Development. Wiley.
- 4. Rajaventhan Srirajaskanthan, Victor R. Preedy, 2017 Nanomedicine and Cancer. CRC Press
- 5. Anshu Mathur, 2016 Nanotechnology in Cancer, 1st Edition. Elsevier.

PRACTICAL 2: 6 CREDITS

Objective: This paper aims in enabling the students to get thorough knowledge in quantitative analysis and techniques used in biochemical assays.

Outcome: The students will learn the experimental calculations of the biochemical assays which will help them in their dissertation work and research career. The students get the practical edge of the subjects learnt in the semester.

- 1. Determination of pKa and PI values of an amino acid by titrimetric method
- 2. Estimation of proteins by Lowry, Bradford methods
- 3. Determination of total carbohydrates by Phenol-Sulfuric Acid method
- 4. Determination of reducing sugars by DNS method
- 5. Estimation of Ca++/Zn ++ by EDTA titrimetric method
- 6. Isolation of DNA from bacterial, plant and animal cells.
- 7. Estimation of DNA and RNA by UV absorption method and determination of purity of nucleic acids.
- 8. Estimation of DNA by Diphenylamine method
- 9. Agarose gel electrophoresis for separating DNA and PCR products
- 10.Determination of melting temperature (Tm) of DNA
- 11.Estimation of RNA by Orcinol method.
- 12.PCR
- 13.Identification of Drosophila mutants

Reference Books:

1. Wilson, K., & Walker, J. (Eds.), 2010, Principles and Techniques of Bio-

chemistry and Molecular Biology. Cambridge University Press.

- 2. Robyt, J. F., & White, B. J, 1990, Biochemical techniques: theory and practice (Vol. 2). Prospect Heights, IL: Waveland Press.
- 3. Pingoud, A, 2002, Biochemical methods: A concise guide for students and researchers, Wiley-VCH Verlag GmbH & Co
- 4. Holtzhauer, M, 2006, Basic methods for the biochemical lab.
- 5. Varley, H., Gowenlock, A. H., McMurray, J. R., &McLauchlan, D, 1988, Varley's Practical Clinical Biochemistry. Heinemann Medical.
- 6. Oser, B. L., & Hawk, P. B, 1965, *Hawk's physiological chemistry*.Mc-Graw-Hill.

SEMESTER III PAPER 9: PLANT BIOCHEMISTRY 4 CREDITS

Objective: The paper aims to provide information on the physiological processes of plant at molecular level. It explains the biochemical and cellular aspects of photosynthesis, respiration and other special functions of plants.

Outcome: It enables the students to appreciate the functioning of plants by specialized molecular processes. The knowledge can be extrapolated during their research work.

Unit I: Thermodynamics: Laws of thermodynamics and its relevance with biological processes. Enthalpy, entropy, free energy and chemical equilibrium. Energy currency, ATP, ADP, creatine phosphate, phosphoenol pyruvate as energy rich compounds.

Respiration: Plant mitochondrial electron transport and ATP synthesis, ATP synthesis complex, binding change mechanism, proton motive force, Mitchell's hypothesis. Substrate level phosphorylation, futile cycles and their application. **Mitochondrial electron transport**: Organization of respiratory chain complexes, structure and function of the components; Fe-S proteins, cytochromes, Sequence of electron carriers based on red-ox potentials.

Entry of reducing equivalents for oxidation; malate-aspartate shuttle, glycerol phosphate shuttle. Q cycle, proton transfer, P/O ratio, respiratory control, oxidative phosphorylation, uncouplers and inhibitors.

Biosynthesis of cofactors: NAD+, FAD and coenzyme A, polyamine biosynthesis and their metabolic role

Unit II: Photosynthesis: Photosynthetic apparatus in plants, Photosystems I and II, light harvesting antenna complex. Electron flow and phosphorylation; cyclic and noncyclic, oxygen evolution, Calvin cycle. C3, C4 and CAM cycle. Photorespiration. Regulation of photosynthesis. RUBISCO Bacterial photosynthesis. Plant hormones: Biosynthesis, storage, breakdown and transport. Physiological effects and mecha-

nisms of action of auxins, gibberlines, cytokinins, ethylene, abscisic acid.

Unit III: Nitrogen metabolism: Importance of nitrogen in biological systems, nitrogen cycle. Nitrogen fixation; symbiotic and non-symbiotic, nitrogenase complex, energetics and regulation.Formation of root nodules in legumes. Assimilation of nitrate and ammonium ion

Host parasite interaction: Recognition and entry processes of different pathogens like bacteria, viruses, and alteration of host cell behavior by pathogens, virus-induced cell transformation, pathogen- induced diseases in plants, cell-cell fusion in both normal and abnormal cells

Unit IV: Sensory photobiology: Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins, stomatal movement, photoperiodism and biological clocks. Seed dormancy, inception of germination. Germination and growth regulators, juvenility, vernalization.

Solute transport and photo assimilate translocation: Uptake, transport and translocation of water, ions, solutes and macromolecules from soil, through cells, across membranes, through xylem and phloem. Transpiration, mechanisms of loading and unloading of photo-assimilates

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. *Stress avoidance. Relationship between stress and adaptation.* Secondary metabolites - Terpenes, phenols, flavonoids and nitrogenous compounds and their roles in plant physiology and as alternative medicine. Methods in phytochemicals: Extraction, fractionation and characterization

Reference Books:

- 1. AC. Deb, 2001.Fundamentals of Biochemistry, New Central Book Agency (P) Limited.
- 2. Dey, P. M., & Harborne, J. B. 1997, Plant Biochemistry. Academic Press.
- 3. Hans-Walter Heldt and Birgit Piechulla. 2010, Plant Biochemistry. London Academic.
- 4. Alberts, B., Bray, D., Hopkin, K., Johnson, A., Lewis, J., Raff, M., & Walter, P. 2013, *Essential cell biology*. Garland Science.

PAPER 10: ENZYMOLOGY 4 CREDITS

Objective: The paper aims in enlightening the students with the process of molecular catalysis carried out by the enzymes by involving the methodology involved in assessing the enzyme activity and mechanism of enzyme action. It aims in illustrating the enzyme catalysis, kinetics and regulatory aspects.

Outcome: It helps the students to learn the significant features of the biochemical catalysts and apply it in the pharmacological aspects in evaluating the effective-ness of a drug for enzyme inhibition studies.

Unit I: General aspects: Classification of enzymes, nature of enzymes, localization, isolation, purification and characterization of enzymes. Criteria of purity of enzymes, fold purity. Nomenclature and IUB classification of enzymes. Enzyme specificity, specific activity, assay methods; coupled enzyme assays, continuous, end point and kinetic assay. Units of enzyme activity, IU and Katal.

Unit II: Enzyme kinetics: Michaelis-Menten equation, initial velocity approach, steady state approach. Vmax, Km and their significance. Linear transformation of Michaelis-Menten equation; Lineweaver-Burk plot, Eadie-Hofstee, Wolf and Cornish-Bowden.Scatchard plot. Rate of a reaction, order and molecularity. First order reaction kinetics. Rectangular hyperbola, Michaelis- Menten equation as rectangular hyperbola, asymptote, linear transformation, calculation of slope, intercept. **Inhibition:** Reversible and irreversible inhibition; competitive, non-competitive, uncompetitive product inhibition and suicide inhibition. Determination of Ki and Kd.

Bisubstrate reaction: Cleland's notation with examples of ordered, ping-pong, and random reactions. General rate equation. Primary and secondary plots.

Unit III: Mechanisms of enzyme catalysis: Active site structure; methods of determining active site structure, isolation of ES complex, affinity labeling, chemical modification studies and active site structure investigation.

Nature of enzyme catalysis: Transition state theory, proximity and orientation, orbital steering, acid base catalysis, covalent catalysis, metal ion catalysis, nucle-ophilic and electrophilic catalysis, intramolecular catalysis, entropy effects. Effect of temperature and pH on enzyme catalyzed reaction.

Cooperativity: Binding of ligands to macromolecules; Scatchard plot, cooperativity, positive and negative cooperativity. Oxygen binding to hemoglobin. Hill equation, homotropic and heterotropic effectors, aspartyl transcarb amylase as an allosteric enzyme.

Unit IV: Mechanisms of action of specific enzyme: Chymotrypsin; zymogen activation, acid-base catalysis, charge relay net-work. Lysozyme, alcohol dehydrogenase, ribonuclease, carboxypeptidase A, RNA as an enzyme, abzymes, coenzymic action of NAD+, FAD, TPP, PLP, Biotin, CoA, folic acid and lipoic acid. Isoenzymes; LDH, multifunctional enzymes (DNA polymerase) and multi enzyme complex (PDC)

Unit V: Metabolic regulation of enzyme activity: Feedback and feed forward regulation mechanisms with examples, allosteric regulation, fine control of enzyme activity, multi-enzyme complexes with examples – PDH, fatty acid synthesis.

Reference Books:

- 1. Nelson, D. L., Lehninger, A. L., & Cox, M. M. 2008, Lehninger principles of Biochemistry. Macmillan.
- 2. Berg, J. M., Tymoczko, J. L., &Stryer, L, 2002, Biochemistry 5th edition.
- 3. Voet, D., Voet, J. G., & Pratt, C. W, 2016, Fundamentals of biochemistry: Life at the Molecular Level. New York: Wiley.
- 4. Conn, E., &Stumpf, P, 2009, Outlines of Biochemistry.John Wiley & Sons.
- 5. West, E. S., Todd, W. R., Mascon, H. S., & Van Bruggen, J. T. 1974, Textbook of biochemistry.Oxford and IBH Publishing.
- 6. A. C. Deb, 2001, Fundamentals of Biochemistry, New Central Book Agency (P) Limited.

PAPER 11: INTERMEDIARY METABOLISM 4 CREDITS

Objective: The objective of this course explains major catabolic and anabolic pathways in metabolism of carbohydrates, lipids, amino acids and nucleotides. The

student will be able to learn the key regulatory points in metabolic pathways and be able to explain how diet and hormonal signaling regulate metabolic pathways One can also study the molecular mechanisms underlying major inherited diseases of metabolism.

Outcome: It helps the students in appreciating the integrated approach of interrelated pathways of catabolism and anabolism. It also emphasizes on metabolic disorders at molecular level. It features the regulatory aspects of metabolism for better understanding of physiology and therapeutic applications.

Unit I: Introduction - Catabolism, anabolism, catabolic, anabolic and amphibolic pathways. Integration of metabolic pathways: Integration of carbohydrate and lipid metabolism, and their regulation and manipulation.

Hormonal regulation of metabolism: Effect of insulin and glucagon, catecholamines, growth hormones and corticosteroids on carbohydrate and lipid metabolism in different tissues. Action of thyroid hormones and their mechanisms.

Unit II: Metabolism of Carbohydrates: Digestion and absorption of carbohydrates, cellular ingestion of glucose, glycolysis, energetics regulation. Pathways of utilization of pyruvate-lactate, ethanol, gluconeogenesis, regulation, Cori cycle, glucose paradox, citric acid cycle its regulation, energetics, anaplerosis, glyoxylate cycle. HMP shunt pathway inter-conversion of hexoses. Uronic acid pathway, Utilization of non-glucose sugars, Biosynthesis of sucrose, starch and glycogen

Metabolic disorders: Disorders of carbohydrate metabolism; diabetes mellitus, classification, metabolic disturbances in diabetes

Unit III: Metabolism of Lipids: Degradation of triacylglycerols, phospholipids and sphingolipids and regulations; lipase, hormone sensitive lipase, phospholipases and sphingomyelinase. Fatty acid degradation; b-oxidation Knoop's experiment, saturated and unsaturated fatty acids. Regulation, a and w oxidation. Energetics and biosynthesis of fatty acids; fatty acid synthetase complex, chain elongation and desaturation. Pathways in plants and animals, conversion of linoleate to arachiodnante (scheme only).

Cholesterol synthesis, degradation and regulation: Metabolism of circulating lipids; chylomicrons, HDL, LDL and VLDL. Reverse cholesterol transport by HDL. Oxidized lipids and their metabolism, Foam cell formation. Regulation of blood cholesterol, triglycerides, LDL and HDL. Obesity, and mechanisms, exercise and regulation of energy metabolism.

Phospholipid biosynthesis and regulations: *De-novo* pathway and inter conversion, biosynthesis of phospholipids, sphingolipids, ether lipids and glycolipids. Degradation and biosynthesis of gangliosides and cerebrosides. Biosynthesis of prostaglandins, thromboxanes leukotrienes.

Unit IV: General mechanisms of amino acid metabolism and regulations: Deamination, transamination, decarboxylation desulphuration, degradation and biosynthesis of individual ammo acids. Differences in the pathways in microorganisms, plants and animals. Ketogenic and glucogenic amino acids. Regulation of amino acid biosynthesis; transglutaminase cycle, urea cycle.In born errors of amino acid degradation; Phenyl Ketonuria, alkaptonuria, maple syrup urine.

Proteins: General mechanisms of degradation in cells; ubiquitin-proteosome pathway, lysosomal pathway. Degradation and biosynthesis of glycoproteins and proteoglycans. Biosynthesis and degradation of heme and porphryns. Non ribosomal peptide synthesis: glutathione, gramicidine. Biosynthesis of creatin, polyamines.

Unit V: Purines and pyrimidines: Pathways of degradation of nucleic acids, purines and pyrimidines, uric acid formation. Salvage pathways, de novo biosynthetic pathways and regulations. Gout and Lysch-Nyhansyndrome.Conversion of nucleotides to deoxynuclotides.Mechanisms of action of methotrexate, 5-fluorouridine, azathymidine.

Reference Books:

- 1. Nelson, D. L., Lehninger, A. L., & Cox, M. M, 2008, Lininger Principles of Biochemistry. Macmillan.
- 2. Berg, J. M., Tymoczko, J. L., &Stryer, L, 2002, Biochemistry 5th edition.
- 3. Voet, D., Voet, J. G., & Pratt, C. W, 2016, Fundamentals of Biochemistry: Life at the Molecular level (pp. 817-847). New York: Wiley.
- 4. Conn, E., & Stump, P, 2009, Outlines of Biochemistry. John Wiley & Sons.
- 5. West, E. S., Todd, W. R., Mascon, H. S., & Van Bruggen, J. T, 1974, Textbook of biochemistry. Oxford and IBH Publishing.
- 6. A. C. Deb, 2001, Fundamentals of Biochemistry, New Central Book Agency (P) Limited.
- 7. Vasudevan, D. M., Sreekumari, S., &Vaidyanathan, K, 2013, Textbook of Biochemistry for Medical *Students*. JP Medical Ltd.

PAPER 12: CLINICAL BIOCHEMISTRY 4 CREDITS

Objective: The aims of this course are to demonstrate, through lectures and other learning environments, how basic biochemistry and analytical chemistry can be applied to medical diagnosis, treatment and management. The student will be able to learn about different clinical disorders, the biochemical consequences of particular disease process and the response to therapy.

Outcome: It trains the students to gain concepts of assessing the human physiology using biological fluid. It illustrates the mechanism of metabolic disorders at molecular level. It facilitates in employability in diagnostic and research institutes.

Unit I: Basic concepts: Health and disease. Normal and pathological changes affecting cells in the body. Cell death and the physiological causes; physical, chemical, biological agents and nutritional deficiency

Unit II: Blood: Composition, cells, functions of plasma proteins and lipo-proteins in diseases. Disorders of hemoglobin; thalassemia, sickle cell anemia. Anemias; microcytic, normocytic and macrocytic.

Diagnostic enzymology: Mechanisms of elevated enzyme activities. Clinically important enzymes; alkaline phosphatase, creatine kinase, LDH, AST, ALT and isoezyme changes

Unit III: Endocrine disorders: Laboratory diagnosis to assess the function of pituitary, thyroid, adrenals and gonads. Disorders - Graves' disease, Hashimoto disease, Addison's disease, Hypo- and Hyper secretion of hormones, Acromegaly, Gigantism

Unit IV: Liver: Biochemical indices of hepatobiliary diseases. Bile pigments; formation of bilirubin, urobilinogen, bile acids. Jaundice; pre-hepatic, hepatic and

post hepatic. Diagnosis of liver function tests, diseases of the liver - hepatitis cholestasis, cirrhosis, fatty liver and gallstones.

Kidney: Assessment of renal function; creatine clearance, renal calculi, uremia, laboratory investigation of kidney disorders.

Gastrointestinal disorders: Fractional gastric analysis, hypo and hyper acidity, gastric ulcers, malabsorption syndrome, steatorrhea, diarrhea.

Cardiovascular disorders: Major Cardio vascular system, atherosclerosis, risk factors and pathogenesis. Diagnosis and prognosis.

Unit V: Metabolic disorders of amino acid, lipid, nucleic acid and carbohydrates: Phenylketone urea, alkapton urea. Lesch-Nyhan, Gout.Diagnosis of metabolic disorders, Amniocentesis. Disorders of carbohydrate metabolism; diabetes mellitus, classification, etiology, management. Laboratory investigations; GTT, HbAlc, diabetic complications and advanced glycation end products. In born errors of carbohydrate metabolism; glycogen storage diseases, galactosemia, lactose intolerance, pentosuria. Determination of lipids and lipoproteins.Hyperlipoprotenemia and types of modification of lipoproteins.Taysachs, Nieman-Pick disease, Fabry's disease. Cancer: Etiology, diagnosis, treatment and prognosis. Carcinogens, oncogenes, mechanism. Biochemistry of ageing: Cellular senescence, cystic fibrosis, Mechanism of detoxification of xenobiotics.

Reference Books:

- 1. Varley, H., Gowenlock, A. H., McMurray, J. R., & McLauchlan, D. M, 1988, Varley's practical clinical biochemistry. Heinemann Medical.
- 2. Oser, B. L., & Hawk, P. B, 1965, Hawk's physiological chemistry.Mc-Graw-Hill.
- 3. Vasudevan, D. M., Sreekumari, S., &Vaidyanathan, K, 2013, Textbook of biochemistry *for medical students*. JP Medical Ltd.

ELECTIVE 3 (a) PROTEOMICS 4 CREDITS

Objective: This paper aims in comparing the basic biology of proteins and advanced science of proteomics which aims to look into entire set of proteins in the milieu.

Outcome: The paper will help the students in understanding techniques involved at large in major contribution in transition from protein chemistry to proteomics.

Unit I: Introduction to proteomics, Analytical methods of protein and peptide separations, protein digestion techniques, Mass Spectrometers for protein and peptide analysis. Protein identification by peptide mass fingerprints, peptide sequence analysis by tandem mass spectrometry.

Unit II: Protein sequence analysis using software: Emboss, Data mining pro-

teomes, Motif mapping using Prosite, Prodom, protein expression profiling, protein - protein interactions, protein complexes. Mapping protein modifications. Protein secondary structure analysis, Molecular visualization protein 3D structure using Rasmol, pdb file format.

Unit III: Molecular modeling, Concepts of Molecular Modeling, Molecular structure and internal energy, Energy minimization of small molecules, Ab initio, DFT and semi-empirical methods, Construction of initial model, Refining the Model, Manipulating the model, Rotomer libraries, Three- Dimensional structure prediction, comparative modeling, Homology modeling, Threading, Energy based prediction of protein structures, Modeling software SPDBV. SWISS - Model.

Unit IV: Introduction to basic concepts, Molecular recognition by receptor and ligand design, Generation of Rational Approaches in Drug design, Introduction to drug designing, Discovering a drug, Target identification and validation, Identifying the lead compound, Optimization of lead compound.

Unit V: Docking methods introduction, three dimensional descriptions of binding site environment and Energy calculation, Automatic Docking Method, Three Dimensional database search Approaches, Design of ligands, Drug-receptor interactions automated structure Construction methods, AUTODOCK.

Reference Books:

- 1. Cohen N. C. 1996. Guidebook on Molecular Modeling in Drug. Design. Academic Press.
- 2. Brandon C., Tooze J. 1998. Introduction to Protein Structure. Garland Science Publishing.
- 3. Creighton T E. Proteins. 1983 Structures and Molecular Properties. Freeman, New York

Elective 3(b) Bioethics, Research Design, and IPR 4 Credits

Objective: This course seeks to identify and explore salient ethical, legal, and

policy issues—and possible solutions—associated with the research in life sciences. It aims to enlighten the student with research methodology for their prospective research dissertation work/career.

Outcome: The student gains knowledge on IPR by knowing how to acquire the patent and copyright for their innovative works. The gain the insights of research design which is very important for their project work. They learn also about plagiarism.

Unit I. Ethics; Bioethics; Human dignity and human rights; Consent; Human vulnerability and personal integrity; Privacy and confidentiality; Equality, justice and equity; Social responsibility and health; Protecting future generations; Protection of the environment, the biosphere and biodiversity; Protection of Human subjects; Stem Cell Ethics; The Ethics of Plant Use such as in case of transgenic crops, Biosafety and management.

Unit II. Research methodology: Meaning, objective, motivation, significance of research; types of research; research approaches; research methods versus methodology; Research and scientific methods; Research process; Criteria for good research.

Research problem and research design: Selecting research problem; necessity of defining a problem; techniques involved in defining the problem; need for research design; different research designs; basic principles of experimental design; important experimental designs.

Unit III. Review of related literature: Understanding the role of review; how to begin a search for related literature- Library reference, recording and indexing, classification of references, internet sites for biological references; Writing research proposal: Characteristics of a proposal; content and organization of a proposal; weakness in proposal seeking funding.

Interpretation and report writing: Meaning of interpretation; technique of interpretation; precautions in interpretation; significance of report writing; layout of research report; types of reports; Presentation of research work- oral, poster and writing research paper; Precautions for writing research report and plagiarism.

Unit IV. Overview of Intellectual Property- Introduction and the Need for Intellectual Property Right (IPR), IPR in India – Genesis and Development, IPR In Abroad, Some important examples of IPR. Role of Intellectual Property Rights (IPR) in Research and development, Infringement of intellectual property rights, Enforcement Measures. World intellectual property (WIPO), Patent Cooperation Treaty (PCT), India as a Receiving Office (RO), National Phase Patent applications and conventional applications.

Inventions which are patentable in India (Section 3 of Indian Patents Act), novelty and inventive step requirements (Section 2 of Indian Patents Act), compulsory licensing in India, Overview of US patent practice: statutes 35 USC 101, 112, 102 and 103.

Unit V. Ethical, legal, social and scientific issues in biological research. Basic knowledge of organizing conferences, symposia, workshop, exhibition etc. A brief idea of funding agencies such DST, DBT, ICMR, CSIR and UGC. Patents, Utility Models, Patent filing, different layers of the international patent system, Copyright, Trademark.

Life Sciences Research and Intellectual Property Rights Management, Licensing

and Enforcing Intellectual Property, Commercializing Invention, Case studies of Biotechnology.

Reference Books:

- 1. Dr. G.B. Reddy (2016) Intellectual Property Rights and the Law, Gogia Law Agency.
- 2. B.L.Wadehra (2016); Law relating to Intellectual Property, Universal Law Publishing Co.
- 3. P. Narayanan (2008); Intellectual Property Law, Eastern Law House
- 4. Dr.S.R. Myneni (2003); Law of Intellectual Property, Asian Law House.
- 5. Sheetal Chopra (2010); Patent Agent Examination, Lexis Nexis

PRACTICAL 3: CLINICAL BIOCHEMISTRY 6 CREDITS

Objective: The aim of this course is to learn to determine the biochemical constituents of blood and urine.

Outcome: It trains the students to gain concepts of assessing the human physiology using biological fluid. It facilitates in employability in diagnostic and research institutes.

1. Analysis of Blood for:

- Glucose by chemical (O-toluedene, Folin-Wu methods)
- Enzymatic methods (GOPO)

2. Analysis of serum for:

- Creatine and creatinine
- Uric acid by chemical and enzymatic methods
- Urea
- Inorganic phosphorus
- Bilirubin
- Vitamin-E and Vitamin-C
- Total Cholesterol, HDL and LDL cholesterol
- Total proteins, albumins and globulins by dye binding method
- SGOT and SGPT
- LDH
- Acid and Alkaline Phosphatase
- Amylase

3. Analysis of Plasma for Fibrinogen

4. Analysis of Urine for:

- Qualitative tests and microscopic examination
- Urea by DAM method.

Fourth Semester Summer project work – 2 Credits Thesis and viva-voce examination – 12 Credits

MSc Cosmetic Science

The aims of the program are to:

 Provide knowledge on cosmetics, and related sciences cosmeceuticals (cosmetics with skin, hair and oral care benefits), Personal care and hygiene products.

- Provide multidisciplinary scientific knowledge to gain expertise in the field and to respond the industry challenges effectively.
- Provide with knowledge on marketing approaches on studying consumer need, need gaps, managing competition and global markets.
- Provide practical skills in the area of biology, formulation science and analytical techniques required to scientifically design and develop products.
- Develop your potential to have a career in this fast growing industry in the area of product development & research, regulatory, quality assurance and manufacturing or pursue academic research in the area or to become an entrepreneur in the field.

Upon successful completion of this course students, will be able to demonstrate:

- 1. Your scientific knowledge in design and development of a product that is safe, efficacious and meeting consumer, regulatory and business needs.
- 2. An understanding at strategic level, the structure and functioning of the industry.
- 3. Knowledge to have a career in all technical area in this field.

Distinctive features of the program

- Faculty from the field of pharmaceutical sciences, life sciences, physical sciences, basic medical sciences, management studies and industry form integral part of the program
- Opportunity of research-led Master's Project.
- Provision of a vocationally relevant Master's degree course.

Distinctive features of the course

- Currently not many postgraduate courses in Cosmetic Science in India, hence the proposed course offers a unique educational experience and very good employment prospects
- Developed in consultation with the industry and professional bodies

Eligibility to Join the Program

Degree in science.

	Semester I	Credits	
Paper 1	Basic human Anatomy and Physiology	4	
Paper 2	Cosmetics principles	4	
Paper 3	Fundamentals of Nanotechnology	4	
Paper 4	Analytical techniques	4	
Electives 1	Fundamentals of Biochemistry and Bio-molecules	4	
Practical 1	Human Anatomy and Physiology	6	
	Total	26	
Semester II			
Paper 5	Cosmetics Biology	4	
Paper 6	Cosmetics Formulation Science	4	
Paper 7	Cosmeceuticals	4	
Paper 8	Herbal Science	4	
Electives 2	Genetics.	4	
Practical 2	Formulation Science	6	
	Total	26	
Semester III			
Paper 9	Cosmetics – Analysis and Evaluation	4	
Paper 10	Statistical Methods for Biology	4	
Paper 11	Applied Microbiology	4	
Paper 12	Industrial Cosmetics	4	
Electives 3	Environmental aspects of Nanomaterials	4	
Practical 3	Cosmetics – Analysis & Evaluation	6	
	Total	26	
	Semester IV		
	Summer Project: Marketing case studies Dissertation and Viva-Voce examination	2	
	Project work – Dissertation and viva voce examination	12	
	Total	14	
	Total Credits	92	

Course Curriculum

SEMESTER I

Paper 1: Basic Human Anatomy & Physiology 4 CREDITS

Course Objectives: This course teaches the basic anatomy and physiology of human body. The students are taught the functioning aspects of the human body at molecular level.

Course outcomes: At the end of this course the students will be able to appreciate the anatomical and physiological aspects of the human body.

Unit I. Introduction: Definition, scope of anatomy and physiology, basic terminologies. General cellular anatomy and physiology: Cell, cell junctions, transport mechanisms, homeostasis, ion channels. Tissues: Definition classification of tissues, their location, characteristics and Functions. Body fluids and blood: Body fluids, composition and functions of blood, haemopoiesis, mechanism of coagulation. Blood grouping and its significance, lymphatic system.

Unit II. Human skeleton: Structure, composition, classification and function of bones. Identification and few salient features of important bones of axial and appendicular skeleton. Classification of joints, types of movements. Cardio-Vascular system -Anatomy and physiology of heart. Blood circulation, blood pressure.

Unit III. Digestive system: Physiology with special reference to liver, pancreas and intestine.

Respiratory system: Anatomy of respiratory tract. Transport of oxygen and carbon dioxide.

Urinary system: Structure and function of kidney. Skeletal muscle: Physiology of muscle contraction, definition of myasthenia gravis

Unit IV: Nervous system: Definition and classification of nervous system. Anatomy and functions of cerebrum, cerebellum, brain stem (pons, medulla and mid brain), hypothalamus, thalamus, basal ganglia

Cranial nerves- names and their functions. Autonomic nervous system-Anatomy and functions of sympathetic and parasympathetic nervous system

Unit V. Endocrinology: Physiology of pituitary, thyroid, parathyroid, adrenal and pancreas.

Reproductive system: Sex hormones, menstrual cycle. Definition of the term "pharmacology"

Basic understanding of the terms: Pharmacodynamics, Pharmacokinetics, Pharamacogenetics, adverse drug reactions, and pre-clinical & clinical studies.

- 1. Fundamentals of Anatomy and Physiology for Student Nurses by John Wiley and Sons
- 2. Anatomy and Physiology for Nurses, by Watson
- 3. Anatomy and Physiology for Nurses by Evelyn C. Pearce
- 4. Physiology and Anatomy: A Basis for Nursing and Health Care by Sigrid Rutishauser
- 5. Anatomy and Physiology for Nurses and Students of Human Biology by Sears, W.Gordo

- 6. Anatomy and Physiology for Nurses, by Ross, Jean R.W.
- 7. Anatomy and Physiology for Nurses by Tony William Alpha
- 8. Basic & clinical Pharmacology by Katzung B.G.

Paper 2: Cosmetic Principles 4 CREDITS

Course Objectives: This paper facilitates the students in learning the technical aspects of cosmetic formula preparation up to a product level. It trains the students with the use of ingredients in cosmetics and methods of separation of suspensions, emulsions and techniques involved in characterizing the preparation.

Course Outcomes: The student overall learns the vital concepts implemented in cosmetic development enabling them to have greater chances of employability

Unit I. Regulatory definition of Cosmetics. Broad classification of cosmetic products for skin, hair and oral care. Application of various product forms in cosmetics: Solutions, creams, lotions, ointment, paste, gels, sticks, tablets, capsules, powders and aerosols. Examples from marketed product. Product Development: Generation of data. Requirement of a successful formula. Product development process: Defining the product, selection & sources of ingredients, formula optimization, test batches.

Unit II. Cosmetic Ingredients: Water: Special consideration for cosmetics use. Surfactants: Classification and application in cosmetics – Foaming agents, emulsifiers, and solubilizes. Emollients, humectants and rheological additives: Classification and application in cosmetics. Antioxidants, antimicrobial and chelating agents used as preservatives. Factors affecting effectiveness of antimicrobial preservatives. Perfume: Classification of perfumes. Perfume ingredients listed as allergens in EU guidelines.

Unit III. Suspensions and Emulsions: Suspensions: Definitions, general method of preparation, flocculated and de-flocculated suspension, Stoke's law. Emulsions: Definition, classification, general method of preparation of a cosmetic emulsion, stability of emulsion – creaming, cracking and phase inversion. Multiple emulsions, concept of HLB and micelles.

Unit IV. Micrometrics: Particle size and distribution, average particle size, number and weight distribution, particle number, methods of determining particle size, optical microscopy, sieving, sedimentation measurements, particle shape, specific surface, methods of determining surface area, permeability, adsorption, derived properties of powders, porosity, packing arrangement, densities, bulkiness and flow properties.

Unit V. Rheology: Newtonian systems, law of flow, kinematic viscosity, effect of temperature on viscosity, non-Newtonian systems – Plastic, pseudoplastic and dilant system, thixotropy determination of viscosity, capillary, falling ball and rotational viscometers.

- 1. Harry's Cosmeticology Wilkinson, Moore, seventh edition, George Godwin.
- 2. Cosmetics Formulation, Manufacturing and Quality Control, P.P. Sharma,

4th edition, Vandana Publications Pvt. Ltd., Delhi.

- 3. Drugs and Cosmetic act/rules by govt. of India Publication
- 4. European Union regulation for cosmetics.
- 5. Poucher's Perfumes, Cosmetics and Soaps, Hilda Butler, 10th Edition, Kluwer Academic Publishers
- 6. Handbook of Cosmetic Science and Technology, 3rd Edition, André O. Barel, Marc Paye, Howard I. Maibach, Marianne Mahieu Informa Healthcare USA, Inc.
- 7. Theory and practice of industrial pharmacy by Lachmann
- 8. E.A.Rawlins, Bentley's text book on pharmaceutics, 8th edition, 1997.

Paper 2: Fundamentals of Nanotechnology 4 Credits

Course Objectives: By the end of the course, students will understand the creation of, characterization of, and manipulation of nanoscale materials, systems, and devices and how they can be exploited for new applications. Students will learn about exciting applications of nanotechnology at the leading edge of scientific research. Students will apply their knowledge of nanotechnology to a topic of personal interest in this course.

Course Outcome: This is an interdisciplinary and emerging area. The students are taught the basics of nanotechnology and their applications in various fields. The course introduces the students to the new and novel applications to solve biomedical problems through nanotechnology.

Unit I: Background to Nanotechnology: Emergence of nanotechnology, Challenges in nanotechnology, Applications of Nanotechnology. Nanomaterials and bulk solids. Carbon Nanotechnology - Bucky balls, carbon nanotubes, graphene and diamond. Production of carbon tubes – arc discharge, CVD, Pyrolatic technique, purification and separation of carbon nanotubes, diamond synthesis routes, preparation of nano-diamonds.

Unit II: Properties of nanomaterials: Fundamental properties of nanomaterials – Size dependent properties, Surface to volume ratio. Optical – Surface Plasmon Resonance, size effect on optical properties, magnetic, mechanical, catalytic, thermal, electrical & electronic properties.

Unit III. Synthesis of Nanomaterials: Overview of methods of synthesis. Top-Down Approach and Bottom-up approach with examples.

Physical Methods – Lithography, nanoimprint lithography, soft lithography, Moulding/Replica moulding: PDMS stamps, Printing with soft stamps, Edge lithography, Dip-Pen Lithography, set up and working principle and ball milling.

Chemical Methods – Colloidal methods and self-assembly, and sol-gel, micelles and micro emulsion techniques. VLS growth of nanowires, Hybrid methods. Introduction to thin film technologies.

Biological Synthesis of Nanomaterials – Use of bacteria, fungi, Actinomycetes for nanoparticle synthesis, Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; Mechanism of formation; Viruses as components for the formation of nanostructured materials; Synthesis process and application, Role of plants in nanoparticle synthesis. **Unit IV: Classification of nanomaterials** - Zero dimensional, one-dimensional and two dimensional nanostructure materials. Semiconductors, quantum dots, ceramics and nanocomposites and core-shell nanoparticles. Inorganic and organic nanoparticles-liposomes, micelles, nano-emulsions, hydrogels and polymeric nanoparticles, mesoporous silica nanoparticles, zinc oxide nanoparticles, titanium sponges

Unit V. Interaction of nanomaterials with biological systems: Nanoparticle interactions at the cellular level, Interactions of nanoparticles with biomolecule and membranes. Biomolecule-nanoparticle interaction, Vorman effect. Nanoparticle-protein corona formation. Composition of protein corona complex. Mechanism of adsorption of proteins on nanoparticles. Parameters affecting protein corona complex.

Reference Books:

- 1. Nanoscale Science and Technology, Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, John Wiley & Sons, Ltd., UK, 2005, ISSN: 978-0-470-85086-2.
- 2. Introduction to Nanotechnology, Charles P. Poole Jr and Frank J. Owens, Wiley Interscience, New Jersey, 2003, ISSN: 978-0-471-07935-9.
- 3. Bio-Inspired Nanomaterials and Nanotechnology, Edited by Yong Zhou, Nova Science, 2005, ISSN: 978-1608761050.
- 4. Nano:The Essentials: Understanding Nanoscience and Nanotecnology, T.Pradeep, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2008, ISSN: 978-0071548298.
- 5. Nanocrystals: Synthesis, Properties and Applications, C. N. R. Rao, P. J. Thomas and G. U. Kulkarni, Springer, New York, 2007, ISSN: 978-3-54068751-1.

Paper 4: Analytical Techniques 4 Credits

Objectives: In this paper students will be able to demonstrate methods for purifying proteins, and analyzing biological molecules by electrophoresis, Western blotting, and enzyme activity assays. They will acquire the skills required to design and interpret the data from scientific experiments. Also, it will emphasize the learning of basic lab skills (including dilutions, good pipetting technique, and basic statistical analysis) and good lab practices (such as good notebook keeping).

Outcome: The units of this paper are crucial for implementation of research ideas at molecular level. It trains the students in adopting various techniques in biological research. This significantly enhances the employability of the candidates in Biotechnological, Pharmaceutical Industries and Analytical Laboratories and research institutes.

Unit I: Spectroscopy: UV-Visible Spectroscopy: Electronic transitions, Photometric laws, instrumentation and application. IR Spectroscopy: Principles, Modes of vibrations, instrumentation and application.

Unit-II: Chromatography: a. Introduction, classification, Principles of separation. b. General principles, instrumentation and applications of Paper Chromatography, Thin Layer Chromatography and High Performance Thin Layer Chromatography **Unit-III:** Introduction to NMR, Mass and Raman Spectroscopy. Introduction to HPLC and GC Techniques

Unit-IV: Introduction to Electrochemical Methods of Analysis: Conductometry (Principles and Conductometric titrations) and Potentiometry (Principles, Electrodes, measurement of pH, Potentiometric Titrations). Introduction to Thermal Methods of analysis: Theory and applications of Thermo Gravimetric Analysis (TGA), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC) and Thermo Mechanical Analysis (TMA).

Unit-V: Method Validation: Analytical method development and Validation. Quality assurance in Cosmetic Industry.

Reference Books:

- 1. Spectrometric Identification of Organic compounds Robert M Silverstein, Sixth edition, John Wiley & Sons, 2012.
- 2. Principles of Instrumental Analysis Doglas A Skoog, F. James Holler, Timothy A. Nieman, 5th edition, Eastern press, Bangalore, 2014.
- 3. Vogel's Text book of quantitative chemical analysis Jeffery, Basset, Mendham, Denney, 5th edition, ELDS, 2011.
- 4. Chromatographic Analysis of Pharmaceuticals, John A. Adamovics, 2nd Edition.
- 5. Practical Pharmaceutical Chemistry, Part two, A. H. Beckett & J. B. Stenlake – 4th Edition.
- 6. Instrumental Methods of Chemical Analysis B. K. Sharma 9th Edition.
- 7. Instrumental Methods of Analysis Hobert H. Willard, 7th Edition.
- 8. Organic Spectroscopy William Kemp, 3rd Edition

Elective 1: FUNDAMENTALS OF BIOCHEMISTRY AND BIOMOLECULES 4 CREDITS

Objective: The course aims to highlight the role of biomolecules in structure and function of life. It spans over the significance and methodology involved in characterizing major biomolecules.

Outcome: This paper trains students to appreciate the salient features of biomolecules in the organization of life. It helps the students in understanding the classification, functions and application aspects of biomolecules.

Unit I. Classification of carbohydrates: Monosaccharides: Configuration and conformation of monosaccharides, Reducing and optical properties of sugars, Derived monosacharides: deoxyglucose, amino sugars, muramic acid, neuraminic acid. Disaccharides: Stability of glycosidic bond, Sucrose, Lactose, Maltose, Trehalose Polysaccharides: Homopolysaccharides and heteropolysaccharides, Structural polysaccharides-cellulose, hemicellulose, pectin, lignin, chitin, chitosan, Storage polysaccharides; starch, glycogen, inulin, Stearic factors in polysaccharides folding, sugar code and lectin, Glycosaminoglycans, mucopolysaccharides, hyaluronic acid, Chondriotin sulfate, keratan sulfate, dermatan sulphate, Bacterial cell wall – proteoglycans and peptidoglycans

Structural elucidation of carbohydrates: Structural Elucidation of Glucose, Carbohydrate characterization: graded acid hydrolysis, enzyme hydrolysis, periodate oxidation, methylation, acetylation, GC-MS, and NMR. Glycobiology: Glycoproteins;

N- and O-glycosylation, lectins, Proteoglycans; agreecan, syndecan, and decorin. Carbohydrates in tissue engineering.

Unit II. Amino acids: Nomenclature, classification and buffering properties of amino acids, zwitterionic structure, reaction of amino acids, unusual amino acids, non-protein amino acids. Peptides: Features of the peptide bond, naturally occurring peptides; glutathione, Gramicidin, enkaphalins and endorphins. Chemical synthesis of peptides; Khorana's solution phase synthesis, Merrifield's solid phase synthesis.

Hierarchy of protein structure: Primary Structure: Determination of amino acid composition: Acid and base catalyzed hydrolysis, separation, quantification, Determination of primary structure Sequencing strategies, Determination of N and C terminal residues, Automated sequanators, determination of site of glycosylation and type of linkage (o-glycosyl and n-glycosyl). Determination of s-s-bond position Secondary structure of protein: a, β sheet, β -bend, β -turn and super secondary structures. Secondary structure prediction methods; Ramachandran plot, Chou and Fasman algorithm.

Tertiary and quaternary structures: Protein folding and conformation: Anfinsen's experiment. Bonds in protein folding: Weak forces of interaction; hydrogen bonding, Vander Waal's forces, London force, ionic interactions, hydrophobic interactions, S-S bridges, peptide bond, glycosidic bond, phospodiester bond, and allolysine. Chaperones in protein folding and Levinthal paradox. Denaturation (pH, temperature, chaotropic agents) and renaturation of proteins, molten globule. Protein-protein interactions. Structures of myoglobin hemoglobin, immunoglobulin, collagen, chymotrypsin and keratin. Isolation of proteins; overview of purification and criteria of purity.

Unit III. Lipids: Classification of lipids: Simple, Compound and Derived Lipids. Fats, oils, and waxes. Occurrence and properties of fatty acids. Esters of fatty acids, Triacylglycerols. Phosopholipids, Glycolipids, Sphingolipids, Cerebrosides and Gangliosides. Steroids, Sterols, Cholesterol, Bile acid and Bile salts.

Lipid mediators: Eicosanoids, prostaglandins, leukotrienes, prostacyclins, thrombaxanes, DAG and ceramide.

Unit IV. Nucleic Acids: Nitrogenous bases: Purines, Pyrimidines; nucleosides, nucleotides, unusual bases. Physiochemical properties of nucleic acids. Difference between RNA and DNA. Chemical reactions of DNA and RNA. Secondary structure of DNA. Watson and Crick model; B and Z DNA, other models of DNA structure. Supercoiling of DNA. Denaturation and renaturation of Nucleic acids. Melting of DNA, Tm; factors affecting Tm, Cot curve, classification of DNA based on cot curve. Nucleotides as regulatory molecules, enzyme cofactors and mediators of chemical energy in cells. Other secondary structural features in DNA, steam loop structure, palindromic sequences, cruciforms. DNA protein interaction; zinc finger leucinc zipper, helix-turn-helix, other motifs, DNA bending and kinks. Sequencing of DNA: Maxam Gilbert method, dideoxy method. Genetic Code, Chargaff's rule. Types and roles of RNA, Secondary structure of tRNA: cloverleaf model. Isolation of DNA and RNA from biological sources (microbes, plants and animals). Purification of nucleic acids.

Unit V. Porphyrins – Structure and properties of porphyrins – Heme, chlorophyll and cytochromes. Vitamins – Water soluble and insoluble vitamins, structure and function, deficiency symptoms. DRI, RDA. Reactive oxygen species and detoxification mechanisms.

Reference Books:

- 1. Nelson, D. L. & Cox, M. M. Lehninger, 2013, Principles of Biochemistry. Freeman - 6th edition,
- 2. Berg, J. M., Tymoczko, J. L. and Stryer, L. 2011, Biochemistry. Freeman 7th edition.
- 3. Voet, D., Voet, J. G., & Pratt, C. W. 1999. Fundamentals of Biochemistry (pp. 408-409). New York: Wiley – 4th edition.
- 4. Conn, E., &Stumpf, P. 2009. Outlines of Biochemistry. John Wiley & Sons 5th edition.
- 5. West, E. S., Todd, W. R., Mascon, H. S., & Van Bruggen, J. T. 1974. Textbook of Biochemistry. Oxford and IBH Publishing - 4th Edition

Practical-1: Anatomy and Physiology – 6 Credits

- 1. Microscopic study of different tissues.
- 2. Blood experiments:
 - a. Study of appliances used in hematological experiments
 - b. Determination of total Red Blood Corpuscles (RBC) count
 - c. Determination of White Blood Corpuscles (WBC) count
 - d. Estimation of hemoglobin
 - e. Estimation of Differential Leukocyte Count (DLC)
 - f. Estimation of Erythrocyte Sedimentation Rate (ESR)
 - g. Determination of Blood groups.
 - h. Determination of Bleeding and Clotting time
- 3. To record human heart rate, and pulse rate.
- 4. Recording of human body temperature and Body Mass Index (BMI).
- 5. Determination of tidal volume & vital capacity.

SEMESTER II Paper-5: Cosmetics Biology 4 Credits

Course Objectives: The students will learn the structural and functional aspects of skin. The paper teaches the students to understand the various mechanisms of skin physiology at various levels of human growth.

Course Outcomes: The students at the end will learn the biology behind the use of cream and cosmetics which enables higher chances of employability in cosmetic companies.

Unit I. Structure and function of skin with detailed emphasis on epidermis, dermis and hypodermis. Types of Skin and Hyperkeratotic Condition

Unit II. The Development and physiology of Baby Skin, Differences between baby's skin and adult skin, Frequent Skin Problems in Newborns, The Care of Baby Skin. Age-Associated Changes in Human Skin: Morphological and Histological Changes. The cosmetic care of elderly skin. Racial (Ethnic) Differences in Skin Properties

Unit III. Mechanisms of allergic reaction and skin conditions. General Concepts of Skin Irritancy: Principles and Molecular mechanisms of Skin Irritation, Irritancy and Skin Irritant Evaluation and Symptoms, Factors Predisposing to Cutaneous Irritation, Cosmetic and Occupational Irritants.

Unit-IV. Safety Terminologies: Contact Dermatitis, Irritant Contact Dermatitis (Irritation), Allergic **Contact Dermatitis**, Photo-irritant Contact Dermatitis, Photoirritation or Phototoxicity, Photoallergic Contact Dermatitis, Contact Urticaria Syndrome, Acnegenicity, Sensitive Skin. Alternate safety testing methods (substitute animal testing). Cell line techniques

Unit V. Anatomy of tooth & Gums, The Structure and Properties of Hair & hair growth cycle. Anatomy and physiology of nail, Physico-chemistry and Aesthetics of nail. Anatomy and physiology of eye.

- 1. Harry's Cosmeticology Wilkinson, Moore, seventh edition, George Godwin.
- 2. Poucher's Perfumes, Cosmetics and Soaps, Hilda Butler, 10th Edition, Kluwer Academic Publishers
- 3. Handbook of Cosmetic Science and Technology, 3rd Edition, André O. Barel, Marc Paye, Howard I. Maibach, Marianne Mahieu Informa Healthcare USA, Inc.
- 4. Cosmetic formulation of skin care products Eric Jungerman (Cosmetics and science technical series 3)

Paper-6: Cosmetic formulation science 4 Credits

Course Objectives: The students learn various mechanism of delivery of active component to skin, hair, and toothpaste. The students learn the important components of skin creams, baby powders, shampoos, and toothpastes.

Course Outcomes: The students at the end learn to appreciate the protocol followed in formulation and development of cosmetics.

Unit-I: Dermal Delivery: Factors affecting penetration through skin. Permeation enhancers. Iontophoresis. Site specific skin care needs: Face, eyelids, lips, hands, feet, nails & cuticle, scalp, neck, body, and underarms. Skin hydration, skin lipids, natural moisturizing factors, dry skin and ways to moisturize skin. Skin Cleansing products: soap and chemistry of soap making, evolution of syndet bars, face wash and body wash, their formulation differences and skin benefits.

Unit II. Skin creams: Classification of skin creams based on their cosmetic benefits and their physicochemical properties. Requirements of Ideal skin cream. Building blocks and formulation of cold cream, vanishing cream, moisturizing cream, body lotion and moisturizing gels. Skin benefits of petroleum jelly. Face mask – benefits and application of clay based, peel off and tissue face mask. Building blocks and formulation of hand-made soap, face wash, clay based mask and peel off mask.

Unit III: Requirements of an Ideal shampoo. Shampoo Building blocks and formulations. Mechanism of hair conditioning. Building blocks and formulation of Hair conditioners and hair oils. Baby shampoo Classification of hair dyes. Chemistry and formulation of Para Phenylene diamine based hair dyes.

Unit IV. Requirements of an ideal toothpaste. Oral care: Building blocks and formulation of toothpaste and mouth wash. Color Cosmetics: Building block and formulation of Lipsticks, mascara, and nail polish.

Unit V. Building blocks and formulation of Face and body powder, Shaving cream, after shave, depilatories and hair straightening products. Deodorants and antiperspirants , Active ingredients and mechanism of action.

- 1. Harry's Cosmeticology Wilkinson, Moore, seventh edition, George Godwin.
- 2. Drugs and Cosmetic act/rules by govt. of India Publication
- 3. European Union regulation for cosmetics.
- 4. Cosmetics Formulation, Manufacturing and Quality Control, P.P. Sharma, 4th edition, Vandana Publications Pvt. Ltd., Delhi.
- 5. Poucher's Perfumes, Cosmetics and Soaps, Hilda Butler, 10th Edition, Kluwer Academic Publishers
- 6. Handbook of Cosmetic Science and Technology, 3rd Edition, André O. Barel, Marc Paye, Howard I. Maibach, Marianne Mahieu Informa Healthcare USA, Inc.
- 7. Cosmetic formulation of skin care products Zoe Diana Draelos and Lauren A.Thaman

Paper 7: Cosmeceuticals 4 Credits

Course Objectives: This course enables the students to know the evolution process of cosmetics into cosmeceuticals.

Course Outcomes: It explains the mechanism of ailments like skin pigmentation, wrinkles, acne, sun burns, prickly heat, and dandruff. The students will learn the research aspects in developing a cosmetic into a cosmeceutical by studying the basis of treatment on par.

Unit I. a) Features of cosmetic product regulation in the European Union -- Ingredients, Safety assessment, Efficacy data. Labelling requirements for cosmetic products. Evolution of Cosmetics to Cosmeceuticals. Japanese and USFDA regulation for quasi drugs and OTC cosmetics. b) Environmental and safety concerns of certain cosmetic ingredients that are debated and discussed – Examples: nano size inorganic sunscreens, parabens, triclosan, formaldehyde liberator, polythene beads, petroleum oils, sodium & ammonium laureth sulfates, triclosan, phthalates. c) Private body (Cosmos) guidelines on green cosmetics with respects to use of colors, preservatives, emulsifiers and excipients, challenges in green formulation. In each category listed below a case study will be conducted on a marketed product addressing the condition. Case study will be based on labeled ingredients and claim.

Unit- II. Skin Pigmentation and wrinkles. Skin Pigmentation: Melanogenesis, and ethnic differences. Ways to control skin pigmentation: Tyrosinase inhibitors, melanosome transfer – examples of actives. Building blocks and formulation of an anti-blemish cream. Case study on a skin lightening product. Differences between skin bleaches and skin lightening products. Skin Wrinkles: Factors that leads to skin wrinkles. Role of antioxidants in reducing skin wrinkles. Building blocks and formulation of an anti-wrinkle product. Case study on an anti-aging / anti-wrinkle product.

Unit-III. Sun protection: Solar spectrum and wavelength, UV A and UV B rays of sun. skin damages caused by over exposure to sun, organic and in-organic sunscreens, SPF and tan-protection. Challenges in developing sunscreen formulation. Global regulatory aspects of sunscreen products. Case study on sunscreen products.

Unit-IV: Acne, Prickly heat and dandruff. Causes and current treatment. Building blocks for the development of anti-acne, prickly heat and anti-dandruff formulation. Case study on marketed products.

Unit-V: Common problems associated with teeth, gums and oral cavity. Halitosis, plaque, cavities, sensitive teeth. Basic understanding of the cause. Role of antimicrobial, antioxidant and astringents for oral care. Denture cleansers. Building blocks and formulation of an anti- cavity, and tooth sensitivity relief toothpaste. Case study on marketed products.

- 1. Drugs and Cosmetic act/rules by govt. of India Publication
- 2. European Union regulation for cosmetics
- 3. Cosmetics Formulation, Manufacturing and Quality Control, P.P. Sharma,

4th edition, Vandana Publications Pvt. Ltd., Delhi.

- 4. Harry's Cosmeticology Wilkinson, Moore, seventh edition, George Godwin.
- 5. Poucher's Perfumes, Cosmetics and Soaps, Hilda Butler, 10th Edition, Kluwer Academic Publishers
- 6. Handbook of Cosmetic Science and Technology, 3rd Edition, André O. Barel, Marc Paye, Howard I. Maibach, Marianne Mahieu Informa Healthcare USA, Inc.
- 7. Cosmetic formulation of skin care products Zoe Diana Draelos and Lauren A.Thaman

Paper 8: Herbal Science 4 Credits

Course Objectives: In this paper, the student learns the basic principles in use of alternative medicine.

Course Outcomes: It helps the students to span over the phytochemical importance of various herbs proposed by various medicine systems like Ayurveda, Unani, Siddha and Homeopathy.

Unit-I: Introduction: Definition, present status, future scope & development of Herbal Science Classification of herbs: Alphabetical, biological, chemical, taxonomical, pharmacological, chemo taxonomical & serotaxonomical classifications. Basic principles involved in the alternative system of medicine and their application in skin, hair and oral care: Ayurveda, Siddha, Unani and Homeopathy.

Unit-II: a) Study of the following herbs with specific emphasis on source, collection & preparation, constituents, chemical tests, substitutes and adulterants. Bael, Gum acacia, black catechu, myrobalan, castor oil, chaulmoogra oil, cinnamon, centella and lemon grass. b)Source , collection and adulterants of Honey and bees wax.

Unit-III: Adulteration of crude herbal extracts & their detection by different methods of evaluation. WHO Guidelines for the assessment of Herbal Drugs. Definition, need and methods of herbal preparation standardization. Stability testing of herbal extracts.

Unit IV. Principles of methods of extraction of phyto-constituents from herbs: Maceration, decoction, Hydraulic press, Soxhlet distillation, solvent extraction, effleurage, eucelle, and supercritical fluid extraction, microwave extraction.

Unit-V: Role of Herbs in Cosmetics. Hair care preparation: Henna, Amla, Hibiscus, Bhringaraj. Skin Care preparation: Aloe vera, Turmeric, Sandal wood. Oral care preparation: Babool, Neem, Clove.

- 1. Trease, G.E. and Evans, W.C. "Trease and Evans' Pharmacognosy" WB Saunders Co.Ltd., London, Philadelphia, Toronto, Sydney, Tokyo (1994, 2005).
- 2. James Bobbers, Marilyn K, Speedice & Verro E. Tylor. Pharmacognosy and pharmacobiotechnology" Williams & Wilkins., 1996

- 3. Louis Appell. The Formulation and Preparation of Cosmetics, Fragrances and Flavors
- 4. WHO Guidelines website http://www/who.int/druginformation
- 5. Remington's Pharmaceutical Sciences. Mack Pub. Co.; 17th edition
- Pulok K.Mukherjee. Quality Control Herbal Drugs Business Horizons; Reprint 2012 edition
- 7. V. Rajpal Standardization of Botanicals Volume-1-2 Second Edition | 2011
- 8. A.P. Purohit , C. K. Kokate , S. B. Gokhale. Text Book of Pharamcognosy Nirali Prakashan.

Electives 2: Genetics 4 Credits

Overview: The paper aims in highlighting the scope and significance of genetics by imbibing the principles of hereditary genetic transmission and interactions of gene with environment.

Outcome: It helps students to learn the molecular aspects of genetic disorders and mutations. It helps the students to appreciate the concepts of gene and relationship between genotype and phenotype.

Unit I. Introduction to Genetics, Scope and significance of genetics. Principles of Genetic Transmission: Concept of dominance, Principle of dominance and segregation, Principle of independent assortment, Mendel's Experiments, Symbols and terminology, Mendelian inheritance and **use of** probability (Multiplication and Addition **rules**).

Unit II: Extension of Mendelism: Incomplete dominance, codominance, multiple allelism, Gene action (from genotype to phenotype), Gene interaction, penetrance, expressivity, epistasis, pleiotropy, interaction with environment. Allelic variation and gene function. The chromosomal basis of Mendelism: Chromosomes – chromosome number, Chromosome theory of inheritance. Experimental evidence, non-disjunction as proof of chromosome theory, chromosomal basis of Mendel's principles. Linkage and crossing over, sex linkage, sex limited and sex influenced characters.

Polygenic inheritance, extra chromosomal inheritance: Inheritance of Mitochondrial and chloroplast genes, maternal inheritance.

Unit III: Sex Determination: Sex chromosomes, Chromosomal and molecular basis of sex determination in *C.elegans*, Drosophila, Man and Plants. Dosage compensation: Genic balance, Gene dose, Molecular basis of dosage compensation in Drosophila and man

Unit IV: Concept of gene: Fine structure of gene, Types of genes. Molecular anatomy of eukaryotic chromosome: Centromere, Telomere, Nucleosome, Nucleomere, Kinetochore, Chromosome banding techniques. Population genetics, Gene pool, Gene frequency Hardy Weinberg equation. Linkage, genetic drift.

Unit V: Mutations: Types, Spontaneous, Induced mutation, Conditional lethal mutations –Base substitution mutation, Missense, Nonsense and Silent mutations. Chemical, Physical and Biological mutagenesis. Quantification and Detection of

mutations. Structural and numerical alterations of chromosomes: Deletion, duplication, inversion, translocation, ploidy and their genetic implications. Genetic disorder - Color blindness, Cystic fibrosis, Down syndrome, Duchenne muscular dystrophy, Hemophilia, Klinefelter syndrome, Sickle-cell disease, Turner syndrome

Reference Books:

- 1. Hartl, D. L., & Jones, E. W. (1998). Genetics: Principles and analysis. Jones and Barlett Publishers.
- 2. Simmons, M. J., &Snustad, D. P. (2006). Principles of genetics. John Wiley & Sons.
- 3. Andersen, W. R. (1999). Genetics: the continuity of life. Brooks/Cole Publishing Company.
- 4. Atherly A G, Girton, J R and Mc Donald J F, 1999. The Science of Genetics, Saunders College Publishing, Harcourt Brace College Publishers.
- 5. Brooker, R. J. (1999). Genetics: Analysis and Principles. Reading, MA: Addison-Wesley.
- 6. Gardner E J, Simmons M J, Snustad D P 1991. Analysis and Principles of Genetics. Ed. Benjamin Cummings. California.
- 7. Griffith A J F, Miller J H, Suzuki D T, Lewontin R C, Gelbert W M.1996. Principles of Genetics. John Wiley & Sons, Inc.
- 8. Griffiths, A. J. F., Miller, J. H., Suzuki, D. T., Lewontin, R. C., &Gelbart, W. M. (2000). An Introduction to Genetic Analysis, WH Freeman. New York.
- 9. Strickberger, M. W. (1976). Genetics. Macmillan, New York. Genetics. 2nd ed. Macmillan, New York.
- 10.Watson, J. D., Baker T. A., Bell S. P., Gann A., Levine M., Losick R. 2004. Molecular Biology of the Gene. Pearson Education Pte. Ltd., New Delhi, India - 5th Edition
- 11.Klug, W S, and Cummings M. R. 1998. Essentials of Genetics. Prentice Hall, Upper Saddle River, NJ. 3rd edition.
- 12.Hartl, D L & Jones E W 2006. Essential Genetics: a genomics perspective, Jones and Bartlett Publishers, Boston 4th Edition.
- 13.Tamarin R. H. 2002. Principles of Genetics. Tata-McGraw Hill, Seventh Edition.

Practical 2. Formulation science 6 credits

1. Design and development of;

- Face wash
- Moisturizing cream,
- cold cream
- vanishing cream.
- Moisturizing gel
- Body lotion
- Shampoo
- Hair conditioner
- Toothpaste

- Lip Balm
- 2. Assignments on green formulation design for all the above products.
- **3.** Design and development of a cosmeceutical product
- 4. Design and development of an herbal cosmetic.
- **5. Des**ign and development of handmade soaps.

SEMESTER III

Paper 9: Cosmetics Analysis & Evaluation 4 Credits

Course Objectives: This trains the students to know the experimental basis of analysis and evaluation of cosmetics. The students also learn the standard specifications for sampling and testing of various cosmetics.

Course Outcomes: At the end, the students are trained towards evaluating cosmetic products

Unit-I: Determination of acid value, ester value, Saponification value, rancidity, moisture, ash, Volatile matter, heavy metals, fineness of powders, density, viscosity of cosmetics raw materials and finished products

Unit-II: General methods of analysis of following raw material used in cosmetic manufacture as per BIS: Castor oil, Mineral oil, SLS, SLES, Calcium carbonate, Sorbitol, Methyl parahydroxy benzoate, cetyl alcohol, isopropyl myristate, Talc, Boric acid, glycerine, Titanium Dioxide, Para Phenylene diamine

Unit-III. Indian standard specifications laid down for sampling and testing of various cosmetics in finished forms such as baby care powders, skin care products, dental products, personal hygiene preparations, lips sticks, hair products and skin creams by the Bureau Indian Standards.

Unit-IV. Principles of equipment to measure product performance of skin and hair care products - Sebumeter, corneometer, Trans-epidermal water loss, Skin color, hair tensile properties, hair combing properties.

Unit-V: Principles of performance evaluation of shampoos, antiperspirants, deodorants, sunscreens, foam baths and abrasiveness of dentifrices.

Reference Books:

- 1. Cosmetics Formulation, Manufacturing and Quality Control, P.P. Sharma, 4th edition, Vandana. Publications Pvt. Ltd., Delhi.
- 2. Indian Standard specification, for raw materials, BIS, New Delhi.
- 3. Indian Standard specification for 28 finished cosmetics BIS, New Delhi.
- 4. Harry's Cosmeticology Wilkinson, Moore, seventh edition, George Godwin.

Paper 10. Statistical Methods for Biology 4 Credits

Course Objectives: To train the students intensively in both theoretical and practical aspects of statistics, to bring them in contact with basic concepts and methods

and to create a problem-solving attitude with the aid of statistical methodology.

Course Outcomes: It provides an introduction to selected important topics in Biostatistical concepts and reasoning. This course represents an introduction to the field of data and data types. The students learn specific topics including tools for describing central tendency and variability in data; methods for performing inference on population means and proportions via sample data; statistical hypothesis testing and its application to group comparisons; issues of power and sample size in study designs; random sample and other study types.

Unit I. Numerical Methods to Represent Variation:

Importance and Scope of Statistics, Data Types, Frequency Distribution, Graphical Representation Methods (Histogram, Bar Charts, Pie Charts), Measures of Center Tendency (Mean, Median, Mode,) and Dispersion (Standard Deviation, Variance) Advantages and Disadvantages, Co-Efficient of Variance.

Unit II. Probability:

Basic Terminology, Definition of Probability, Basic Laws of Probability, Types of Probability,

Additional Rule of Probability and Multiplication Rule of Probability, Probability Distribution-Bernoulli Distribution, Binomial Distribution, Poisson distribution and Normal Distribution-Simple Problems.

Unit III. Sampling Methods:

Collection of Data, Census Method, Concept of Population, Sample, Sampling, Sample Size, Sampling Error, Advantages and Disadvantages of Sampling Method, Necessity of Sampling, Types of Sampling Methods, Types of Random Sampling Methods – SRS, Stratified Random Sampling, Systematic Random Sampling and Cluster Sampling.

Unit IV. Testing of Hypotheses:

Statistical Hypotheses-Null and Alternative, Level of Significance, Type I and Type II Error, Critical Region, Power of the Test, P Value, Degrees of Freedom, Chi-Square Test for Independence of Attributes and Goodness of Fit, Student's t Test: One Sample t Test and Paired t Test, F Test.

Unit V. Regression and Analysis Of Variance:

Simple Linear Regression, Multiple Linear Regression (Definition, Assumptions, Applications, and Examples), Analysis of Variance –Introduction, Definition of ANOVA, Assumption, Test of ANOVA, Types of ANOVA, Construction of One Way Analysis of Variance.

- 1. Fundamentals of Biostatistics. Veer Bala Rastogi. Publisher: ANE Books. 2nd Edition, 2009.
- 2. Fundamentals of Mathematical Statistics, S.C. Gupta and V. K. Kapoor, Publisher: Sultan Chand & Sons (2014).

- 3. Fundamentals of Statistics. S.C. Gupta. Publisher: Himalaya Publishing House Pvt. Ltd.Edition.7th Edition, 2012
- 4. Introductory Statistics for Biology. R. E. Parker. Publisher: Cambridge University Press 2nd Edition, 1991.
- 5. Statistics for behavioral science. Chintamani Kar. Publisher: Dominant Publishers & Distributors (P) Ltd. (2015).

Paper 11: Applied Microbiology 4 Credits

Course Objectives: This fundamental paper discusses the importance of applications of microorganisms. The course throws light on types of microorganisms in cosmetic products

Course outcomes: At the end of the course, the student has understanding on the concept of culturing microbes, sterilization techniques and estimating the number of microbes in a given sample of cosmetic product.

Unit I: History of Microbiology. Principles of classification of microbes; morphological, metabolic and molecular criteria for the classification, A brief introduction to major group of bacteria. Ultra-structure of bacteria.

Unit II: Microbial Cultivation: Nutritional types requirements of bacteria. Cultivation of bacteria: Pure culture techniques different media. Culture media and preparation: Preservation of cultures, aerobic and anaerobic culture techniques. Batch and synchronous cultures. Growth curve and factors influencing growth.

Unit III: Control of Microbial growth: Principles and techniques, Physical and Chemical methods. Disinfection, Method of action of disinfectants. Methods of testing disinfectants.

Unit IV: Microbial physiology: Staining characteristics, Gram staining, AFB staining, florescent staining, serological characteristics:-surface antigen, capsular antigen &flagellar antigen, Cultural characteristics, Photosynthetic microorganisms, cyclic and non-cyclic photophosphorylation, electron transport chain in photosynthetic bacteria. Bacterial aerobic respiration, Bacterial anaerobic respiration: introduction. Nitrate, carbonate and sulfate as electron acceptors. Electron transport chains in some anaerobic bacteria. Mechanism of oxygen toxicity. Bacterial transport system-ABC, Sec pathway, PTS, role of permeases in transport, different permeases in E. coli, Microbial drug resistance.

Unit V: Microbial Diversity: Human microbial flora in application, General properties of fungi, fungal classification, economic importance of fungi, Mycoplasma, Actinomycetes, Arche bacteria (extremophiles) and microbial algae. General properties of virus, lifecycle.

- 1. Microbial Physiology and Metabolism by Caldwell D.R. 1995Brown Publishers.
- 2. Microbial Physiology by Moat A.G. and Foster J. W. 1999. Wiley.
- 3. Prokaryotic Development by Brun. Y.V. and Shimkets L.J. 2000. ASM Press.
- 4. Advances in Microbial Physiology. Volumes. Edited by By A.H. Rose. Academic Press, New York.
- 5. Applied Microbial Physiology by Rhodes.

- 6. Principles of bacteriology, virology and immunology Vol I Topley and Wilson Zinser, Microbiology
- 7. Microbiology, Prescottt, Harley and klien
- 8. Foundations in Microbiology Talaro and Talaro
- 9. Text book of Microbiology, R Ananthanarayanan C K J Panicker
- 10.Microbiology, Pelczar, Chan and Kreig

Paper12: Industrial cosmetics: 4 credits

Course Objectives: This course explores the regulatory aspects, equipment's, manufacturing process, packaging, and maintenance aspects related to cosmetic industry.

Course outcomes: By the end of the course, the student is familiarized with regulatory guidelines to launch cosmetic products and equipment, packaging of cosmetics.

Unit-I: a) Indian regulation for cosmetics: Regulatory provisions relating to import of cosmetics. Misbranded and spurious cosmetics. Regulatory provisions relating to manufacture of cosmetics – Conditions for obtaining license, prohibition of manufacture and sale of certain cosmetics, loan license, offences and penalties.

Unit II. Equipment used and manufacturing process of shampoo, creams and toothpaste. Indian regulatory requirement for factory premises : Location and surroundings, designing of plant layout, building, lighting, ventilation, water supply, disposal of waste, first aid, packaging facilities, sanitation in manufacturing premises and health clothing & sanitary requirement of staff.

Unit-III: Significance of pilot plant scale up studies. Stability studies: Change in Parameters to be observed. Photo-stability. Accelerated stability testing – Temperature & Humidity, Freeze-thaw test, Stress test. Aerosol product stability studies. Technology transfer of formulations from R&D to factory – Quality assurance documentations required as per regulatory guidelines.

Unit-1V: Packaging: Functions: Packaging materials: Plastics: Type of plastics and application. Metal, Glass, laminates, paper and paper boards. Considerations for selecting containers, product packaging material compatibility.

Unit V. Industrial Management: Principles of management, financial management, material management, Plant maintenance management, inventory management, production planning and control. Introduction to ISO 9000, 14000 and 22000. Importance of patent and intellectual property rights.

Reference Books:

- 1. Drugs and Cosmetic act/rules by govt. of India Publication
- 2. European Union regulation for cosmetics
- 3. Cosmetics Formulation, Manufacturing and Quality Control, P.P. Sharma, 4th edition, Vandana Publications Pvt. Ltd., Delhi.
- 4. Harry's Cosmeticology Wilkinson, Moore, seventh edition, George Godwin.
- 5. Peter, F.Drucker, Management-tasks, responsibilities, practices, Allied publishers pvt ltd, Mumbai 2003.

Elective 3

Elective 3. Environmental Nanoscience 4 Credits

Course Objectives: This course describes both the advantages and disadvantages of nano products to the environment.

Course Outcomes*:* By the end of the course, the students have an appreciation for the benefits of nanotechnology in improving the environment. After the successful completion of this course, the student will be able to: 1. Understand the basic and essential elements of battery materials 2. Explain the mechanism of harnessing solar energy. 3. Discuss the fabrication of solar cell structures. 4. Define and design how hydrogen energy can be stored 5. Describe the working principle of various fuel cells and model it. 6. Analyze the safety and precautionary issues in handling nanomaterials

Unit I. Environmental pollution: Environmental fate and transport of Nanomaterials, physical-chemical interactions, aggregation and deposition, definition of air pollution, water pollution and ground pollution, contribution of nanoparticles in aggravating pollution.

Unit II. Nanotoxicology: Exposure and risk assessment, dose-response, mechanisms of toxicity, definition of eco-toxicity, routes of entry of nanomaterials into the environment, cytotoxicity of nanomaterials.

Unit III. Health effects of nanoparticles: Sources of nanoparticles, epidemiological evidence, entry routes into the human body – Lung, Intestinal Tract, Skin, effect of nanoparticle size and charge, effects of nanoparticles on - cardiovascular, liver and gastrointestinal and nervous system, coagulation and thrombosis, bloodbrain barrier. Impact of CNT's on respiratory systems.

Unit IV. Environmental application of nanomaterials: Environmental Remediation, nanoparticles reactivity, fate, and lifetimes in the subsurface, ground water remediation with nanoparticles, nanomaterials for water and wastewater treatment.

Unit V. Nanotechnology for controlling air pollution: Nanomaterials for sensing toxic gases. Gas sensing materials and devices. Techniques used for gas sensing (resistance, capacitance and electrochemical), Sensor properties, advantages of nanomaterials, synthesis and characterization of nano-metal oxides (tin oxide, zinc oxide, indium oxide), mixed oxides, nanoscale materials for sensors (quantum dots, CNTs, nanotubes, wires and belts), colloidal silver and gold, magnetic nanoparticles, application of nanomaterials in sensors, CNT-based sensors, Graphene-based sensors, active devices based on Nanostructures. Remediation and monitoring.

Reference Books:

- 1. Environmental Biotechnology, Alan Scragg, Pearson Education Limited, England, 2007, ISSN: 0199228612, 9780199228614.
- 2. Environmental Biotechnology, S.N. Jogdand, Himalaya Publishing House, Bombay, 2006.
- 3. Wastewater Engineering Treatment, Disposal and Reuse, Metcalf and Eddy, Inc., Tata Mc Graw Hill, New Delhi, 2013, ISSN: 0073401188, 9780073401188.
- 4. Environmental chemistry, A.K. De, Wiley Eastern Ltd, New Delhi, 2009, ISSN: 8122426174, 9788122426175.
- 5. Introduction to Bio-deterioration, D. Allsopp, C. Gaylarde and K.J. Seal, ELBS/Edward. Arnold, 2004, ISSN: 0-521-821355, 0521528879.
- 6. Biotechnology for Wastewater Treatment, P Nicholas Cheremisin, Elsevier Science, 2013, ISSN: 0080946453, 9780080946450
- 7. Biotechnological Methods of Pollution Control, SA Abbasi and E Ramaswami, Universities Press, India, 1999, ISSN: 8173710988.

Practical- 3-Cosmetics -analysis 6 Credits

- 1. Determination of Iodine value.
- 2. Determination of hydroxyl value and acetyl value.
- 3. Determination of acid value and saponification value.
- 4. Qualitative and quantitative analysis of rancidity in hair oils and Lipsticks
- 5. Determination of Fluorides in tooth paste by Potentiometry
- 6. Determination of aryl amine content and Developer in hair dye
- 7. Determination of foam height and SLS content of Shampoo.
- 8. Determination of total fatty matter in creams (Soap, Skin and hair Creams)
- 9. Detection and Determination of Perfumes by Gas chromatography
- 10. Analysis of antioxidants in cosmetics by HPLC
- 11. Analysis of formaldehyde in cosmetics by colorimetry
- 12. Moisture and ash analysis of finished cosmetics

Semester- IV

Summer Internship- 2 Credits

(Marketing case studies- dissertation and Viva Voce Examination) **Project work, dissertation and viva Voce exam -** 12 credits **M.Sc GeoInformatics**

Overview of the Program

Post Graduate Degree in GeoInformatics, offered by JSS Academy of Higher Education and Research, is well designated program, Geoinformatics is the synergy of multiple disciplines, namely GIS (Geographical Information System), Remote Sensing, Photogrammetry, GPS (Global Positioning System), Information Technology and Geodesy. Now a days GeoInformatics has emerged as an effective tool which can be applied in all the fields, such as Environment, Health, Socio-economics, Disaster management, Crime analysis and Resource Management, etc. GeoInformatics deals with spatial and non-spatial data where acquisition, management, analysis and dissemination methods are followed. Application of Geoinformatics is mainly oriented to real world management problems pertaining to natural and man-made environment. Geoinformatics is an increasingly pervasive information processing system and its ubiguitous nature poses new research challenges and provides new opportunities for novel implementation, helps to analyze large datasets, understanding of terrestrial process and human activities which improve socio – economic viability and enhance environmental quality. Geoinformatics is an emerging field catering to Societal, Industry and Scientific needs of the country and has attained a unique position in Global space.

The M.Sc. in GeoInformatics aims to provide conceptual knowledge on GIS, remote sensing and related fields, Information Technology, and hands-on training in GIS, data interpretation, digital image processing, digital photogrammetry, digital cartography and GPS. The course contents have been designed keeping in view the emerging trends in the field of Geoinformatics and the increasing needs of skilled manpower for the viable society.

Career opportunities: Geoinformatics can be applied in every imaginable discipline. Career opportunities lie in both Government and Private sectors related to land resource management, integrated emergency management, water and wastewater management, disaster management, risk assessment and management, transportation, urban planning, environment, hydrology, forestry, agriculture, military, mining, business, health, defence, space research, geology and several related fields. Candidates could find placements as GIS specialists, analysts, developers, disaster management officers, industrial specialists, urban management & Planners and teaching professionals, etc. Geoinformatics has a burgeoning market through wide ranging applications in diverse fields and highly paid job opportunities in practically every sector.

Eligibility

The candidate should have passed B.Sc/B.Tech/B.A in Geography Degree from recognised university, with at least 50% aggregate marks at undergraduate level.

	Semester I	Credits
Paper 1	Fundamentals of Mathematics	4
Paper 2	Fundamentals of Computer Sciences and programming C	4
Paper 3	Introduction to Spatial Data Sources	4

Course Curriculum

Paper 4	Introduction to Remote Sensing	4
Elective 1	Statistical Methods for Biology	4
Practical 1	Techniques of Interpretation in spatial data	6
		26
	Semester II	
Paper 5	Principles of Geographical Information System	4
Paper 6	Introduction to Spatial Data Analysis	4
Paper 7	Digital Cartography	4
Paper 8	Digital Image Processing	4
Electives 2	Elective: 2.1 Geoinformatics for Hydrology Elective: 2.2 Geostatistics	4
Practical 2	Image Processing and Analysis in GIS	6
		26
	Semester III	
Paper 9	Advances in Geo informatics	4
Paper 10	Photogrammetry	4
Paper 11	Application of Geoinformatics in Natural Resources Management	4
Paper 12	Geodatabase for GIS	4
Elective 3	Elective 3.1: Advances in Public Health Geoinformatics Elective 3.2 : Urban GIS	4
Practical 3	Advance in GIS and Remote Sensing	6
		26
	Semester IV	
	Summer Project	2
	Thesis and viva voce examination	12
		14
	Total Credits	92

SEMESTER I

Paper 1: FUNDAMENTALS OF MATHEMATICS 4 Credits

Objectives: The purpose of this course is to introduce the students to basics in mathematics as relevant to geoinformatics program. The students learn trigonometry, elementary mathematics, matrices, numeral methods and vector algebra

Outcomes: The purpose of this course is to introduce the students to basics in mathematics as relevant to geoinformatics program. The students learn trigonometry, elementary mathematics, matrices, numeral methods and vector algebra. At the end of the course, the student is well versed in the necessary mathematics components to understand the field of geoinformatics.

Unit I: Trigonometry and Analytical Geometry: Trigonometric functions, trig-

onometric ratios of standard angles, allied angles, compound angels. Cartesian rectangular coordinate system, distance formula, section formula, straight lines, slopes, types of straight lines. Application in solving life science problems.

Unit II: Elementary Mathematics: Solutions of simultaneous linear equations, quadratic equations, progressions, permutations and combinations.

Unit 3: Matrices & Determinants: Introduction to Matrix, Transpose of a Matrix, Elementary row and column operations of Matrix, determinants, Properties of determinants (Without Proof) Rank of a Matrix, Minor and Co-factors Inverse of a matrix.

Unit IV: Numerical Method: Gauss Jordan, Jacobi and Gauss sidle methods, Newton-Raphson method. Transcendental function- Logarithmic and exponential functions, Application in solving Biological science problems

Unit V: Vector Algebra: Definition, Types of Vectors, two and three dimensional vectors, Scalar (dot) and Vector (cross) product. Application in solving Biological science problems

References:

- 1. T.B : SCHAUM Series books of calculus , vectors, statistics & matrices
- Pharmaceutical Mathematics with Application to Pharmacy PharmMed Press, a Unit of BSP Books Pvt Ltd, 4-4-309/316, Giriraj Lane, Sultan Bazar, Hyderabad – 500 095 - Panchaksharappa Gowda D.H.
- 3. Introduction to Mathematics for life scientist Publisher- Springer (India) Pvt. Ltd- Edward Batschelet.
PAPER 2: FUNDAMENTALS OF COMPUTER AND PROGRAMMING USING C & C++ 4 CREDITS

Objectives:

- Students will demonstrate the ability to extend current knowledge and/ or skills to a computing environment or problem currently unknown to the student.
- Students will demonstrate the ability to solve problems in the discipline.

Outcome:

 Upon successful completion of a basic in computer sciences, students will be able to: Demonstrate proficiency in problem-solving techniques using the computer. Demonstrate proficiency in at least basics of tools in computer science, two programming languages and experts' operating systems.

Unit I: Introduction to Computer- History and development of computers; generations of computers; (I, II, III, IV and V), classifications of computers; analog computers, digital computers, mainframe computers, miniframe computers, micro-computers, fundamentals of logical concepts. Digital Computers:- Basic principle of operation of digital computers, structure of digital computers; arithmetic unit, central unit, memory unit, Input unit and output unit. Computer Coding:- Number system, decimal number system, binary number system, binary to decimal conversion, Binary arithmetic, octal number system, hexadecimal number system.

Unit II: Languages and flow charts and Operating Systems:-Machine level languages, assembly level languages, high level languages. Input and Output devices :-Punched card reader, paper tape reader, magnetic tape, floppy disk, magnetic disk, optimal scanner, voice data, entry terminal, teleprocessing terminal, visual display unit, modern input devices, Output devices; CRT, printer, plotter. Memory- primary and secondary memory. Operating Systems - DOS, windows, UNIX/LINUX, Mac OS.

Unit III: Introduction to programming C- History of C, Characteristics of C, Program Structure, Constants. Data types, Variables, Keywords, Console Input/output Statements, Compilation and Execution, Algorithms and flowcharts, Operators, Branching & Looping Statements, Arithmetic Unary Assignment Relational & Logical Conditional, If Statement, Nested if, Statement else-if. Ladder switch, Statement.

Unit IV: Looping. Concepts for loop, while loop, do-while loop, Jump and continue Statements, Arrays- Array Concepts Rules & Restrictions, Single & Multi-Dimensional Arrays, Functions- Types of Functions, Functions and Arrays Function, Prototyping, Scope of Variables Built-in Functions.

Unit V: Introduction to programming C++ - Overview of C++, Sample C++ program, Classes and objects- Class specification, class objects, scope resolution operator, access members. Constructors and destructors. Inheritance and polymorphism.

- 1. Computer programming with C by E, Balaguruswamy.
- 2. Elements of Statistics by Gupta.

PAPER 3: INTRODUCTION TO SPATIAL DATA SOURCES 4 CREDITS

Course objectives: The objective of this paper is to understand the concept of map, interpretation of topographical maps, aerial photos, aerial cameras, satellite images and GPS.

Student learning outcome: Students will have clear information about maps, map projections, analysis of topographical maps, measurement of aerial photographs, and interpretation of satellite image and applications of GPS.

Unit I. Map and Scales: History of maps, Map scales, Map projections, enlargement, reduction, types and conversions, symbolization, Representation of statistical data on maps,

Unit II. Topographical maps: Introduction to SOI topographical maps, numbering, scale, grid reference, signs etc, study and interpretation of SOI maps, Identification of land forms and cultural features from toposheets.

Unit III. Aerial Photos: Basics of Aerial Photography, Historical development - principles of photography- types and uses - camera and films used Interpretation keys for aerial photography.

Unit IV. Remote Sensing Data: Remote Sensing Images: Basics of Remote sensing images, types of data products, visual interpretation of remote sensing images.

Unit V. GPS Data: Introduction - Historical development - various GPS software products and peripherals System overview - Space Segment - GPS Satellite Systems, application of GPS.

Reference Books:

- 1. Prithvish Nag, M. Kudrat, Digital Remote Sensing, concept publishing company, New Delhi.
- 2. Ganesh, A., and Narayana Kumar, R., (2006). GPS Principles and Applications, Satish Serial Publishing House, Delhi.
- 3. Kumaraswamy, K. (2003) Remote Sensing for Environmental Studies, Department of Geography, Bharathidasan University, Tiruchirappalli.
- 4. Prithvish Nag, Thematic Cartography, Ashok kumar mittal, Concept publishing company, New Delhi.
- 5. Ramesh P A, Fundamentals of Cartography, Concept publishing Co., New Delhi.

PAPER 4: INTRODUCTION TO REMOTE SENSING 4 CREDITS

Objectives:

- Attain a foundational knowledge and comprehension of the physical, computational, and perceptual basis for remote sensing.
- The subject will be synthesized by developing an overall application of the discipline, not just knowledge in one aspect
- The course will be taught with an emphasis on the geographical applica-

tions of remote sensing; however, in certain instances other disciplines will be introduced as well.

• At the end of the semester students should have a good understanding and basic skills of remote sensing.

Student Learning Outcomes (SLOs):

- students will be able to recognize and explain at basic level fundamental physical principles of remote sensing
- Students will be able to recognize and explain basic computational properties of remote sensing data acquisition, storage, and processing
- Students will be able to apply mathematical relationships (at a pre-calculus level) describing fundamental physical, geometric, and computational principles relevant to remote sensing.
- Students will be able to identify key applications of land, marine, aquatic, and atmospheric remote sensing and relate them to the properties of historical, current, and planned remote sensing instruments, approaches, and datasets.

Unit I: Development of Remote Sensing: Definition, types, chronological development, international remote sensing centers, Indian remote sensing centers and their activities, new satellite programs of India.

Unit II: Remote Sensing System - Elements of EMR - wavelength regions – energy interaction in atmosphere – Absorption – scattering - atmospheric windows – terrestrial Interaction-Interaction with soil, water and vegetation – spectral reflectance curves –active and passive remote sensing.

Unit III: Satellites and Sensors: Types of satellites – platforms – satellite characteristics: orbits and swaths – scanning methods – FOV and IFOV - resolution: spatial, spectral, radiometric and temporal – hyperspectral sensors and imaging - pixel size and scale.

Unit IV: Remote Sensing Satellites: Orbit - sensor characteristics and applications of Weather satellites: GOES, NOAA, METEOSAT, INSAT - Land observation satellites: LANDSAT, SPOT, IRS, IKONOS, GEOEYE, WORLDVIEW - Marine observation satellites: Seasat, Nimbus: CZCS, MOS, SeaStar: SeaWiFS, Oceansat.

Unit V: Thermal Remote Sensing: Plank's blackbody law – displacement law and emissivity effects - heat capacity, thermal conductivity - thermal inertia – diurnal heat effects – thermal property of objects – thermal sensors – thermography – thermal image interpretation.

- 1. Joseph, G. (2004): Fundamentals of Remote Sensing, Universities Press, Hyderabad, India
- 2. Lillis and T.M, R.W. Kiefer & Chipman (2015) Remote Sensing and Image Interpretation (7th edition). John Wiley & Sons, New York.
- 3. Sabins F. F Jr. (2007) Remote Sensing: Principles and Interpretation, Waveland Pr. Inc.
- 4. Jensen, J. R. (2007): Remote Sensing of the Environment: An Earth Resource Perspective, (2nd Edition) Pearson Publication
- 5. Campbell, J. and Wynne R. H. (2011): Introduction to Remote Sensing (5th edition) The Guilford Press.

- 6. Curran P.J (1985) Principles of Remote Sensing, Longman, London.
- 7. Gibso, P., and Clare H. Power, (2000) Introductory Remote Sensing: Principles and Concepts, Routledge, London.
- 8. Hayesm L., (1991) Introduction to Remote Sensing, Taylor and Francis Publication, London.
- 9. Kumaraswamy, K. (2003): Remote Sensing for Environmental Studies, Department of Geography, Bharathidasan University, Tiruchirappalli.
- 10.Gupta. R. P (2005) Remote Sensing Geology (2nd Edition), Springer India, New Delhi.

Elective 1: STATISTICAL METHODS FOR BIOLOGY 4 Credits

Objectives: To train the students intensively in both theoretical and practical aspects of statistics, to bring them in contact with basic concepts and methods and to create a problem-solving attitude with the aid of statistical methodology.

Outcomes: It provides an introduction to selected important topics in Biostatistical concepts and reasoning. This course represents an introduction to the field of data and data types. The students learn specific topics including tools for describing central tendency and variability in data; methods for performing inference on population means and proportions via sample data; statistical hypothesis testing and its application to group comparisons; issues of power and sample size in study designs; random sample and other study types.

Unit I. Numerical Methods to Represent Variation:

Importance and Scope of Statistics, Data Types, Frequency Distribution, Graphical Representation Methods (Histogram, Bar Charts, Pie Charts), Measures of Center Tendency (Mean, Median, Mode,) and Dispersion (Standard Deviation, Variance) Advantages and Disadvantages, Co-Efficient of Variance.

Unit II. Probability:

Basic Terminology, Definition of Probability, Basic Laws of Probability, Types of Probability,

Additional Rule of Probability and Multiplication Rule of Probability, Probability Distribution-Bernoulli Distribution, Binomial Distribution, Poisson distribution and Normal Distribution-Simple Problems.

Unit III. Sampling Methods:

Collection of Data, Census Method, Concept of Population, Sample, Sampling, Sample Size, Sampling Error, Advantages and Disadvantages of Sampling Method, Necessity of Sampling, Types of Sampling Methods, Types of Random Sampling Methods – SRS, Stratified Random Sampling, Systematic Random Sampling and Cluster Sampling.

Unit IV. Testing of Hypotheses:

Statistical Hypotheses-Null and Alternative, Level of Significance, Type I and Type II Error, Critical Region, Power of the Test, P Value, Degrees of Freedom, Chi-Square Test for Independence of Attributes and Goodness of Fit, Student's t Test: One Sample t Test and Paired t Test, F Test.

Unit V. Regression and Analysis Of Variance:

Simple Linear Regression, Multiple Linear Regression (Definition, Assumptions, Applications, and Examples), Analysis of Variance –Introduction, Definition of ANOVA, Assumption, Test of ANOVA, Types of ANOVA, Construction of One Way Analysis of Variance.

Reference Books

- 1. Fundamentals of Biostatistics. Veer Bala Rastogi. Publisher: ANE Books. 2nd Edition, 2009.
- 2. Fundamentals of Mathematical Statistics, S.C. Gupta and V. K. Kapoor, Publisher: Sultan Chand & Sons (2014).
- 3. Fundamentals of Statistics. S.C. Gupta. Publisher: Himalaya Publishing House Pvt. Ltd.Edition.7th Edition, 2012
- 4. Introductory Statistics for Biology. R. E. Parker. Publisher: Cambridge University Press 2nd Edition, 1991.
- 5. Statistics for behavioural science. Chintamani Kar. Publisher: Dominant Publishers & Distributors (P) Ltd. (2015).

PRACTICAL 1 Practical 1: Techniques of Interpretation in spatial data

- Exercise 1:- Maps And Scale: Introduction to maps, classification of maps, users of maps introduction to scale, classification of scale, uses of scale.
- Exercise 2:- Introduction to Topographical Maps. Interpretation of topo sheet, Maps of Survey of India, marginal information of topographical maps -all Signs and Symbols.
- Exercise 3:- Interpretation of Physiographic Information of Topographical Maps, Relief, drainage and vegetation.
- Exercise 4:- Interpretation of Cultural Information of Topographical Map, Land use, means of communication and settlements.
- Exercise 5:- Introduction to Air Photo Information. Marginal information of air photo product,
- Exercise 6:- Stereo Scope Viewing, Pocket stereoscope and Mirror stereoscope
- Exercise 7:- Application and Map Making Through Air Photo. Visual interpretation keys.
- Exercise 8:- Fluvial Geomorphology Using Air Photo. Transport and settlements using air photo.
- Exercise 9:- Satellite Image Information. Fluvial geomorphology, Coastal geomorphology

SEMESTER II

PAPER 5: PRINCIPLES OF GEOGRAPHICAL INFORMATION SYSTEM 4 CREDITS

Objective: To understand the basic principles of GIS, creation of GIS database and develop basic practical skills in the use of GIS software for data inputting and error correction and modelling techniques.

Student learning outcomes: Upon completion of this course, a fully-engaged student will be able to. Prepares the candidate for the geospatial modeling and analysis.

Unit I: Definitions, Evolution of GIS, Components of GIS, Representation of spatial entity in raster and vector models, raster and vector data structures, Advantages and limitations. Geo-referencing /Image Registration and projections, Spatial Data and Non Spatial Data and Spatial Topology.

Unit II. Basic file structures (flat, Sequential and Indexed), Tabular Database and its advantages, types, operations, adapting database to GIS; Representation of spatial entity in raster and vector models, raster Data quality and data standards: Concepts - Definition - Components and assessment of data quality.

Unit III. Spatial Data Input and Editing: Integrated GIS database - Encoding methods of data input: keyboard, manual digitizing scanning and automatic digitizing methods, electronic data transfer - data editing: methods of developing and correcting errors in attributes and spatial data: reproduction, transformation and generalization - edge matching and rubber sheeting - integrated database.

Unit IV. Data Analyzing Operation in GIS: Terminologies - Measurements of lengths, perimeter and area in GIS-queries - reclassification - buffering and neighbourhood functions - Raster and Vector overlay method: point-in-polygon, line-in-polygon and polygon- on-polygon - problems of Raster and Vector overlays - Spatial interpolation - Analysis of surfaces - Network analysis (shortest path problem, traveling problem, location and allocation of resources).

Unit V. GIS Modeling for decision support: Models of spatial processes: natural and scale analogue models - conceptual models - mathematical model - models of physical and environmental processes - modeling human processes - gravity model - problems related to using GIS to model spatial processes.

- 1. An Introduction to Urban Geographic Information Systems (Huxhold, WE, Oxford University Press, 1991
- Linda L. Hill, Georeferencing: The Geographic Associations of Information (2006); Past Time, Past Place: GIS for History (2002), edited by Anne Kelly Knowels.
- 3. Ganesh, A., (2006). Dimensions of Geomatics, Bharathidasan University, Tiruchirappalli.
- 4. Ganesh, A., and Narayana Kumar, R., (2006). GPS Principles and Applications, Satish Serial Publishing House, Delhi.

PAPER 6: INTRODUCTION TO SPATIAL DATA ANALYSIS 4 Credits

Objectives: To understand and be able to:

- Describe the theoretical foundations of geospatial analysis.
- Understand, create, and apply geographic and other data to learn more about the importance of place and its role in shaping or moderating environmental exposures, health-related impacts and outcomes, and the efficacy of health care delivery systems.
- Discuss the relevant spatial analysis approaches and techniques for working with health-related geospatial data

Student Learning Outcomes:

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

- Plan, design and implement a spatial analysis project demonstrating the ability to select, apply and critically interpret appropriate methods for the analysis of geographical information.
- List several different approaches to spatial analysis and differentiate between them.
- Outline the geographic concepts of distance, adjacency, interaction and neighborhood and discuss how these are fundamental in performing spatial analysis
- Explain how point patterns, including clustering, can be identified and understood as realizations of spatial processes
- Discuss how linear feature concepts of length, direction and connection are represented and analyzed in networks.

Unit I: Spatial Organization: Spatial Structure, Process: physical, economic and social and spatial organizations. Significance of spatial analysis. Overview of tools for analysis

Unit II: Spatial Analysis: Location and distributions of phenomena; interaction of people, goods and services between places and regions. Spatial data for GIS -Creation of spatial data (Raster, Vector & Non-spatial) - Conceptual model for spatial problems.

Unit III: Spatial Analysis of point entity: Methods for evaluating point patterns: clustered and random distribution. Mapping Density and Density based analysis: Global, local density. Neighborhood. Centrography: Mean Median and Standard Distance. Distance based analysis. Gravity model.

Unit IV: Spatial analysis of line entity: Concepts, Accessibility – Network – Connectivity -Detour index, evaluation of network complexity using Alpha-gamma indices. C-matrices for evaluating connectivity of the network. Network data mode. Types of network analysis: Route, Closest facility, Service areas, Origin-Destination (OD) cost matrix, Vehicle routing problem, Location-allocation.

Unit V: Spatial analysis of area entity / surface: Zonal Statistics. Interpolations and their types. Trend surface Analysis. TIN, DEM, DTM, Contour, Slope, Aspect, Hill shade, View shed. Auto-correlation, semi-variogram.

Reference Books:

1. Abler, R., Adams, J. S., and Gould P., (1972). Spatial Organization: The Geographer 's View of the World, Prentice-Hall, London.

- 2. Mitchell A. (2001) The ESRI Guide to GIS Analysis, Volume 1: Geographic Patterns and Relationships, ESRI.
- 3. Mitchell A. (2001) The ESRI Guide to GIS Analysis, Volume 2: Spatial Measurements and Statistics, ESRI.
- 4. Burrough, P. A., (1986). Principles of Geographical Information Systems for Land Resource Assessment, Oxford University Press Inc., New York.
- 5. Heywood, I., Cornellius, S., and Carver, S., (2001). An Introduction to Geographical Information Systems. Parsian Education (Singapore) Pvt. Ltd., 2nd Indian Reprint Indian Branch, Delhi.
- 6. Mitchell, A., (1999). The ESRI Guide to GIS Analysis Volume 1: Geographical Patterns and Relationships, Environmental Systems Research Institute, Inc., Red Lands, California.
- de Smith M, Longley P, Goodchild M.: Geospatial Analysis A comprehensive guide http://www.spatialanalysisonline.com, (Winchelsea Press 2006-2011

PAPER 7: DIGITAL CARTOGRAPHY 4 Credits

Objectives: To understand the various purposes, roles and representations of cartography

- To gain and practice the use of cartographic language in the creative design process
- To gain and practice skills in cartographic design, representation and production in a GIS environment

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

- Understand of the purposes of cartography, recognize the elements of cartographic representation, and how maps work
- understand of the theory and principles of cartography and their relationship to practice
- create digital maps in formats reflecting the purpose, content and function of input data
- use digital cartographic methods for exploring, critiquing, confirming and presenting geographical relationships
- increase their proficiency in graphical literacy and increase their proficiency in presentation

Unit I: Cartography: Cartography today – Nature of Cartography – History of Cartography – Cartographic Visualization – Web Cartography – Graticule – Cartometry –Map Characteristics - Modern Trends.

Unit II: Basic Geodesy: Earth-Map Relationships – Basic Geodesy – Map Projections – Scale – Reference and Coordinate system – Transformation: Basic Transformation & Affined Transformation.

Unit III: Data base Creation: Sources of data – Ground Survey and Positioning – Remote Sensing data collection – Census and sampling – data – Models for digital cartographic information – Map digitizing.

Unit IV: Map Design: Cartographic design – Color theory and models – Color and pattern creation and specification – color and pattern – Toponomy and lettering in maps – Map compilation – Demography and Statistical mapping.

Unit V: Digital map making: Process of Map Productions: Non-photographic systems – Multiple reproduction processes. Computer application in Cartography – Computer mapping - Remote sensing and cartography - use of air photographs and satellite images – GIS & GPS application in cartography.

Reference Books:

- 1. Burrough, P.A., (1986). Principles of Geographical Information Systems for Land Resource Assessment, Oxford University Press Inc., New York.
- 2. Geogre P. Kellay, (1979). Map Projections, B.I. Publications, New Delhi.
- 3. Keates, J.S., (1973). Cartographic Design and Production, Longman Inc., London.
- 4. Menno Jan Kraak, and Ormeling, F., (2004). Cartography Visualization of Geospatial Data (2nd Edition), Pearson Education, New Delhi.
- 5. Misra, R.P., and Ramesh, A., (2002). Fundamentals of Cartography, Concept Publishing Company, New Delhi.
- 6. Arthur H. Robinson et al., (2004). Elements of Cartography, John Wiley & Sons, New York
- 7. Slocum, Terry A. (1999): Thematic Cartography and Visualization, Prentice-Hall, Upper Saddle Creek, NJ.

PAPER 8: DIGITAL IMAGE PROCESSING 4 CREDITS

Objectives:

- Describe and explain basic principles of digital image processing
- To study the image enhancement techniques
- Be familiar with image classification and segmentation techniques.
- Develop a theoretical foundation of fundamental Digital Image Processing concepts.
- Provide mathematical foundations for digital manipulation of images; image acquisition; preprocessing; segmentation

Student Learning Outcomes:

- Have a clear understanding of the principals the Digital Image Processing terminology used to describe features of images.
- Analyze images in the frequency domain using various transforms.
- Evaluate the techniques for image enhancement, classification and image restoration.
- Apply image processing algorithms in practical applications

Unit I: Introduction: Origin – Steps in Digital Image Processing - Digital images: Types. Image processing software and hardware's - Elements of Visual Perception - image storage formats.

Unit II: Pre-processing and Rectification: radiometric, geometric distortions and corrections - Systematic and Non - systematic error and corrections - image transformation, ground control points and re-sampling techniques: Nearest Neighbour,

Bilinear interpolation, Cubic Convolution.

Unit III: Image Enhancement - spatial filtering techniques: Contrast stretch - linear and nonlinear - Low frequency filtering - high frequency filtering - gradient / directional filters: edge detection and edge enhancement - non-gradient filters - Image color space transformation and band rationing.

Unit IV: Image Classification Techniques and pattern recognition: band suitability – supervised classification - training sites - spectral signatures and signature evaluation - Image classifiers - unsupervised classification. Principal Component Analysis. Image segmentation. Sub-pixel and image fusion.

Unit V: Accuracy Assessment: Reference Data, Sampling techniques, Error of Commission and omission, Error Matrix, Kappa Statistics, Change Detection Analysis

Reference Books:

- 1. Lillisand T.M, R.W. Kiefer & Chipman (2015) Remote Sensing and Image Interpretation (7th edition). John Wiley & Sons, New York.
- 2. Jensen, J. R. (2016): Introductory Digital Image Processing: A Remote Sensing Perspective (4th Edition), Pearson Publication.
- 3. R.C.Gonzalas and R.E.Woods (2016): Digital Image Processing, Prentice Hall, 3rd Ed., Pearson India.
- 4. A.K.Jain (2015): Fundamentals of Digital Image Processing (1st Edition), Pearson Education India.
- 5. Prithvish Nag, and Kudrat, M., (1998). Digital Remote Sensing, Concept Publishing Company, New Delhi.
- 6. Paul Gibson, and Clare H. Power, (2000). Introductory Remote Sensing: Digital Image Processing and Applications, Routledge Publisher, London.
- 7. Richards, J. A., Jia, X. (2000): Remote Sensing and Digital Image Processing, Springer, Verlag Berlin

ELECTIVE 2.1. GEOINFORMATICS FOR HYDROLOGY 4 CREDITS

Objectives: The main objective of this paper student will understand hydrological concept and its parameters, watershed managment, surface and subsurface water exploration and mangement through remote sensing. Also understand runoff modelling and hydro geomorphological mapping.

Student learning Outcome: On completion of this course students will be able to understand watershed problems and solution through geoinformatics and also understand geomorplogical concept of surface water and sub surface water.

Unit I. Hydrologic Cycle, Hydrological parameters, porosity, permeability, specific yield, types of aquiers. Watershed Management: Watershed characterization, delineation and codification, watershed problems and management strategy. Geoinformatics approach for watershed prioritization.

Unit II. Remote Sensing in Surface- Subsurface Water Exploration: Application of remote sensing in hydro- geomorphological interpretation for ground water exploration, water quality monitoring through remote sensing.

Unit III. Operational Applications in Water Resources: Flood prediction, drought evaluation, snow cover mapping and reservoir sedimentation evaluation.

Unit IV. Geoinformatics Models in Water Resources: Geo informatics based Runoff and hydrological modelling, flood Hazards modelling, snowmelt runoff modelling.

Unit V. Case Studies: Hydro-geomorphological mapping in Plateau region, Flood Prone zone mapping in Indo- Gangetic Plains, Water harvesting Initiatives in Urban built up the lands.

Reference Books:

- 1. Schultz, G A and Engman E T 2000. Remote Sensing in Hydrology and Water Management, Springer- Verlag, Berlin, German.
- 2. Lillisand T M and Keifer R W 1994. Remote Sensing and Image interpretation John Willey and Sons, New York.
- 3. Jenson J R 2000 Remote Sensing of the environment- An Earth Resources Perspective, Prentice Hall Inc.
- 4. P S Roy (2000) Natural Disaster and their Mitigation Published by Indian Institute of Remote Sensing (IIRS) 2000.

ELECTIVE: 2.2 GEOSTATISTICS 4 Credits

Objectives: To study and understand the concept of geostatistics and its applications in Geoinformatics. To study the methodology and designs, geospatial relations and spatial process and modelling.

Student learning outcomes: On completion of this course the students will be able to solve various problems in the field of geostatistics employing project management, statistical relation with geospatial technology.

Unit I. Project management and GIS: Project types-general project management methodology-project life cycle-geographic project planning- GIS objects and attributes-working scale-data standards and errors - cataloging - indexing-meta-data.

Unit II. Methodological and Designs: Problem identification-objectives-variables and attributes-management of univariate and multivariate data - concepts and application of Normal-Gamma and Gaussian distributions - population-sample-sampling-spatial sampling practice - Statistical testing t, f, X2 and Z applications.

Unit III: Basic of data exploration: Raw data relative data tables - dot plots in univariate – bivariate explorations - Diagram as tools of exploration: histogram – bar chart – paretochart – line graphs-box plots – stem or leaf plots - q-q plots p-p plots – ogives – class interval selection in thematic mapping.

Unit IV: Geospatial relations: Concepts of interdependence – dependences – independence, correlations: simple – multiple correlation – autocorrelation – cross correlation – variograms – kriging –partial correlations – univariate – multivariate – polynomial curve fitting – regression models – time series analysis – trend surface analysis.

Unit V: Spatial processes and modeling: Pattern recognition in point – line – area distribution – network analysis – space partitioning – multivariate classification methods: factor analysis methods – classification methods – overlay analysis.

Reference Books:

- 1. Aslam Mahmood, and Moonis Raza, (1986). Statistical Methods in Geographical Studies, Rajesh Publications, New Delhi.
- 2. Davis, (1986). Statistics and Data Analysis in Geology, John Willy & Sons Inc., New York.
- 3. ArcGIS Geostatistical Analyst: ArcGIS 9 by ESRI Press Publisher, Red Lands, California.
- 4. FitzGerald B. F., (1974). Development in Geographical Method, Science in Geography 1, Oxford University Press, Oxford.
- 5. Doaugherty Richard, (1974). Data Collection, Science in Geography 2, Oxford University Press, Oxford.
- 6. Davis Peter, (1974). Data Description and Presentation, Science in Geography - 3, Oxford University Press, Oxford.
- 7. McCullagh Patrick, (1974). Data Use and Interpretation, Science in Geography 4, Oxford University Press, Oxford.

PAPER 9. ADVANCES IN GEOINFORMATICS 4 CREDITS

Objectives:

- Introduction to trends and advances in GIS.
- To acquire skills in advance techniques such Microwave, Hyperspectral Li-DAR and GPR scanning for mapping, modeling and monitoring.
- New ways of data collections, dissemination and applications of GIS technology.
- Advances in remote sensing techniques and its application to solve real word problems

Student Learning Outcomes:

- Provide latest state of art in GIS technology.
- Enable students to solve real word problems using modern techniques of GIS and remote sensing and help to execute decision making.

UNIT I. Microwave, Hyperspectral Remote Sensing: Concept, Sensors, Radar Operating Principles, Synthetic Aperture Radar, Radar Image Characteristics, SAR Interferometry and its applications

UNIT II. LiDAR and GPR: Concepts, LiDAR sensor system, Accuracy of LiDAR measurements, Ground Penetrating Radar (GPR) and its application

UNIT III. Spatial decision analysis: Multi-criteria decision analysis, estimation of weights, Fuzzy logic, operations on fuzzy set. Fuzzy vs. Boolean, Basic rules for inference, Artificial Neural Network, Image Segmentation

UNIT IV. Recent Trends in GIS: Basic concepts, conventional vs. database modeling with OOGIS, history of network technology, network architecture, internet GIS and its components, implementation and benefits Inter-operability speci-

fications, open source GIS- Cloud computing, crowd sourcing and open geospatial consortium. Mobile GIS, Distributed GIS systems

UNIT V. Decision support systems: Types of problems, efficiency and effectiveness of decision making, architecture of DSS, tools, significance of DSS, DSS and Expert Systems.

Reference Books

- 1. Remote Sensing Digital Image Processing by Richards J. A, Xiuping Jia, Published by Springer Verbg Berline Heidelberg My. 1999
- 2. Demers, M. N. (2000): Fundamentals of Geographic Information Systems, John Wiley & Sons, New Delhi
- 3. Malczewski, J. (1999): GIS Multi-criteria Analysis, John Wiley & Sons, New York
- 4. Environmental Systems Research Institute, Inc. (1998): Understanding GIS: The ARC/INFO Method, ESRI Press, Redlands

PAPER 10: PHOTOGRAMMETRY 4 CREDITS

Objectives:

- describe and explain to the student's photogrammetric techniques of carrying out reliable measurement from stereopairs
- train the students on photogrammetric mapping techniques of natural resources

Student Learning Outcomes (SLOs):

- Understand photographic methods of mapping Earth features
- Describe photographic techniques of taking reliable measurement from high resolution imageries and viewing earth objects in 3D.

UNIT I. Introduction: Historical Development and Fundamentals of aerial photography, Vertical and Oblique aerial photography, Classification of Aerial Film Cameras, Digital cameras Components of aerial Cameras, Camera Calibration, Photogrammetric Applications and Products.

UNIT II. Scale, Geometry and Ground Coverage of Aerial Photographs, Area calculation & Flight Planning.

UNIT III. Binocular and Stereoscopic vision, Conditions for Stereovision, Photographic overlap Image Parallax, Height determination from stereo pairs - Parallax Equation, Ground Control.

UNIT IV. Co-ordinate Systems used in Photogrammetry, Relief distortion and Tilt distortions, Rectification, Ortho Rectification, Height determination from single photograph, Planimetric map compilation, Digital Elevation Model (DEM), Digital

orthophotos.

UNIT V. Principles of digital photogrammetry: hardware & software requirements, imagenmeasurement, orientation procedure, epipolar geometry, aerotriangulation, block Adjustment, mosaics of dtm & ortho images.

Reference Books:

- 1. Analytical Stereoplotter Advanced Exercise, System specifications, intro to softcopy photogrammetry
- 2. Elements of photogrammetry with Applications in GIS, 3rd Ed, Paul R Wolf and Bon Dewitt.
- 3. Keates J S (1973): Cartographic Design and production, London
- 4. Ramesh P A (2000) Fundamental of Cartography, Concepts Publishing Co., New Delhi
- 5. Rampal K K (1993): Mapping and Compilation, Concept Publishing Co., New Delhi
- 6. Anson R W & Ormeling F J (1993) Basic Cartogrsphy, Vol.1, 2nd , Elservier Applied Science, Publishers, London

PAPER 11: APPLICATION OF GEOINFORMATICS IN NATURAL RESOURCES MANAGEMENT 4 CREDITS

Objectives: On completion of study of this subject the students would have a sound knowledge of application of remote sensing, GIS, GPS and other tools for understanding the concepts of natural resources management and would be able to prepare suitable action plans for its sustainable development.

Outcome: completion of this course the students will be able to solve all types of natural resource problems through geoinformatics modelling.

Unit I. Resource Conservation: Remote sensing based land use- Land cover mapping for resource monitoring and management Sustainable development of natural resource. Land Resource: Introduction to soil, mineral resource, remote sensing in mapping soil degradation, impact of surface mining on land resource.

Unit II. Bio-Resource: Remote sensing application in agriculture, forest resource and wildlife habitat assessment, Mapping of forest density and type, issues in forest management.

Unit III. Water Resource: Remote sensing in application in surface and sub surface water resources evaluation, water mining and pollution, issues in water resources managements.

Unit IV. Energy Resources: Coal, Oil, and Nuclear Energy, non-conventional energy resources, future potential and requirement of energy resources. GIS in Energy resources management.

Unit V. Geo informatics Models in Resource Managements: Forest fire modelling, Wild Life Habitat Assessment Modelling, Soil Erosion Modelling, and Land Resources development Prioritization Modelling.

Reference Books:

- 1. Robert G Reeves; manual of Remote Sensing Vol II American Society of Photogrammetry and remote sensing, Falls Church
- 2. Donald A Davidson : Soils and land use Planning , Longman, London, 1998
- 3. Robert W Colwell. Monitoring of Earth Resources from Aircraft and Spacecraft.

PAPER 12: GEODATABASE FOR GIS 4 CREDITS

Objectives: To study the concept of DBMS, RDBMS, and its structure. Also student can understand geographical modelling will help them to solve real world problems.

Outcome: On completion of this subject, students should have a sound knowledge about the database concepts, database management systems and their applications in GIS and modeling the real world.

Unit I. Introduction to DBMS – types of DBMS – data models – ER model: concepts – design. GIS data model: Conceptualizing the real world in GIS.

Unit II. Relational Data Base Management Systems: Concepts – Constrains – Relational Data base Design – Relational Models Extended with ADT. SQL – simple – complex –spatial join.

Unit III. Representation of Spatial Objects: Geographic space modeling – Representation Modes – Representing the Geometry of a Collection of objects – Spatial data formats and Exchange formats – Object Oriented GIS

Unit IV: Geodatabase: Arc Geodatabase – topology – defining the relationship class – geometric networks – Geocoding services – Building geodatabases with CASE tools

Unit V: Emerging Trends: Data Mining: concepts – application of data mining, Data Warehousing: Characteristics of Data Ware house – applications, Intelligence Decision making: Artificial Intelligence, Decision support system, Expert system – design – applications.

Reference Books:

- 1. Korth, H.F., Silberschatz, A., and Sudarshan, S., (2002). Database System Concepts (5th Edition), McGraw - Hill Book Company, New York.
- 2. Rigaux, P., Scholl, M., and Voisard, A., (2002). Spatial Databases: with Application to GIS, Morgan Kaufmann, New York.
- 3. Ramez Elmasri, and Shamkant B. Navathe, (2002). Fundamentals of Database Systems, 5th Edition, Pearson Education, New Delhi.
- 4. Building Geodatabase, (2002). GIS, ESRI Publication, Red Lands, California.
- 5. Thomas Ott, and Frank Swiaczny, (2000). Time-Integrative Geographic Information Systems, Springer, Berlin

ELECTIVE 3: 3.1 ADVANCES IN PUBLIC HEALTH GEO INFORMATICS 4 CREDITS

Objectives:

• To enable students to critically evaluate contemporary developments in

health from a spatial analysis perspective

- to understand the use of GIS-based analyses of health alongside a range of complementary approaches to explanation and the implications for the results and interpretations presented;
- to understand the issues involved in representing people, their health and potential explanatory factors as spatial objects in GIS.
- to be able to discuss the relative roles of individual-level effects and area-level effects (or composition and context) in influencing patterns of health and the role that GIS can play in exploring these;
- to be able be able to critically evaluate the evidence for and against causal relationships between health outcomes and environmental factors and to know how to use GIS tools to identify spatial patterns in health and to undertake an exploratory analysis of potential explanatory factors.

Student Learning Outcomes;

Having successfully completed this paper students will be able to:

- Gain detailed knowledge of selected parts of the subject that allow you to study the current literature and engage in discussion with peers in relation to the spatial distribution of health and disease.
- Use appropriate principles, theories and methods to design and undertake primary research within the subject area
- Gain knowledge of contemporary methods used to analyze remotely sensed imagery and other spatial data sets in relation to the identification of spatial pattern in health data
- Conduct spatial data analysis including patterns in point and area-based health data manipulation with the help of geoinformatics
- Analyze and critically interpret primary and secondary data (especially spatial data); statistical methods
- Critically analyze the literature relating to remote sensing and spatial analysis

Unit I. Epidemiology of Diseases: Definition of epidemiology. Uses of epidemiology. Epidemiological triad. Chain of infection. Modes of transmission of infection. Epidemiology of Non-communicable diseases.

Unit II: Public health infrastructure system and Introduction to Health GIS: Understanding of the network of health facilities in India. Primary Health Centre infrastructure, Sub-Centre Infrastructure, Health staff in Periphery. Definition of Health GIS. Uses and application of Health GIS technology in disease management. Examples of application of GIS in Health and Disease. John Snow cholera epidemic.

Unit III. Types of Data for Health GIS: Different types of Data used in health GIS. Sources of Health and Disease data for GIS analysis. Health Information System. Integrated disease surveillance project (IDSP).Data available in Public Domain. Specialty of Spatial data. Limitations associated with spatial data (MAUP, boundary effects, patterns). Privacy and Confidentiality concerns of Mapping health and disease data. Methods of collecting health and disease data.

Unit IV: Spatial analysis and Spatial Statistics for visualizations of spatial health data: Summary statistics, Spatial data distributions. Calculation of risk used to characterize Overall health of Populations (Rate, Ratio, Proportions, Incidence rate, prevalence rate, mortality rates). Basic GIS operations and Five Spatial Analysis for visualizations of health data. Point pattern analysis for vector borne disease data with examples. Spatial Interpolation with examples. Hot Spot analysis for Disease Data with examples.

Unit V. Access to healthcare and healthy environments: Factors determining accessibility to health care. Modeling and Approaches to accessibility to health care based on distance, time and cost. Solutions to improve access to health care.

ELECTIVE: 3.2 URBAN GIS 4 Credits

Objectives:

- To introduce the concepts of urban planning
- To explore the use of the geospatial technology in advanced analysis in

planning.

Student learning outcomes: On completion of this course students shall be able to

- Gain knowledge of urban and regional planning concepts, the use of geomatics technology in planning and management in urban areas and regions.
- Familiarize with case studies, inputs from Remote Sensing and GIS
- Get exposure in modelling in urban land use and its forecasting

Unit I: Basic Concepts: Urban - scope and content of urban GIS – urban area – urban morphology – Urban hierarchy - urban models and functions.

Unit II: Data Source And Collection: Platforms - scale and resolution – scope and limitations – interpretation from aerial and satellite images –– GPS survey for urban data collection –cadastral data – Lidar, digital image processing technique; image classification - image extraction - image fusion

Unit III: Urban Structure: Infrastructure – utility mapping – process and change analysis – 2D and 3D – CBD – urban density – fringe dynamics – slums – urban sprawl

Unit IV: Urban Administration: Municipal and local administration – electoral application – solid waste management – water supply and sanitation – recreation site identification – property tax – tax assessment - network analysis – optimum route/ shortest route –traffic and parking studies – accident analysis – vehicle

tracking - case studies.

Unit V: Urban Modeling: Urban Growth Modeling – Expert Systems in Planning - Environmental quality – crime mapping – location based services (LBS) – 3D city modeling and applications.

Reference Books:

- 1. Jean-Paul Donnay, Mike J Barnsley and Paul A Longley., (2001) Remote Sensing and Urban Analysis. Taylor and Francis, London.
- 2. Harold Carter., (1995) The Study of Urban Geography, Arnold, A Division of Hodder Headline, PLC, London.
- 3. Sokhi B S and Rashid S M., (1999) Remote Sensing of Urban Environment. Manak Publications Private Limited.
- 4. William E Huxhold., (1991) An Introduction to Urban Geographic Information Systems. Oxford University Press.
- 5. Timothy.L.N and Piotr Jankowski., (2010) Regional and Urban GIS A Decision Support Approach, The Guilford press, New York.

SEMESTER IV Summer project work – 2 Credits Thesis and viva-voce examination – 12 Credits

M.Sc. MOLECULAR BIOLOGY

Overview

Molecular biology is the study of biology at a molecular level. It is the study of molecular underpinnings of the process of replication, transcription and translation of the genetic material. The field overlaps with other areas of biology and chemistry, particularly genetics and biochemistry. The field chiefly concerns itself with understanding the interactions between the various systems of a cell, including the interrelationship of DNA, RNA and protein synthesis and learning how these interactions are regulated. In view of the increasing demand for training manpower in the area of Molecular Biology, Genetic Medicine and Biotechnology, it was consensus of the committee (Faculties & experts) that this course should be broad based and should be able to give a good insight into modern biology and important component of hands-on training to the students. Thus by nature it will be an interdisciplinary course. All the subjects included in the syllabus are at an advanced level. The course aims to provide an in-depth knowledge in the field of molecular biology and offer practical experiences to the students on current techniques in molecular research, molecular diagnostics, health care and industry. Teaching is imparted in the form of lectures, seminars, demonstrations, web-based exercises, experimental and theoretical sessions as well as assignments, project work, site visits and symposia. The entire course deals with the basic core molecular biology knowledge sharing, instruments and practical aspects, which might be very useful to carryout, various studies in molecular biology, immunology, molecular medicine, radiobiology, genomics & proteomics.

An emphasis is also laid on the Molecular medicine in the course which is highly relevant to understand molecular disease mechanism, and its relation to drug designing. Molecular and cellular radiobiology paper is introduced in the final year for the students to have in depth molecular details of how the radiations can help combat related human disorders and also on their hazardous reactions. The students are required to submit a dissertation thesis in the last semester on any of the topics related to molecular biology area. The aim is to provide students experience in research design, data analysis and interpretation. The development of critical thinking processes and proficiency in scientific reading and writing will be emphasized throughout the course.

	Semester I	Credits
Paper 1	Fundamentals of Molecular Biology	4
Paper 2	Advances in Molecular Biology	4
Paper 3	Fundamentals of Biochemistry and Biomolecules	4
Paper 4	Molecular Genetics and Evolution	4
Elective 1	Statistical Methods for Biology	4
Practical 1	Experimental Molecular Biology	6
		26
	Semester II	
Paper 5	Molecular Developmental Biology	4
Paper 6	Molecular Cell Signalling	4
Paper 7	Immunology & Vaccine development	4
Paper 8	Genetic Engineering	4
Elective 2	Cell and Tissue Culture Technology	
Practical 2	Animal Cell Culture and Immunotechniques	6
		26
	Semester III	
Paper 9	Cancer and Stem Cell Biology	4
Paper 10	Molecular Medicine	4
Paper 11	Molecular and Cellular Radiobiology	4
Paper 12	IPR, Bioethics & Bio-safety	4
Elective 3.1	Sequence Analysis & Pharmacogenomics	
Elective 3.2	Genomics & Proteomics	4
Practical 3	r-DNA techniques and in silico sequence analysis	6
		26
	Semester IV	
	Summer Project	2
	Thesis and viva voce examination	12
		14
	Total Credits	92

Course Curriculum

SEMESTER I

PAPER 1: FUNDAMENTALS OF MOLECULAR BIOLOGY

Objective

This paper focuses on the objective of introducing to basic principles of biochemistry, genetics, molecular biology, and recombinant DNA technologies with the material being presented introduces modern biology at the molecular level.

Scope

At the successful completion of the course, the students will be able to understand the core biology concepts at molecular level where they can apply in teaching as well as molecular research jobs.

Unit I. The Central dogma - flow of information in biological system; Evidences of DNA as genetic material - historical perspectives – experiments of Hammerling, Griffith, Avery - MacLeod & McCarty, Hershey & Chase; Structure of DNA - Watson & Crick model – different forms of DNA (A,B,Z) - nearest base frequency (anti parallel nature) analysis. RNA – structure and functions; mRNA, rRNA & tRNA – structures and functions.

Unit II DNA replication- Semiconservative model of DNA replication (Meselson and Stahl's experiment); Prokaryotic DNA replication – different models – rolling circle model - bacterial DNA polymerases – characteristics & functions; Viral DNA replication. Eukaryotic DNA replication – Okazaki fragments - role of helicases, topoisomerases, DNA polymerases and DNA ligases - formation of replication fork; Telomere synthesis and functions of telomerase.

Unit III. Transcription – Prokaryotic gene transcription – bacterial RNA polymerases – mechanism and regulation of bacterial transcription; Eukaryotic gene transcription – eukaryotic RNA polymerases – transcription factors – mechanism (initiation & elongation) and regulation of eukaryotic transcription; Post transcriptional modification – 5'CAP formation, polyadenylation, splicosome assembly, splicing & editing. Ribozymes – mechanism of action and applications.

Unit IV. RNA Translation- Genetic code, experiments of Khorana and Nirenberg, feature of genetic code triplet codon, degeneracy, wobble hypothesis, variation in codon usage, structure of ribosome - A, P, E sites of ribosomes, translation in prokaryotes & eukaryotes- activation of amino acids, initiation: shine dalgarno complex, initiation factors, elongation: elongation factors, peptide bond formation, termination: release factors.

Unit V. Concept of gene: Fine structure of gene, Beadle and Tatum's One gene one enzyme concept, One gene one polypeptide concept, Complementation test, Intragenic complementation, Cistron, Recon and Muton, Split gene, Jumping gene, Overlapping gene & multiple genes. Operon concept- *lac* operon, Arabinose and tryptophan operon.

- Watson, J. D., Hopkins N. H., Roberts J. W., Steitz J. A., Weiner A. M. 2014. Molecular Biology of the Gene. Benjamin/Cummings. 7th edition.
- Gardner E J, Simmons M J, Snustad D P. 2006, Principles of Genetics. John Wiley & Sons, Inc., 8th edition.
- Griffith A J F, Miller J H, Suzuki D T, Lewontin R C, Gelbert W M.2000. An introduction to Genetic Analysis. W.H. Freeman and Co. New York, 7th edition.
- Strickberger, M. W. Genetics. 2008, Macmillan New York:, 3rd edition.
- Lewin B., Gene. 2012, Oxford University press, Oxford., 11th edition.

PAPER II: ADVANCES IN MOLECULAR BIOLOGY

Objective

Cell biology is the study of the structure and function of prokaryotic and eukaryotic cells. In this course we will examine many aspects of basic cellular biology of prokaryotes and eukaryotes at the molecular scale.

Scope

At the successful completion of the course, the students will be able to understand the basic structural and cell biology-related molecular mechanisms in both prokaryotic and eukaryotic cells.

Unit I. Plasma membrane: Membrane biogenesis-lipids and proteins, membrane flow hypothesis, regulation of plasma membrane composition, membrane lipid and protein turnover, polarized cells Mechanism of protein sorting and targeting (ER, golgi, plasma membrane, mitochondria), signal peptide.

Special features of other organelles: Golgi & ER – processing of glycoproteins, peroxisomes – lipid degradation and oxidative stress, vacuoles and their functions.

Unit II. Membrane dynamics: Lateral diffusion, FRAP, FRET, single particle tracking, transbilayer movement of lipids (flip-flop) (flippase, floppase, scramblase), microdomains caveolae, rafts. Membrane fusion eg: neurotransmitters release. Membrane Transport: Law of diffusion overview, glucose transporter, Na+ K+ AT-Pase, receptor mediated endocytosis, Ion channels (ligand gated and voltage gated), aquaporin channel, ionophores, and patch clamp technique.

Unit III. Structural frame work of eukaryotic cell: cytoskeleton, microfilaments, microtubules, and intermediate filaments. Composition, assembly and function. Cell dynamics – Flagella and cilia, structure and assembly, cell movement, diapedisis, and movement of vesicles (vesicular trafficking).

Unit IV.Cell cycle regulation: cell cycle overview, cell cycle check points, cell cycle regulatory genes, cyclins (D, E, A, and B), cdk's role, phase transition regulation (G1- S, S-G2, G2-M), S phase replication initiation regulation by S-cdks & MCM proteins, role of microtubule & kinesin, dynein in anaphase, anaphase promoting complex, and cytokinesis.

Unit V. Cell death: Apoptosis & necrosis role and mechanism, caspases and cathepsins. Cell death signals, survival factors, cell death genes. Cell death pathways, pro & anti apoptotic molecules. Molecular markers for apoptosis: Membrane markers and DNA ladders.

- 1. Cooper Geoffrey M. 2000. The Cell A Molecular Approach. 2nd Edn. ASM Press. Washington.
- 2. Bray A. D., Lewis J., Raff M., Roberts K. and Watson J.D. 2002, 4th edition, Molecular Biology of the Cell. B. Garland Publishing, New York and London.
- 3. Freifelder D. 2004. Molecular biology. Narosa Publishing House, New Delhi
- 4. Gardner E J, Simmons M J, Snustad D P. 2006, Principles of Genetics. John Wiley & Sons, Inc., 8th edition.
- 5. Sambamurthy, A.V.S.S. 2005. Genetics. Narosa Publishing House, New Delhi.

6. Strickberger, M. W. Genetics. 2008, Macmillan New York:, 3rd edition..

PAPER III: FUNDAMENTALS OF BIOCHEMISTRY AND BIOMOLECULES

Unit I. Carbohydrates - Structure and classification of carbohydrates. Chemistry of monosaccharides - Pentoses, hexoses, deoxyglucose, amino sugars, muramic acid, neuraminic acid. Linkages in sucrose, lactose and maltose, trehalose and glycosides. Isolation of polysaccharides - Homopolysaccharides and heteropolysaccharides, starch, cellulose, glycogen, hyaluronic acid, chondroitin sulphate, chitin, xylans, bacterial cell wall polysaccharides, blood group polysaccharides, pectin and pectic polysaccharides. Structural elucidation of carbohydrates - graded acid hydrolysis, periodate oxidation, methylation, acetylation, GC-MS, IR and NMR. Glycobiology - Glycoproteins; N- and O-glycosylation, lectins, carbohydrates in tissue engineering. Proteoglycans; agreecan, syndecan and decorin.

Unit II. Aminoacids - Nomenclature, classification and buffering properties of amino acids, zwitterionic structure, reaction of amino acids, unusual amino acids, non-protein amino acids. Peptide bond - Features of the peptide bond, naturally occurring peptides; glutathione enkaphalins and endorphins. Chemical synthesis of peptides; Khorana's solution phase synthesis and Merrifield's solid phase synthesis. Determination of amino acid compositions- Acid and base catalyzed hydrolysis, separation, quantification, determination of N and C terminal residues, determination of site of glycosylation and type of linkage (o-glycosyl and n-glycosyl). Elucidation of structure of proteins- Isolation of proteins; overview of purification and criteria of purity.

Determination of primary structure - Sequencing strategies; N-terminal and C-terminal, sequencing methods. Automated sequanators. Determination of s-s-bond position. Secondary structure of protein; a, β sheet, β -bend, β -turn and super secondary structures. Secondary structure prediction methods: Ramachandran plot, Chou and Fasman algorithm. Tertiary and quaternary structures. Factors responsible for protein folding and confirmation - Anfinsen's experiment. Weak forces of interaction; hydrogen bonding, Vander Waal's forces, London force, ionic interactions, hydrophobic interactions, S-S bridges, peptide bond, glycosidic bond, phospodiester bond, and allolysine. Denaturation and renaturation of proteins, molten globule. 3D Structure of myoglobin hemoglobin, immunoglobulin, collagen, chymotrypsin and keratin. Chaperons and Levinthal paradox.

Unit III. Lipids - Classification of lipids; oils, fats, and waxes. Occurrence and physico-chemical properties of fatty acids, esters of fatty acids, cholesterol, phosopholipids, glycolipids, sphingolipids, cerebrosides and gangliosides.

Lipid mediators - Eicosanoids, prostaglandins, leukotrienes, prostacyclins, thrombaxanes, DAG and ceramide.

Unit IV .Nucleic Acids - Nitrogenous bases, nucleosides, nucleotides, physicochemical properties. Isolation of DNA and RNA from biological sources (microbes, plants and animals). Purification of nucleic acids, physiochemical properties of nucleic acids, melting of DNA, Tm; factors affecting Tm, Cot curve, classification of DNA based on cot curve. Chemical reactions of DNA and RNA; Nucleotides as regulatory molecules, enzyme cofactors and mediators of chemical energy in cells. Sequencing of DNA-Maxam Gilbert method, dideoxy method. Chargaff's rule, secondary structure of DNA. Watson and Crick model; B and Z DNA, other models of DNA structure. Types of RNA, secondary structure of tRNA and cloverleaf model; Other secondary structural features in DNA, stem loop structure, palindromic sequences, cruciforms. DNA protein interaction; zinc finger, leucine zipper, helix-turn-helix, other motifs, DNA bending and kinks.

Unit V. Porphyrins – Structure and properties of porphyrins – Heme, chlorophyll and cytochromes. Reactive oxygen species and detoxification mechanisms. Vitamins – Water soluble and insoluble vitamins, structure and function, deficiency symptoms.

- 1. Lehninger principles of biochemistry 5th edition David Nelson and Michael M. Cox
- 2. Biochemistry 5th edition Jeremy m. berg; John I. Tymoczko and Lubertstryer
- 3. Biochemistry 4th edition Donald Voet and Judith g. Voet
- 4. Outlines of biochemistry 5th edition Erice Conn and Paul Stumpf
- 5. Text book of biochemistry 4th edition Edward Staunton west; Wilbert r. todd; Howard S. Mason and John T. van Bruggen

PAPER IV: FUNDAMENTALS OF MOLECULAR GENETICS & EVOLUTION

Objective

With a primary focus on eukaryotic organisms, this course deals with genetics at cellular and organism levels, population genetics and microevolutionary processes with an emphasis on understanding of basic molecular evolution at whole genome level.

Scope

At the completion of the course the students will be having a firm foundation of how molecular evolution has shaped the evolutionary and genetic mechanisms of life. The understanding of such core mechanisms assists them in future research as well as teaching professional endeveours.

Unit I. Mendelism: History and Mendel's experiments, Laws of inheritance-dominance and recessive concept, law of segregation, law of independent assortment, back cross and test cross, sex-linked inheritance, sex linked genes, sex limited genes and sex influenced genes.

Extension of Mendelism: incomplete dominance, codominance, multiple alleles, Pseudo alleles, Lethal alleles, Penetrance and expressivity, Interaction of genesepistasis- dominance, recessive (atavism), complementary genes, supplementary genes, interaction of genes in comb pattern of fowls, polygenic inheritance, pleotropism.

Unit II. Chromosomal aberrations: Structural- Deletion, Duplication, Inversion, Translocation, Centric fusion and fission; Numerical variations – Aneuploidy, Euploidy & Polyploidy; Chromosome syndromes - Causes & consequences of chromosomal aberrations; Karyotyping and chromosome banding.

Chromosomes: Types of chromosomes, Chromosome theory of inheritance, Special chromosomes – B chromosome, Polytene & Lamp brush

Unit III. Extra Chromosomal inheritance: Maternal effect – Pigmentation in Ephistia, inheritance of shell coiling in Limnaea, Infectious heredity of Paramecium, Cytoplasmic inheritance – Male sterility in maize and plastid inheritance in Mirabilis jalapa. Mutations: Spontaneous, Induced mutation, Conditional lethal mutations – point mutation, Base substitution mutation, Mutation rates. Chemical mutagens, radiation induced mutation, reverse mutations and suppressor mutations - intergenic and intragenic suppression, Missense, Nonsense and Silent mutations; and Detection of mutations induced by chemicals (Ames test), radiations (CIB technique)

Unit IV. History of evolution of life on earth: elements, molecules to species. Evolution of the genome - DNA, RNA and proteins, origin of the genetic code: chemical basis of evolution.

Theoretical aspects: Neutral theory of molecular evolution (Kimura), Darwin Wallace theory of evolution by natural selection, Role of Mutation in evolution. Divergence rates as a function of heterozygosity and gene functionality. Computation of phyogenetic trees using distance matrix methods, Maximum Parsimony method, Maximum likelihood and Bayesian inference.

Unit V. Evolutionary change by mutation, gene flow, genetic drift, natural selection and non-random mating. Role of gene duplication, transitions and transversions, chromosomal deletions and insertions in evolution. Role of repetitive DNA,

transposable elements and junk DNA in evolution. Homology of proteins and DNA in evolution.

The concept of the Molecular Clock. Calibration. Limitation of molecular clock models. Human molecular clock: deducing evolutionary histories through mitochondrial DNA and Y chromosome.

Reference Books:

- 1. Gardner E J, Simmons M J, Snustad D P. 2006, Principles of Genetics. John Wiley & Sons, Inc., 8th edition.
- 2. Griffith A J F, Miller J H, Suzuki D T, Lewontin R C, Gelbert W M.2000. An introduction to Genetic Analysis. W.H. Freeman and Co. New York, 7th edition.
- 3. Strickberger, M. W. Genetics. 2008, Macmillan New York:, 3rd edition..
- 4. Watson, J. D., T. A. Baker, S. P. Bell, A. Gann, M. Levine, R. Losick. 2004. Molecular Biology of the Gene. 5th Edition. Pearson Education Pte. Ltd., New Delhi, India.

Statistical Methods for Biology (4 Credits)

Course Objectives: To train the students intensively in both theoretical and practical aspects of statistics, to bring them in contact with basic concepts and methods and to create a problem-solving attitude with the aid of statistical methodology.

Course Outcomes: It provides an introduction to selected important topics in Biostatistical concepts and reasoning. This course represents an introduction to the field of data and data types. The students learn specific topics including tools for describing central tendency and variability in data; methods for performing inference on population means and proportions via sample data; statistical hypothesis testing and its application to group comparisons; issues of power and sample size in study designs; random sample and other study types.

Unit I. Numerical Methods to Represent Variation:

Importance and Scope of Statistics, Data Types, Frequency Distribution, Graphical Representation Methods (Histogram, Bar Charts, Pie Charts), Measures of Center Tendency (Mean, Median, Mode,) and Dispersion (Standard Deviation, Variance) Advantages and Disadvantages, Co-Efficient of Variance.

Unit II. Probability:

Basic Terminology, Definition of Probability, Basic Laws of Probability, Types of Probability,

Additional Rule of Probability and Multiplication Rule of Probability, Probability Distribution-Bernoulli Distribution, Binomial Distribution, Poisson distribution and Normal Distribution-Simple Problems.

Unit III. Sampling Methods:

Collection of Data, Census Method, Concept of Population, Sample, Sampling, Sample Size, Sampling Error, Advantages and Disadvantages of Sampling Method, Necessity of Sampling, Types of Sampling Methods, Types of Random Sampling Methods – SRS, Stratified Random Sampling, Systematic Random Sampling and Cluster Sampling.

Unit IV. Testing of Hypotheses:

Statistical Hypotheses-Null and Alternative, Level of Significance, Type I and Type II Error, Critical Region, Power of the Test, P Value, Degrees of Freedom, Chi-Square Test for Independence of Attributes and Goodness of Fit, Student's t Test: One Sample t Test and Paired t Test, F Test.

Unit V. Regression and Analysis Of Variance:

Simple Linear Regression, Multiple Linear Regression (Definition, Assumptions, Applications, and Examples), Analysis of Variance –Introduction, Definition of ANOVA, Assumption, Test of ANOVA, Types of ANOVA, Construction of One Way Analysis of Variance.

Reference Books:

- 1. Fundamentals of Biostatistics. Veer Bala Rastogi. Publisher: ANE Books. 2nd Edition, 2009.
- 2. Fundamentals of Mathematical Statistics, S.C. Gupta and V. K. Kapoor, Publisher: Sultan Chand & Sons (2014).
- 3. Fundamentals of Statistics. S.C. Gupta. Publisher: Himalaya Publishing House Pvt. Ltd.Edition.7th Edition, 2012
- 4. Introductory Statistics for Biology. R. E. Parker. Publisher: Cambridge University Press 2nd Edition, 1991.
- 5. Statistics for behavioral science. Chintamani Kar. Publisher: Dominant Publishers & Distributors (P) Ltd. (2015).

PRACTICAL I: EXPERIMENTAL MOLECULAR BIOLOGY

Objective

The objective of the practical is to make the student describe and carry out basic molecular genetics methods; including work with bacteria, PCR amplification and analysis and electrophoresis of nucleic acid and to describe and carry out basic cell culture and microscopy.

Scope

After the successful completion of the course, students will be familiar with all the necessary basic molecular biology techniques which directly assist them to apply in their future research works.

The paper is mainly focussed on hands-on training the students with basic molecular biology advanced techniques which may directly lend them jobs in several prestigious research institutions.

- 1. Agarose gel electrophoresis of DNA.
- 2. Plasmid Isolation.
- 3. Isolation of DNA from liver and quantification using Spectrophotometer.
- 4. Estimation of RNA by Orcinol Method. (BC)
- 5. Preparation of Salivary gland chromosomes of Drosophila melanogaster.
- 6. Study of morphology and handling of Drosophila melanogaster.
- 7. Polyacrylamide gel electrophoresis (PAGE) of proteins. (BC)
- Salivary amylase assay Specific activity, pH, Temperature, Time Kinetics, Km & Vmax. 2. Effect of Activators and Inhibitors on Salivary amylase activity. (BC)

9. Determination of Isoelectric point of Amino acid. (BC) 10.Study of bar body.

SEMESTER II

PAPER V: MOLECULAR DEVELOPMENTAL BIOLOGY

Objective

Developmental biology seeks to address how complex multicellular organisms with diverse forms and cell types arise from single cells. The paper comes with an objective of introducing students to the molecular and cellular mechanisms that underlie the early development of organisms.

Scope

At the successful completion of the course the students will be having profound molecular understanding of an organism at whole body level which serve them to conceptualize developmental disorder manifestations.

Unit I. Introduction to developmental biology, origin and history. Concepts and stages of development in animals. Gametogenesis - Structure of the Gametes; Isogamy and Anisogamy, Spermatogenesis vs. Oogenesis. Fertilization, Sperm and Egg Recognition

Unit II. Fertilization - sperm and Egg Binding; Membrane and Pronuclear Fusion, Gamete Fusion and the Mechanisms of Prevention of Polyspermy. Molecular Activation of fertilized Egg Metabolism. Genes and Development - The Embryological Origins of the Gene Theory, Homologous Pathways of Development.

Unit III. Molecular basis of early development and differentiation: Caenorhabditis elegans: Anterior- posterior axis formation, formation of the dorsal – ventral and right- left axes, control of blastomere identity. Differentiation of pharynx. Drosophila: Primary axis formation during oogenesis. Generating dorsal – ventral pattern in embryo. Segmentation and the anterior – posterior body plan, segmentation genes, homeotic selector genes.

Unit IV. Sex Determination - Drosophila and mammals; Transcriptional Regular tion of an Entire Chromosome: Dosage Compensation. Hox Genes: Descent with Modification. Mammals: Anterior – posterior axis formation, the dorsal – ventral and right – left axes in mice.

Unit V. Molecular basis of later development: The Central Nervous System (CNS) and Epidermis - Formation and Differentiation of the Neural Tube, The Neural Crest, The Epidermis, Mesoderm -Paraxial Mesoderm, Intermediate Mesoderm, Latr eral-Plate Mesoderm. Endoderm and Limb Formation - Formation and molecular differentiation of the Limb Bud, Cell Death and the Formation of Digits and Joints, Front Limb vs. Hind Limb formation, Very Late - And Post Embryonic Development.

- 1. Gilbert S. F. 2006. Developmental biology 8th edn. Sinaeur Associates, Massachusett
- 2. Bhojwani S.S. and Soh W.Y. (2001). Current Trends in Embryology of An-

giosperms, Kluwer Academic Publishers.

- 3. Srivastava, L. M. 2003. Plant growth and development. Oxford University Press.
- 4. Raghavan V. (2000) Developmental Biology of Flowering Plants. Springer Verlag.
- 5. Buchanan B. B., Gruissem W. and Jones R. L. (2000) Biochemistry and Molecular Biology of Plants. Americal Society of Plant Physiology, Maryland.

PAPER VI: MOLECULAR CELL SIGNALLING

Objective

The aim of the paper is to describe how cells exploit signalling components to assemble the specific signalling pathways, which they require to communicate which each other or to adapt to changes of external environment. Attention will be focused on the role of signalling pathways in control of gene expression, cellular metabolism and cell death.

Scope

After the successful completion of the course, students will be having a better understanding to teach the complex topic of cell signalling in various molecular biology and genetics courses, as well as to apply in various research jobs.

Unit I. Introduction to molecular cell signaling- Introduction, significance of cell signaling. Concept of cell signaling: Endocrine, paracrine, merocrine, juxtacrine and autocrine signaling. Hormone receptors - structure of Insulin receptor, cyto-kine receptor, EGF receptor, receptor up regulation, down regulation, desensitization.

Unit II. Signaling in Bacteria- Quorum sensing in Bacteria, mechanism of chemokine signaling. Molecules and mechanisms. Signaling in yeast, Signaling in plant - Signaling by stress and light. Phytochrome system.

Unit III. Signaling in animal systems- Signaling by hydrophilic molecules - Receptors & 7 TM helical segments, Tyrosine kinase receptors, cytokine receptors, e.g. TNF alpha G proteins, G protein cycle, SH and PH motifs, PI3K, PLC, SMase, Second messengers-c AMP, discovery, function and regulation by Cholera toxin and Pertusis toxin. Lipid second messengers - DAG and ceramide.

Unit IV. Signaling Pathway- MAPK pathway, stress pathway, cytokine pathway, Growth factor pathway, Transcription factors - NF KB-regulation - Role in disease progression and development.

Unit V

Signalling by hydrophobic molecules- Steroid hormone signaling, cytoplasmic receptors, signaling cross talk, Glucocorticoid and estrogen receptors and their mechanism of action, antihormones (Eg. RU 486) Hormone replacement therapy.

- 1. Cooper G. M. 2000.2nd edition. The Cell A Molecular Approach, Sinauer Associates, Inc.,
- 2. Molecular Biology of the Cell. 2014, 6th edition.B. Alberts, D. Bray, J. Lewis, M. Raff, K. Roberts and J.D.Watson. Garland Publishing, New York and London.
- 3. Watson, J. D., Hopkins N. H., Roberts J. W., Steitz J. A., Weiner A. M. 2014. Molecular Biology of the Gene. Benjamin/Cummings. 7th edition.

PAPER VII: IMMUNOLOGY AND VACCINE DEVELOPMENT

Objective

This paper will provide an introduction to the cellular and molecular mechanisms underlying the development of human cancer at the genetic and molecular basis of cellular transformation & complex interactions along with exploring wide-ranging topics related to stem cell and its wide range of application and technologies.

Scope

After the successful completion of the course, the students will be having a basic understanding of how the interactions within human immune system tackle disease manifestations.

The course opens up the opportunity for students to get into various biomedical research jobs as immunologists as well as biomedical scientist.

Unit I. Introduction: Historical development and milestones in immunology, Primary and secondary lymphoid organs – Lymphatic system, Reticulo-endothelial system, Types of immunity, Innate & Acquired.

Antigens: Chemical nature & properties, Epitopes, Antigenecity, Immunogenecity, Valency of antigens, Haptens. Antibodies: Structure, Classes and subclasses, Paratopes, Immunoglobulin variants – Isotypes, Allotypes&Idiotypes, Valency of antibody, antibody diversity.

Unit II. Immune responses: Primary and secondary, class switching. Cellular basis of immunity: Hematopoiesis, Biology of T-cells and B-Cells. T-cell subsets. T-cell and B-Cell receptors. Structure &functions-MHC antigens in man. Clonal selection, Cytokines – role in immunity.

Transplantation: Tissue typing-Autograft, Isograft, Allograft &Xenograft. Graft versus host reactions (GVHI). Immunosuppression. Hypersensitivity: Types of Hypersensitivity reactions. Types I, II, III & IV Anaphylexis.

Unit III. Immunological techniques: Preparations, agglutinations, Complement fixation, Immunodiffusion, Immunoelectrophoresis, Immunofluroscence, RIA & ELISA, Western blotting.

Monoclonal antibodies – preparations & applications, Disorders of immunity: Immunological tolerance, Autoimmunity. Immunodeficiency disorders, SCID, AIDS, Tumor immunology: Tumor associated antigens & Tumor specific antigens. Immune surveillance, TNFa & β immunotherapy.

Unit IV. Introduction to vaccinology, vaccines and vaccination in historical and current perspective.Molecular immunology as applied to vaccine development: recent advances in immunology, impact on vaccine development, identification of B and T cell epitopes through structural charactersation and peptide technology,

Vaccines: Vaccines and their preparations (traditional and recombinant vaccines) BCG, Polio, DPT, HBV, Adjuvants. DNA based vaccines: extending the technology -naked DNA vaccines. Immunopotentation, adjuvants, nonliving antigen delivery systems.

Unit V. Live antigen delivery system, attenuated virus as a live vector for expression of immunogens, attenuated poliovirus as live vector, BCG as a recombinant

vaccine vector. Experimental vaccines, HIV-1 vaccines, vaccines against malaria. Commercial and regulatory aspects of vaccine production and distribution, vaccines development: the long road from initial idea to product licensure, the role of the food and drug administration in vaccine testing and licensure.

Reference Books

- 1. Kuby J. Immunology. 2001. Second Edition. W H Frecman& Company NewYork.
- 2. Roitt I M Delves P J. Essential Immunology 10th ed 2001 Blackwell Scientific Publications.
- 3. https://books.google.co.in/books/about/Cellular_and_Molecular_Immunology_E_Book.html?id=RWYWBAAAQBAJ&redir_esc=y
- 4. https://archive.org/details/FundamentalImmunology7thEdition-2013PDF_201511

PAPER VIII: GENETIC ENGINEERING

Objective

This topic covers key immunologic concepts which give advanced knowledge at the molecular level about the components of the immune system and the role of vaccines and its development.

Scope

After the successful completion of the course, the students will know to manipulate the genetic material of the cell for the human application in biomedical fields. After the successful completion of the course the students will be able to land on jobs as genetic engineers in various biotech, research firms, agricultural sector, and the research and development departments of the government and private sectors.

Unit I. Genetic Engineering - extraction and purification of nucleic acids (DNA and RNA) from biological sources. Gene cloning - genomic cloning, C-DNA cloning. Vectors - plasmids, phage, cosmids and phagemid, yeast cloning vectors, plant vectors, bacterial artificial chromosome (BAC), SV40, shuttle vectors, phagemids construction of expression vectors. Restriction endonucleases - blunt end and staggered cut. Isochizomers. Preparation of end labeled DNA, other labeling methods, fluorescent labelling. Recombinant DNA techniques, Gene cloning in E.coli, cloning in gram Positive Bacillus.

Unit II. Techniques - Blotting techniques - dot blot, southern, northern, western blot, DNA foot print assay, DNA fingerprint assay, gel retardation assay nuclease protection assay. RFLP, RAPD, PCR Ligation - blunt end ligation, use of linkers, colony hybridization, plaque hybridization. Gene transfer techniques, transgenic plants and animals, gene knockout. PCR Concept, methodology, types and applications.

Unit III. Gene construction methods-Reporter gene, Marker gene and their conformation. Heterologous expression, recombinant protein and expression. RNAi, Antisense constructs, Micro RNA and Their application in transgenic and functional genomics.

Unit IV. Biosafety: Laboratory methodologies, Handling of GMOs, Testing, Evaluation, Toxicity, Allergenic & Animal ethical issues, Disposal methodologies, Natural

guidelines, role of IBSC, RCGM, GEAC.

Unit V. Application: Gene therapy. Applications in agriculture, medicine and industry. GM foods, terminator gene negative impact of genetic engineering.

Reference Books

- 1. Sambrook J, Frisch E and Maniatis T Molecular Cloning: A Laboratory manual. 2000. Old Spring Harbor Laboratory Press New York,
- 2. Kaufman P B, Kim W.Wu.D and Cseke L J. 2011.Molecular and Cellular methods in Biology and Medicine, CRC Press, Boca Raton Florida.
- 3. Watson, J. D., Hopkins N. H., Roberts J. W., Steitz J. A., Weiner A. M. 2014. Molecular Biology of the Gene. Benjamin/Cummings. 7th edition
- 4. An introduction to genetic engineering.2010,3rd edition.Nicholl.

ELECTIVE 2: CELL AND TISSUE CULTURE TECHNOLOGY

Objective

The laboratory exercises for this course will focus on developmental phenomena studied in several of the most prominently utilized model organisms including Dictyostelium, Caenorhabditis elegans, Drosophila melanogaster, Danio rerio, amphibians, and chicks.

Scope

After the successful completion of the course, the students will be knowing to practically handle cell cultures as well as various immune tools and techniques. After the course completion, the students will be open to various job offers from cell culture labs, immune biotech and pharmaceuticals.

Unit I. History and milestones in Tissue Culture. Advantages of tissue culture over intact plants. Laboratory organisation - Infractructure for Tissue culture laboratory. equipments and general practice. Major components of a culture medium - Stock preparation - Composition of a culture medium Additions to basic media - Preparation and sterilization of media.

Techniques of tissue culture – culturing explants and haploids, protoplasts fusion and embryoids. Methods of gene transfer to plants, animals and bacteria – Ca-transfection, electroporation, shot gun, Micro injection, Biolistics and lipofection. Biodegradation stimulation and its applications.

Unit II. Callus and organ culture - Source of explants - surface sterilization of explants - Principle of callus culture - Initiation of callus - Types of callus - Maintenance of callus culture - Initiation and maintenance of cell suspension culture - Principles and protocol - Importance and applications - Organ culture - Root, shoot tip or meristem - their uses and advantages.

Regeneration and organogenesis: Totipotency - cytodifferentiation - Induction of regeneration - Principles and factors influencing organogenesis - Applications - Decline in totipotency in tissue culture - Somatic embryos - Production of synthetic seeds - Preservation - Applications and advantages of synthetic seed production - Haploid culture: Anther culture - Ovary and ovule culture - Doubling of chromosome numbers - Dihaploid (homozygous) production - Genetic variation in dihaploids - Somaclonal variation: Sources of Somaclonal variation - Selection of somaclones - progeny testing of somaclones - Application of somaclonal variation to crop improvement.

Unit III. Protoplast culture: Important properties of protoploast, Protoplast isola-

tion and culture. Methods of protoplast fusion - Chemofusion, electrofusion - Somatic hybrids - Cybrids - Principles, protocols, and importance. Selection of heterokaryons. Preservation and cryopreservation of germplasm – Principles, procedure and uses.

Micropropagation techniques in horticulture and crop improvement – source tissue for micropropagation – methods of micropropagation – Problems that arise in vitro during micropropagation –Problems that arise in vivo after micropropagation-Variation in clonal plants- Advantages and disadvantages of micropropagation .

Strategy for plant transformation through gene transfer- Gene manipulation with Agrobacterium tumefaciens- Non tissue culture based transformation using A. tumefaciens- Tissue culture transformation not based on A. tumefaciens – Genetically engineered characters in crop plants.

Unit IV. Introduction to animal cell culture: principles and applications, composition of animal cell culture media, characterization of cells in culture, generation and maintenance of animal cells in culture, applications of animal culture and immortal cells, chick embryo, HUVEC, cell lines, characterization of cultures ploidy, cell doubling time. Amplified cultures continuous cultures, applications.

Types of cell culture- primary and established culture, organ culture, tissue culture, three dimensional culture and tissue engineering, feeder layers, disaggregation of tissue and primary cell culture, Cell separation, cell synchronization, cryopreservation, Culture media, cell culture in continuous, hollow fiber reactor, mass transfer in mammalian cell culture.

Unit V. Importance of stem cell cultures, what are stem cells, types of stem cells, sources of stem cells and properties. Stem cell cultures in the production of transgenic animals. Introduction to Bio artificial organs- Historical background- Liver, Kidney- skin, pancreas- Urinary Bladder- bone- challenging and advantages.

IPR Issues: Forms of IPR, IPR legislation in India, implication of IPR legislation on India and other developing countries, WIPO, WTO, GATT, Trips Agreement, Introduction to patenting and patenting process. Biodiversity board.

Reference Books:

- 1. Medical Molecular Biology P.C. Trivedi (2008).
- 2. Principles of cell and Tissue engineering- Robert Lanza (2005).
- 3. Freifelder D. 2004. Molecular biology. Narosa Publishing House, New Delhi.
- 4. Basic cell culture, J.M.Davis.2nd edition.2005.

PRACTICAL II: ANIMAL CELL CULTURE AND IMMUNO TECHNIQUES

Objective

The laboratory exercises for this course will focus on developmental phenomena studied in several of the most prominently utilized model organisms including Dictyostelium, Caenorhabditis elegans, Drosophila melanogaster, Danio rerio, amphibians, and chicks.

Scope

After the successful completion of the course, the students will be knowing to practically handle cell cultures as well as various immune tools and techniques. After the course completion, the students will be open to various job offers from

cell culture labs, immune biotech and pharmaceuticals.

1. Observation of cancer cells (cytology tests) by H & E staining.

- 2. Lymphocyte culture technique, Preparation of human metaphase Chromosomes.
- 3. Temporary preparation of stained samples for Mitosis in onion root tips. (CB)
- 4. Cell viability assay by Trypan blue dye exclusion method. (CB)
- 5. Methods for Aerobic and Anaerobic Microbial Culture
- 6. Representative Pathological slides identification
- 7. cAMP assay by ELISA.
- 8. Immunoelectrophoresis.
- 9. Isolation of IgG form human serum.
- 10. Tissue Processing and Staining Methods

SEMESTER III

PAPER IX: CANCER AND STEM CELL BIOLOGY

Objective

The paper aims to provide a molecular understanding of how normal cellular processes change, fail or are destroyed by disease and how the intervening of molecular biology concepts and techniques assist in countering the disease molecule manifestation.

Scope

After the successful completion of the course, the students will be eligible to land in various medical profession jobs with a career in cancer stem cell research and stem cell therapy.

Unit I. Cancer Biology: Introduction, historical perspective, classification, Carcinogenesis, cancer initiation, promotion and progression, Cancer cell cycles, Apoptosis, Genes and proteins as players in apoptosis, DNA viruses/ cell immortalization.

Understanding Cancer as a Disease: Natural history of cancer development, Free radicals, antioxidants and metabolic oxidative stress and cancer, Genetic instability and epigenomic changes in cancer (DNA methylation, histone acetylation), Epidemiology of selected cancers. Hallmarks of cancer –Tumors: benign tumors vs. malignant tumors, types of cancer, common symptoms, growth signal autonomy, evasion of growth inhibitory signals, evasion of apoptosis, unlimited replicative potential, angiogenesis, invasion and metastasis.

Unit II. Molecular basis of cancer - Cancer Genes: Oncogenes and signal transduction, Oncogenes / proto oncogene activity; Growth Factors and Growth Factor receptors that are Oncogenes; Transcription factors and cancer, Retroviral oncogenes, Tumor suppressors, Tumor suppressor gene pathways, DNA methylation, epigenetic silencing of suppressor genes.

Unit III. Animal models of cancer – carcinogen induced models, xenografts, genetically modified models. Cancer screening; Early and advanced detection. Detection using biochemical assays, tumor markers, molecular tools for early diagnosis of cancer. Different forms of therapy; chemotherapy, radiation therapy, gene therapy. Immuno therapy: advantages and limitations. Strategies of anticancer gene therapy/translating therapies from the laboratory to the clinic. Gene discovery in cancer research; Cancer genome anatomy project. Stem cells and their applications in cancer therapy.

Unit IV. Stem Cells – Basics, Properties and Classification. Types of Stem cells – Hematopoietic Stem Cells, Mesenchymal Stem Cells, Embryonic Stem Cells, Fetal Stem Cells, Stem cells from adult organs and their characteristics. Principles of Isolation, Culture and Characterization of stem cells - Three-Dimensional Cell Culture, Organ Culture, Organotypic Culture.

Unit V. Tumor Stem Cells – Role of stem cells in cancer. Regulation of stem cells – role of microRNAs in stem cell regulation. Induced Pluripotent Stem Cells (iPSCs); Reprogramming of stem cells. Stem Cells in Gastrointestinal, Liver, Pancreas, Kidney, Heart, Spinal Cord and Lung Regeneration, Stem Cells in Eye Diseases and Disorders. Applications of stem cells in tissue engineering and prospects.

Reference Books:

- 1. Cooper G. M. 2000.2nd edition. The Cell A Molecular Approach, Sinauer Associates, Inc.,
- 2. Molecular Biology of the Cell. 2014, 6th edition.B. Alberts, D. Bray, J. Lewis, M. Raff, K. Roberts and J.D.Watson. Garland Publishing, New York and London.
- 3. Watson, J. D., Hopkins N. H., Roberts J. W., Steitz J. A., Weiner A. M. 2014. Molecular Biology of the Gene. Benjamin/Cummings. 7th edition.
- 4. R. Lanza, J. Gearhart et al (Eds), Essential of Stem Cell Biology. (2014), Elsevier Academic press.2nd edition.
- 5. Stein et al. Human Stem Cell Technology and Biology: A Research Guide and Laboratory Manual.Wiley-Blackwell; 1st edition, 2011.
- 6. Robert Lanza et al. Principles of Tissue Engineering, 3rd Edition. Academic Press; 3rd edition (2007)

PAPER X: MOLECULAR MEDICINE

Objective

The paper is an introduction to molecular and gene technology from an evolutionary perspective, and about the methods that are used in the area. The possibilities and limitations of the gene technology are discussed. Looking at the vast implications, topics on Bioethics and Biosafety, implicit in such a technology will also be covered.

Scope

After the successful completion of the course, the students will be qualified for a wide range of careers including research in hospitals, colleges, universities or research institutes, teaching as well as practical clinical work in hospital laboratories.

Unit I. Molecular Medicine – Introduction, Basic Principles in Human Pathology, General pathology – cell injury and causes. Reversible injury – Types, morphology, swelling, hyaline, fatty change; Irreversible injury – Types of necrosis, apoptosis, calcification, dystrophic, Metastasis.

Unit II. Molecular basis of genetics - Concepts of disease, Monogenetic Disorders, Mutifactorial Disorders. Molecular Basis of Diseases - Mechanisms of Host Defence, Complement System in Health and in Disease, Molecular mechanisms of bacterial, viral, and parasite pathogenesis. **Unit III.** Molecular Pathomechanism of Specific disease Systems - Cardiovascular system (Myocardial infarction), respiratory system (tuberculosis), nervous system (parkinsonism), bone and joint (arthritis), muscle (ALS).

Unit IV. Bioimaging and cell analysis - FACS analysis, Fluorescence microscopes and confocal laser scanning microscopes, Fluorescent dyes. Molecular Analysis - STR genotyping, DNA methylation analysis, Chromatin immunoprecipitation analysis of histone modifications, Proximity Ligation Assay (PLA) in solution *in situ*, differentiation of stem cells and digital image analysis.

Unit V. Genomic and Epigenomic Medicine – High throughput sequencing - SOLiD, Illumina, 454FLX. Chromatin immunoprecipitation (ChIP), assessing a cancer drug's effect on the epigenetic status at promoters and enhancers. HTSs (ChIP-Seq). Human Proteome Atlas, personal genome project (PGP) and current personalized medicines.

Reference Books:

- 1. John M. Davis. Animal Cell Culture: Essential Methods.Wiley; 1 edition (June 13, 2011)
- 2. Robbins. Basic Pathology, 8/e 2007. Saunders 2007
- 3. Peter John Wood.Understanding Immunology.Prentice Hall; 2 edition (8 Feb 2006) 10 edition (August 16, 2001)
- 4. 9. James G. Cappuccino and Natalie Sherman. Microbiology: A Laboratory Manual, 7/e.Pearson Education 2007
- 5. B DETRICK (Author). Manual of Molecular and Clinical Laboratory Immunology : 7th Edn. Asm Press; 7th Revised edition edition (2006)
- 6. Textbook of Molecular Medicine: Science in Medicine, Andrew R. Marks, Ushma S. Neill, 2010.
- 7. https://www.sciencedirect.com/science/book/9780126990577#book-info

PAPER XI: MOLECULAR AND CELLULAR RADIOBIOLOGY

Objective

This course provides the student with principles of radiation protection and biology. Topics include radiation protection responsibility of the personnel and the public, principles of cellular radiation interaction and factors affecting cell response.

Scope

Upon completion the students can opt for teaching career where they can demonstrate radiation protection practices and fundamentals of radiation biology. Also the field opens upon job opportunities in various radio diagnostics and radiotherapy centres as well as in radiation biology research institutes.

Unit I. Radiation Quantities and Units – Exposure , Absorbed dose, Equivalent dose, Effective dose, Collective dose, Principles of radiation dosimetry, Direct and indirect effects.

Interaction of X-Radiation with Matter - Sources of ionizing radiation, Types of ionizing radiation, Particulate radiations, Linear energy transfer, Radiation dose and units.

Unit II. Radiation lesions in DNA, Major types of DNA repair, Damage recognition and signalling, Consequences of unrepaired DNA damage: chromosome damage,
Radiobiological definition of cell death, Suvival curves and models, Cell cycle effects, Relative biological effectiveness (RBE), Cellular repair exemplified in survival curves.

Unit III. Cellular hyper-radiosensitivity (HRS) and induced repair (IRR), Other molecular targets: bystander (epigenetic) effects, Radiation sensitizers, Radiation protectors.

Cellular and tissue response, acute tissue responses, Late tissue responses, Predicting normal tissue response, Therapeutic ratio, Whole body irradiation.

Unit IV. Epidemiological studies in radiation-exposed populations, Mechanisms of radiation-induced cancer, Radiation effects in the developing embryo and fetus, Radiation-induced heritable diseases.

Unit V. Predicting the response of tumors, Predicting normal tissue response, combined radiation and drug treatments, Clinical radiobiology of common cancers.

Reference Books:

- 1. Fliedner, T.M., Friesecke, I., Beyrer, K., Medical management of radiation accidents manual on the acute radiation syndrome. British Institute of Radiology Supplement (2001).
- 2. Albert van der Kogel, Michael C. Joiner 2009 Michael C. Joiner Basic Clinical Radiobiology Fourth Edition
- 3. Handbook Of Radiobiology,2016.Kuppusamy Thayalan.
- 4. https://www.ebooks.com/624229/elements-of-radiobiology/selman-jo-seph/

PAPER XII: IPR, BIOETHICS & BIOSAFETY 4 Credits

Objective

This paper will introduce students to the world of international intellectual property law, biotechnology bioethics and laboratory biosafety.

Scope:

The course is designed to introduce fundamental aspects of Intellectual property Rights to life science students who are going to play a major role in development and management of innovative projects in biotech industries.

Unit I. Introduction to Intellectual Property: Types of IP: Patents, Trademarks & Copyright, IPR – patentable and non-patentable. IPR in India – Genesis and Development; IPR in abroad; some important examples of IPR.

Unit II. Patent and kind of inventions protected by a patent, Patent document, How to protect the inventions? Granting of patent, Rights of a patent, how extensive is patent protection? Why protect inventions by patents? Licensing and Enforcing Intellectual Property; Commercializing Invention - Case studies. Indian Patent Act 1970 & recent amendments.

Unit III. Bioethics: Introduction to ethics/bioethics; benefits and risks of genetic engineering – ethical aspects of genetic testing – ethical aspects relating to use of genetic information – genetic engineering and bio warfare.

Protection of GMOs IP as a factor in R&D; IPs of relevance to genetic engineering – few Case Studies.

Unit IV. Biosafety: Introduction & historical background; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Recommended Biosafety Levels for Infectious Agents and Infected Animals.

Unit V. Biosafety Guidelines: Biosafety guidelines and regulations (National and International) – operation of biosafety guidelines and regulations of 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.

Reference Books:

- 1. Ethics in engineering, Martin. M.W. and Schinzinger. R. III Edition, Tata McGraw-Hill, New Delhi. 2003.
- 2. BAREACT, Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., 2007
- 3. Kankanala, K. C. 2007. Genetic Patent Law & Strategy, 1st Edition. Manupatra Information Solution Pvt. Ltd., Noida, India.
- 4. Jose B. Cibelli, Robert P. Lanza, Keith H. S. Campbell, Michael D.West. 2002. Principles of Cloning, Academic Press, SanDiego, Gurdon.
- 5. Hoosetti, B.B.2002. Glimpses of Biodiversity. Daya, New delhi.
- 6. http://www.cbd.int/biosafety/background.shtml
- 7. http://web.princeton.edu/sites/ehs/biosafety/biosafetypage/section 3.html

ELECTIVE 3.1: SEQUENCE ANALYSIS & PHARMACOGENOMICS

Objective

Gene sequences and the rest of the genome play an important role in determining how an organism functions normally and reacts when situations change. The details of this data reveal basic information such as gene and protein structures, or may lead us to major discoveries like gene-disease associations.

Scope:

This paper teaches the bioinformatics skills used in academic, biotech, and pharmaceutical laboratories for analyzing individual DNA and protein sequences.

Unit I. Biological Literature Information access - Origins and History - Main Sub-disciplines of Bioinformatics, Data- alignment and applications: Collecting and Storing Sequence Data: Sequence assembly; Submission of Sequences; Sequence accuracy; Sequence databases; Sequence formats; Conversion between formats; EST databases; SNP databases; Annotation and Archival. Sequence alignment and applications. Dynamic programming methods for global and local alignments tools-FASTA, BLAST, statistical and Biological significance.

Unit II. Nucleic acid sequence analysis: Reading frames; Codon Usage analysis; Translational and transcriptional signals; Splice site identification; Gene prediction methods; RNA fold analysis. Second generation sequencing techniques – Pyrosequencing and Virtual terminator Sequencing. **Unit III.** Multiple Sequence alignment and applications: Uses; Methods available-Iterative alignment, Progressive alignment – ClustalW, T-Coffee; Profile Methods – Gribskov profile, PSI-BLAST, HMM ; Clustering and Phylogeny; Methods for Phylogeny analysis: Distance and Character based methods; Motif detection ; Protein family databases; Use of Structure based sequence alignment Protein sequence analysis: Compositional analysis; Hydrophobicity profiles; Amphiphilicity detection; Moment analysis; Transmembrane prediction methods; Secondary structure prediction methods

Unit IV. Pharmacogenomics- Introduction, basic concepts about genetic diseases. Personalized medicine- introduction and importance. Pharmacogenomics necessity in drug designing. Drug response to patients, Structural influence in the Drug response. Efficacy and metabolism of drugs. Pharmacogenomics vs. Structural Pharmacogenomics. Drug metabolism pathways and adverse drug reactions.

Unit V. Tools for pharmacogenomic analysis. Pharmacokinetics (PK), Pharmacodynamics (PD). Process in Structural Pharmacogenomics \Box Target Structure optimization, Validation, lead identification, ADME prediction, synthesis, assays and Clinical trials.

Reference Books:

- 1. Pharmacogenomics, Yui-Wing Francis LamLarisa Cavallari 1st Edition, 2013.
- 2. Sandosh Padmanabhan, Handbook of Pharmacogenomics and Stratified Medicine, 1st Edition, 2014.
- 3. Current Protocols in Bioinformatics, Edited by A.D. Baxevanis et al, Wiley Publishers. 2005
- 4. Computational Molecular Biology by P. A. Pevzner, Prentice Hall of India Ltd. 2004
- 5. Bioinformatics by David W. Mount, Cold Spring Harbor Laboratory Press. 2001
- 6. Fundamental concepts of Bioinformatics by D.E. Krane and M.L Raymer, Pearson Education. 2003

ELECTIVE 3.2: GENOMICS AND PROTEOMICS

Objective

The paper deals with various aspects of bioinformatics applications generating useful biological information on genome structure, function, and evolutionary relationships. The paper teaches the bioinformatics skills used in academic, biotech, and pharmaceutical laboratories for analyzing individual DNA and protein sequences.

Scope

The career prospects in genomics and proteomics has been steadily increasing with more and more use of information technology in the field of molecular biology. The students, after the completion of the course may find job opportunities pharmacogenomics, pharmacology, clinical pharmacologist, informatics developer; computational chemist, bio-analytics and analytics.

Unit I. Genomics - Definition & types, Eukaryotic and prokaryotic genomes. Genomic databases of model organisms. EST, genome and Bali base database. Comparative genomics: Basic concepts and applications, Comparative genomics databases & understanding the significance of EXPACY TOOLS, NCBI TOOLS, EMBOSS, Fasta, Blast, Clustal W, ORF Plotting, Gene Finding, Translation using Emboss.

Primer and probes designing wares.

Unit II. Functional genomics: Application of sequence based and structure-based approaches to assignment of gene functions – e.g. sequence comparison, structure analysis (especially active sites, binding sites) and comparison, pattern identification, etc. Use of various derived databases in function assignment, use of SNPs for identification of genetic traits. Gene/Protein function prediction using Machine learning tools viz. Neural network, SVM etc

Unit III. Phylogenetic Analysis: Phylogenetics data analysis, Tree building methods, Rooted tree, un rooted tree, Distance method, UPGMA, NJ, Fitch- Margoliash, Minimum Evolution, Character based methods-Maximum Likelihood and Maximum Parsimony methods, Softwares : Phylip. Molecular Clocks and Estimation of Divergence Time.

Unit IV. Protein sequence analysis using softwares:- Emboss, Data mining proteomes, Motif mapping using Prosite, Prodom, prorein expression profiling, protein - protein interactions, protein complexes. Mapping protein modifications. Protein secondary structure analysis. Molecular visualization of protein 3D structure using Rasmol, pdb file format.

Introduction to basic concepts, Molecular recognition by receptor and ligand design, Generation of Rational Approaches in Drug design, Introduction to drug designing, Discovering a drug, Target identification and validation, Identifying the lead compound, Optimization of lead compound.

Unit V. Docking methods introduction, three dimensional descriptions of binding site environment and Energy calculation, Automatic Docking Method, Three Dimensional database search Approaches, Design of ligands, Drug-receptor interactions automated structure Construction methods, AUTODOCK.

Reference Books:

- 1. Bioinformatics and Functional Genomics by Pevsner, J., John Wiley and Sons, New Jersey, USA. 2003
- 2. Introduction to proteomics Tools for the new biology (1st Ed.) by Liebler, D.C., 2002, Human Press Inc., New Jersey, USA.
- 3. Bioinformatics: Sequence and Genome Analysis by Mount, D., Cold Spring Harbor Laboratory Press, New York. 2004
- 4. Concepts and Techniques in Genomics and Proteomics ,N Saraswathy P Ramalingam.2011,1st edition.

PRACTICAL III:

rDNA TECHNIQUES AND *in-silico* SEQUENCE ANALYSIS 6 Credits

Objective

This practical course provides a hands-on exposure to properties and applications of versatile DNA modifying enzymes, cloning strategies, vector types, host geno-type specificities for selection and screening of recombinants and/or recombinant transformants. Students will also be introduced to prominent nucleic acid labeling techniques.

Scope

After the successful completion of the course, students will be able to perform cloning experiments, design rDNA constructs as well as to perform inslico bioinformatics data handling which is a necessity prerequisite for job opportunities in various biotech and bioinformatics research centers.

- 1. Transformation studies in bacteria.
- 2. Mutation detection by PCR analysis
- 3. Analysis of protein sequence using Expasy.
- 4. Restriction Digestion of -DNA and plasmids.
- DNA Fingerprinting: a) DNA Fingerprinting (Using RAPD techniques) b) Rice variety identification by RAPD analysis c) Genotyping Analysis in Human.
- 6. Ligation of restricted fragments.
- 7. Screening & Analysis: a) GFP Cloning b) Bacterial Gene Expression c) Southern Hybridization.
- 8. Knowledge of different biological database: Protein and gene sequence data bases (NCBI, DDBJ, EMBL, SWISS PROT, PIR) ;Structure databases (MMDB, PDB, FSSP, CATH, SCOP) ;Pathway Databases (KEGG, BRENDA, METACYC, ECOCYC) ; Bibliographic database (PUBMED, MEDLINE)
- 9. Primer and probe designing using genomics tools.
- 10.Identification of SNPs, SNPs databases (DbSNP).

SEMESTER IV Project and Viva Voce Examination 12 Credits

MSc Nanoscience and Technology

Course overview, Curriculum and Syllabus

About the course

Nanotechnology is an emerging paradigm that is interdisciplinary and has great influence in a wide-range of sciences, medical and dental and pharmaceutical sciences. It is an "enabling technology" wherein, existing biomedical or pharmaceutical products have been benefitted and have become efficient. The course structure is technology-centric where students essentially learn from basics to advanced nanotechnology. The course is two years with four semesters. Three semesters are theoretical with relevant practical exposure, enabling hands on experience on various analytical techniques. The fourth semester is research oriented where the student gets to independently work on project under the guidance of a mentor.

In the area of life sciences, several exciting research topics are being explored such as design of nanotechnology enabled drug delivery systems with minimal side effects, scaffolds in tissue engineering for improved integration of biomedical implants, nanoparticle embedded membranes of waste water treatment, impact of nanotechnology in industry, food sector and cosmetics. The field of nanoscience and technology has already made significant impact in fructification into commercial products and is expected to continue to play an important role in several fields to enhance human kind. The course is designed to provide the core principles with the necessary practical skills in this interdisciplinary area to train the students in this new field. Through this training, the students not only seek employment opportunities in traditional life sciences-related industries but also better prepared to seize the emerging employment opportunities in nanotechnology enabled industries.

Core Objectives of the Course

The objectives of M. Sc. Nanoscience and Technology course are;

- To provide an intensive and in-depth learning to students in the field of Nanoscience oriented towards pharmaceutical and biomedical industry.
- Beyond simulating, learning, understanding the techniques, the course also addresses the underlying recurring problems of disciplines in today's scientific and changing business world.
- To train the students to take up wide variety of roles like researchers, scientists, consultants, entrepreneurs, academicians, industry leaders and policy makers.
- Graduates will have successful careers as engineers in the multidisciplinary field of Nanoscience and Technology
- Develop solutions for industry through the use of novel bio-nanomaterials and process
- Analyzing and solving problem in nanoscience and technology by hand on application of knowledge and skills.

Career Opportunities

MSc Nanoscience and Technology graduates have plethora job opportunities in the following fields;

- Research scientist and formulation scientist
- Nanomaterial Product developer
- Government agencies for regulatory monitoring
- Patent examiner
- Entrepreneurship

- Consultancy organizations in pharmaceuticals, Energy, Material Science, Medical, Agriculture, Environment Protection.
- Job in Scientific Research Organizations.
- Enroll for higher degree through research in India or abroad
- Healthcare industry
- Research-Academic career

Eligibility

Any undergraduate Science Degree recognized by UGC with Biology as one of the subjects

Semester I (Odd semester)		Credits	
Name of the paper			
Paper 1	Fundamentals of Chemistry, Physics and Biology	4	
Paper 2	Fundamentals of Nanotechnology	4	
Paper 3	Fundamentals of Biochemistry and Bio- molecules	4	
Paper 4	Characterization of Nanomaterials	4	
Elective 1	Statistical Methods for Biology	4	
Practical 1	Characterization of Nanomaterials	6	
		26	
Students are sent to workshops gain hands-on experience and self-learning exercises through Swayam Portal			
Semester II (Even semester)			
Paper 5	Surface and Colloidal Nano-chemistry	4	
Paper 6	Properties of Nanomaterials	4	
Paper 7	Nano biology	4	
Paper 8	Synthesis and surface modification of nanomaterials	4	
Elective 2	Cancer Nano-therapeutics	4	
	Applications of Nanotechnology for In- dustry		
Practical 2	Surface modification of nanomaterials	6	
		26	
Summer internships in Nanotech industries and self-learning exercises through Swayam Portal			
Semester III (Odd Semester)			
Paper 9	Nanotechnology Product Development	4	
Paper 10	Biopharmaceutics and Pharmacokinetics	4	
Paper 11	Advanced Drug Delivery Systems	4	

MSc Nanoscience and Technology Curriculum Structure

Paper 12	Biomedical Applications of nanomateri- als	4	
Elective 3	Environmental Nanoscience	4	
Practical 3	Biopharmaceutics and Pharmacokinetics	6	
		26	
Semester IV (Even Semester)			
Summer Internship		2	
Thesis and viva voce examination		12	
		14	
Total Credit		92	

SEMESTER I

Paper 1. Fundamentals of Chemistry, Physics and Biology 4 Credits

Course Objectives: The objective of this paper is refresh students learnt subjects in their previous degree. A basic of physics chemistry and biology is important for fundamentals of nanotechnology. This paper will provide a basis for understanding the atomic structure, classical & quantum mechanics, basic structure of cells, cell division and cellular transport.

Course Outcome- Students will have a firm foundation in the fundamentals of chemistry, physics and biology. This paper will focus on basics to nanoscience and Technology. Students will learn to calculate to chemistry problems on molarity, normality and preparing percent solutions. They will also learn basics physics on classical and quantum mechanism. Further, this paper also provides students with a broad conceptual background on basic biology, cell division, cellular transport mechanisms.

Unit I. Basic chemistry and Chemical Bonding: Atomic structure, Dalton's Atomic theory as foundation for chemistry, Bohr's model, structure and size of atoms & ions, ionic compounds & ionization energy. Atomic bonding in solids, Types of bond: Metallic, Ionic, Covalent, Co-ordination bonds; Vander Waals interactions /Electrostatic interactions: Ion pair interactions, solvent effects, Ion-dipole and dipole – dipole interactions. Hydrogen bonding and hydrophobic interactions.

Self-Learning and Tutorials: The Periodic Table with Electron Configurations.

Unit II: Chemical Equilibria: Chemical Equilibria - Activity concept, equilibrium constant and applications, ionization constants of acids and bases. Concept of pH, hydrolysis of salts, Buffers - types, range and capacity, dissociation of polyprotic acids, common ion effect, salt effect. Electrochemistry – Conductivity of electrolytes, electrochemical cells, standard electrode potential. Colligative properties of solutions, ionic equilibria in solution, solubility product, common ion effect, hydrolysis of salts, pH, buffer, Henderson–Hasselbalch equation. Concentration units:

Normality, Molarity, Molality, PPM. Physical and chemical properties of water. **Self-Learning and Tutorials: Factors affecting chemical equilibria**

Unit III. Basics of Physics: Waves and wave functions, polarization, lasers, basics of fluid dynamics, Fundamental concepts of semiconductors, conduction and valence bands, properties of conduction and valance bands. Types of semiconductors, p and n type semiconductors, doping, electron and hole generation. P and N junction and diodes. Quantum mechanics: Quantum and classics mechanics. **Quantum confinement, Variation in energy bands.** Classification of quantum confinement systems.

Self-Learning and Tutorials: Methods of doping in semiconductors OR Applications of quantum confinement

Unit IV. Basic Biology: Eukaryotic and Prokaryotic cells. Structure, functions and chemical composition of biological membranes. Structure of fluid mosaic model. Cell-cell interaction and cell matrix interaction, extracellular matrix, proteoglycan and collagen. Cell-cell adhesion, catherins, desmosomes, gap junction and tight junction.

Self-Learning and Tutorials: Cell cycle regulation

Unit 5: Cellular Transport: Active and passive transport, equilibrium, diffusion –simple and facilitated diffusion, osmosis. Channel and carrier proteins. Hyper and hypotonic solutions, cell crenation, plasmolysis. Transport across cell membrane – Symport, uniport and antiport. Ion channels, sodium potassium ATPase. V type, P type and F type transports. Endocytosis, Phagocytosis, Receptor mediated endocytosis, Protein Trafficking in Endocytosis and exocytosis.

Self-Learning and Tutorials: Cellular transport in pathological conditions

Reference Books:

- 1. Fundamentals of Chemistry by David Goldberg, 5th Edition, ISBN-13: 978-0073221045. 2015
- 2. Basic Physics A Self-Teaching Guide by Karl F. Kuhn, ISBN-13: 978-0471134473. 2015
- 3. Quantum Physics for Beginners: Quantum Mechanics and Quantum Theory Explained by Jason Stephenson ISBN-13: 978-1681274386. 2014
- 4. Basic Cell Biology by Charlotte J Avers, ISBN-13: 2011 .1692356745-978

Paper 2: Fundamentals of Nanotechnology 4 Credits

Course Objectives: By the end of the course, students will understand the creation of, characterization of, and manipulation of nanoscale materials, systems, and devices and how they can be exploited for new applications. Students will learn about exciting applications of nanotechnology at the leading edge of scientific research. Students will apply their knowledge of nanotechnology to a topic of personal interest in this course.

Course Outcome: This is an interdisciplinary and emerging area. The students are taught the basics of nanotechnology and their applications in various fields.

The course introduces the students to the new and novel applications to solve biomedical problems through nanotechnology.

Unit I: Background to Nanotechnology:

Emergence of nanotechnology, Challenges in nanotechnology, Applications of Nanotechnology. Nanomaterials and bulk solids. Carbon Nanotechnology - Bucky balls, carbon nanotubes, graphene and diamond. Production of carbon tubes – arc discharge, CVD, **Pyrolatic** technique, purification and separation of carbon nanotubes, diamond synthesis routes, preparation of nano-diamonds.

Self-learning and Tutorials: Nanotechnology Revolutions

Unit II: Properties of nanomaterials: Fundamental properties of nanomaterials – Size dependent properties, Surface to volume ratio. Optical – Surface Plasmon Resonance, size effect on optical properties, magnetic, mechanical, catalytic, thermal, electrical & electronic properties.

Self-learning and Tutorials: Nano sized Effects

Unit III. Synthesis of Nanomaterials: Overview of methods of synthesis. Top-Down Approach and Bottom-up approach with examples.

Physical Methods – Lithography, nanoimprint lithography, soft lithography, Moulding/Replica moulding: PDMS stamps, Printing with soft stamps, Edge lithography, Dip-Pen Lithography, set up and working principle and ball milling.

Chemical Methods – Colloidal methods and self-assembly, and sol-gel, micelles and micro emulsion techniques. VLS growth of nanowires, Hybrid methods. Introduction to thin film technologies.

Biological Synthesis of Nanomaterials – Use of bacteria, fungi, Actinomycetes for nanoparticle synthesis, Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; Mechanism of formation; Viruses as components for the formation of nanostructured materials; Synthesis process and application, Role of plants in nanoparticle synthesis.

Self-learning and Tutorials: Actinomycetes for nanoparticle synthesis

Unit IV: Classification of nanomaterials - Zero dimensional, one-dimensional and two dimensional nanostructure materials. Semiconductors, quantum dots, ceramics and nanocomposites and core-shell nanoparticles. Inorganic and organic nanoparticles-liposomes, micelles, nano-emulsions, hydrogels and polymeric nanoparticles, mesoporous silica nanoparticles, zinc oxide nanoparticles, titanium sponges

Self-learning and Tutorials: Micro-emulsions and reverse micelles.

Unit V. Interaction of nanomaterials with biological systems: Nanoparticle interactions at the cellular level, Interactions of nanoparticles with biomolecule and membranes. Biomolecule-nanoparticle interaction, Vorman effect. Nanoparticle-protein corona formation. Composition of protein corona complex. Mechanism of adsorption of proteins on nanoparticles. Parameters affecting protein corona complex.

Self-learning and Tutorials: Volumetric interpretation of protein adsorption.

Reference Books:

- 1. 1. Nanoscale Science and Technology, Robert W. Kelsall, Ian W. Hamley and MarkGeoghegan, John Wiley & Sons, Ltd., UK, 2015, ISSN: 978-0-470-85086-2.
- 2. Introduction to Nanotechnology, Charles P. Poole Jr and Frank J. Owens, Wiley Interscience, New Jersey, 2013, ISSN: 978-0-471-07935-9.
- 3. Bio-Inspired Nanomaterials and Nanotechnology, Edited by Yong Zhou, Nova Science, 2015, ISSN: 978-1608761050.
- 4. Nano:The Essentials: Understanding Nanoscience and Nanotecnology, T.Pradeep, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2012, ISSN: 978-0071548298.
- Nanocrystals: Synthesis, Properties and Applications, C. N. R. Rao, P. J. Thomas and G. U. Kulkarni, Springer, New York, 2017, ISSN: 978-3-54068751-1.
- 6. Nanochemistry: A Chemical Approach to Nanomaterials, Geoffrey A. Ozin, Royal Society of Chemistry, Cambridge, UK, 2015, ISSN: 978-1847558954.

Paper 3. Fundamentals of Biochemistry and Biomolecules 4 Credits

Course Objectives: This paper trains students to appreciate the salient features of biomolecules in the organization of life. It spans over the significance and methodology involved in characterizing major biomolecules.

Course Outcomes: It helps the students in understanding the classification, functions and application aspects of biomolecules.

Unit I: Carbohydrates: Classification of carbohydrates. Monosaccharides: Configuration and conformation of monosaccharides, Reducing and optical properties of sugars, Derived monosacharides: deoxyglucose, amino sugars, muramic acid, neuraminic acid. Disaccharides: Stability of glycosidic bond, Sucrose, Lactose, Maltose, Trehalose. Polysaccharides: Homopolysaccharides and heteropolysaccharides, Structural polysaccharides-cellulose, hemicellulose, pectin, lignin, chitin, chitosan. Storage polysaccharides; starch, glycogen, inulin. Stearic factors in polysaccharides folding, sugar code and lectin. Glycosaminoglycan's, mucopolysaccharides, hyaluronic acid. Chondroitin sulfate, keratin sulfate, dermatan sulphate. Bacterial cell wall – proteoglycans and peptidoglycans. Structural elucidation of carbohydrates: Structural Elucidation of Glucose, Carbohydrate characterization: Graded acid hydrolysis, enzyme hydrolysis, periodate oxidation, methylation, acetylation, GC-MS, and NMR. Glycobiology: Glycoproteins; N- and O-glycosylation, lectins, Proteoglycans; agreecan, syndecan, and decorin. Carbohydrates in tissue engineering.

Unit II: Amino acids: Nomenclature, classification and buffering properties of amino acids, zwitter ionic structure, reaction of amino acids, unusual amino acids, non-protein amino acids. Peptides: Features of the peptide bond, naturally occurring peptides; glutathione, Gramicidin, enkaphalins and endorphins. Chemical synthesis of peptides; Khorana's solution phase synthesis, Merrifield's solid

phase synthesis. Hierarchy of protein structure. Primary Structure. Determination of amino acid composition: Acid and base catalyzed hydrolysis, separation, quantification, Determination of primary structure Sequencing strategies, Determination of N and C terminal residues, Automated sequanators, determination of site of glycosylation and type of linkage (o-glycosyl and n-glycosyl). Determination of s-s-bond position. Secondary structure of protein- α, β sheet, β-bend, β-turn and super secondary structures. Secondary structure prediction methods; Ramachandran plot, Chou and Farman algorithm. Tertiary and guaternary structures. Protein folding and conformation: Anfinsen's experiment. Bonds in protein folding: Weak forces of interaction; hydrogen bonding, Vander Waal's forces, London force, ionic interactions, hydrophobic interactions, S-S bridges, peptide bond, glycosidic bond, phospodiester bond, and allolysine. Chaperones in protein folding and Levinthal paradox. Denaturation (pH, temperature, chemotropic agents) and renaturation of proteins, molten globule. Protein-protein interactions. Structures of myoglobin hemoglobin, immunoglobulin, collagen, chymotrypsin and keratin. Isolation of proteins; overview of purification and criteria of purity.

Unit III: Lipids: Classification of lipids: Simple, Compound and Derived Lipids. Fats, oils, and waxes. Occurrence and properties of fatty acids. Esters of fatty acids, Triacylglycerol's. Phospholipids, Glycolipids, Sphingolipids, Cerebrosides and Gangliosides. Steroids, Sterols, Cholesterol, Bile acid and Bile salts. Lipid mediators: Eicosanoids, prostaglandins, leukotrienes, prostacyclin, thromboxane, DAG and ceramide

Unit IV: Nucleic Acids: Nitrogenous bases: Purines, Pyrimidines; nucleosides, nucleotides, unusual bases. Physiochemical properties of nucleic acids. Difference between RNA and DNA. Chemical reactions of DNA and RNA. Secondary structure of DNA. Watson and Crick model; B and Z DNA, other models of DNA structure. Supercoiling of DNA. Denaturation and renaturation of Nucleic acids. Melting of DNA, Tm; factors affecting Tm, Cot curve, classification of DNA based on cot curve. Nucleotides as regulatory molecules, enzyme cofactors and mediators of chemical energy in cells. Other secondary structural features in DNA, steam loop structure, palindromic sequences, cruciform. DNA protein interaction; zinc finger leucine zipper, helix-turn-helix, other motifs, DNA bending and kinks, Sequencing of DNA: Maxam Gilbert method, deoxy method. Genetic Code, Chargaff's rule. Types and roles of RNA, Secondary structure of tRNA: cloverleaf model. Isolation of DNA and RNA from biological sources (microbes, plants and animals). Purification of nucleic acids.

Unit V: Porphyrins – Structure and properties of porphyrins – Heme, chlorophyll and cytochromes. **Vitamins** – Water soluble and insoluble vitamins, structure and function, deficiency symptoms. DRI, RDA. Reactive oxygen species and detoxification mechanisms.

Reference books:

- 1. Lehninger Principles of Biochemistry, 5th Edition, David L Nelson and Michael M. Cox. 2011
- 2. Biochemistry, 5th Edition, Jeremy M. Berg; John L. Tymoczko and Lubert Stryer. 2012
- 3. Biochemistry 4th Edition, Donald Voet and Judith G. Voet. 2016
- 4. Outlines of Biochemistry 5th Edition. Erice Conn and Paul Stump. 2015
- 5. Text Book of Biochemsitry 4th Edition. Edward Staunton West; Wilbert R. Todd; Howard S. Mason and John T. Van Bruggen.2015

Paper 4. Characterization of Nanomaterials 4 Credits

Course Objectives: The course will highlight on the various analytical techniques to characterize the nanomaterials. The students will also gain hands on experience with the instrumentations.

Course Outcomes: To make students understand the importance of characterize the synthesized nanoparticles, underlying principles of analytical techniques that are commonly used for the evaluation of bulk properties of nanomaterials. These include surface analysis technique FTIR spectroscopy; optical properties evaluation by UV-Vis spectroscopy; crystallographic phase identification by XRD; thermal properties evaluation using TGA and DSC; microstructure investigation by Electron microscopy (SEM and TEM); surface area analysis by BET surface area analyzer, particle size- surface charge analysis by DLS and zeta potential techniques.

Unit 1: Structural Studies: DLS - Interaction of light with matter. Suspended and colloidal nanomaterials, Light scattering – static & dynamic scattering. Brownian motion, inter-particle interactions, Zeta potential.

XRD – Introduction to XRD. Bragg law. Experimental diffraction methods. Structural and compositional characterization-principles and applications of X-ray diffraction. Rotating crystal method and powder method.

Brunauer-Emmett-Teller (BET) Surface Analyzer – principles of BET.

Self-learning and Tutorials: Concept of reciprocal lattice or circular dichroism for qualitative protein analysis.

Unit II: Microscopy Techniques: Overview of Microscopy: Electron Microscopy – Over view of Optical microscopes. Basic design of the scanning electron microscopy. Modes of operation – Backscattered electrons & secondary electrons. Resolution and contrast enhancement and Specimen Preparation. Basic principles of transmission electron microscopy Modes of operation, Specimen preparation. **Scanning Probe Microscopy (SPM):** Principles of STM and AFM. Basic components of SPM. Contact and non-contact modes. Tip-sample interaction. Advantages and disadvantages of probe microscopes.

Self-learning and Tutorials: Role of confocal microscopy in imaging nanomaterials.

Unit III: Basic Spectroscopy: Absorption Spectroscopy: Ultra-violet and Visible, Beer's Law and Quantitation, Deviations and limitations to Beer's Law, Instrumentation for UV-VIS spectroscopy. Qualitative and Quantitative spectroscopy. **Fluorescence spectroscopy**: Principles of luminescence, Phosphorescence and Chemiluminescence, Instrumentation for fluorescence and phosphorescence. **IR Spectroscopy**: Principles of IR. FTIR. Instrumentation and applications.

Self-learning and Tutorials: Deviations from Beer Lambert's law

Unit IV: Advanced Spectroscopy: Mass Spectroscopy - Principles, ionization methods. Single and quadrupole, TOF. Mass spectroscopy applications in nano-technology.

NMR – Principles and applications

Self-learning and Tutorials: DESI mass spectrometry imaging

Unit V: Mechanical and Thermal Characterization: Thermogravimetric analysis, Differential scanning calorimetry, Glass transition temperature, Dynamic mechanical thermal analysis.

Self-learning and Tutorials: Young's modulus of elasticity.

Reference Books:

- Nanomaterials: Synthesis, Characterization, and Applications by A. K. Haghi, Ajesh K. Zachariah, Nandakumar Kalarikkal. ISBN 9781926895192 (2013). Wiley Publishers.
- 2. Characterization of Nanomaterials, Sneha MohanSamuel Oluwatobi, Oluwafemi Nandakumar Kalarikkal Sabu Thomas. ISBN: 9780081019733. Elsevier. 2014
- 3. Nanomaterial Characterization: An Introduction 1st Edition by Ratna Tantra. ISBN-13: 978-1118753590. 2016.

Elective 1: Statistical Methods for Biology (common paper) 4 Credits (Biochemistry/ Molecular Biology/ Nanoscience & Technology/ Nutrition& Dietetics/ Geo- informatics/ Environmental Sciences/ Cognitive Neurosciences/Cosmetic Science)

Course Objectives: To train the students intensively in both theoretical and practical aspects of statistics, to bring them in contact with basic concepts and methods and to create a problem-solving attitude with the aid of statistical methodology.

Course Outcomes: It provides an introduction to selected important topics in Biostatistical concepts and reasoning. This course represents an introduction to the field of data and data types. The students learn specific topics including tools for describing central tendency and variability in data; methods for performing inference on population means and proportions via sample data; statistical hypothesis testing and its application to group comparisons; issues of power and sample size in study designs; random sample and other study types.

Unit I. Numerical Methods to Represent Variation:

Importance and Scope of Statistics, Data Types, Frequency Distribution, Graphical Representation Methods (Histogram, Bar Charts, Pie Charts), Measures of Center

Tendency (Mean, Median, Mode,) and Dispersion (Standard Deviation, Variance) Advantages and Disadvantages, Co-Efficient of Variance.

Unit II. Probability:

Basic Terminology, Definition of Probability, Basic Laws of Probability, Types of Probability,

Additional Rule of Probability and Multiplication Rule of Probability, Probability Distribution-Bernoulli Distribution, Binomial Distribution, Poisson distribution and Normal Distribution-Simple Problems.

Unit III. Sampling Methods:

Collection of Data, Census Method, Concept of Population, Sample, Sampling, Sample Size, Sampling Error, Advantages and Disadvantages of Sampling Method, Necessity of Sampling, Types of Sampling Methods, Types of Random Sampling Methods – SRS, Stratified Random Sampling, Systematic Random Sampling and Cluster Sampling.

Unit IV. Testing of Hypotheses:

Statistical Hypotheses-Null and Alternative, Level of Significance, Type I and Type II Error, Critical Region, Power of the Test, P Value, Degrees of Freedom, Chi-Square Test for Independence of Attributes and Goodness of Fit, Student's t Test: One Sample t Test and Paired t Test, F Test.

Unit V. Regression and Analysis Of Variance:

Simple Linear Regression, Multiple Linear Regression (Definition, Assumptions, Applications, and Examples), Analysis of Variance –Introduction, Definition of ANOVA, Assumption, Test of ANOVA, Types of ANOVA, Construction of One Way Analysis of Variance.

Reference Books:

- 1. Fundamentals of Biostatistics. Veer Bala Rastogi. Publisher: ANE Books. 2nd Edition, 2009.
- 2. Fundamentals of Mathematical Statistics, S.C. Gupta and V. K. Kapoor, Publisher: Sultan Chand & Sons (2014).
- 3. Fundamentals of Statistics. S.C.Gupta. Publisher: Himalaya Publishing House Pvt. Ltd.Edition.7th Edition, 2012
- 4. Introductory Statistics for Biology. R. E. Parker. Publisher: Cambridge University Press 2nd Edition, 2011
- 5. Statistics for behavioral science. Chintamani Kar. Publisher: Dominant Publishers & Distributors (P) Ltd. (2015).

Practical 1: Characterization of Nanomaterials 6 Credits

- 1. Hands on experience with DLS for particle sizing, zeta potential of prepared nanoparticles/nanoemulsions
- 2. Quantitative and Qualitative use of UV spectroscopy with basic prepared solutions
- 3. Hands on experience with fluorescence spectroscopy and FTIR
- 4. Gravimetric analysis of prepared nanoparticles
- 5. DSC measurements of polymers
- 6. Animal cell culture techniques.

SEMESTER II

Paper 5: Surface and Colloidal Nanochemistry 4 Credits

Course Objectives: This course will aim at introducing the basic concepts and tools for the analysis of colloidal and interfacial properties, behavior and interactions together with brief introduction to some advanced topics such as self-assembly, meso-patterning of soft materials, functional materials, nano-composites, super-hydrophobicity, super-glue, etc. which have attracted increasing attention recently.

The overall aim of this course is to develop a broad background in colloids and interfaces which will enable students to:

1. Appreciate and understand much of the otherwise specialized contemporary published research in nanoparticles and surfaces.

2. Apply these themes to their own research and development problems effectively.

Course Outcome: Understand the background for surface tension and surface energy and be able to describe and measure properties for both solid and liquid surfaces. Understand the term monomolecular films, measurements on these, and what role they play in emulsions, foams and in biological systems.

Unit I: Surface Nanoscience: Introduction to surface active agents. Types of surfactants. Classification, synthesis of surfactant - Shape, size and structure of surfactants. Micelle, Emulsions, Microemulsions & Gels. Intermolecular forces and forces between surfaces, surface tension, contact angles and monomolecular layers, adsorption from gas and liquid on solid and liquid surfaces.

Self-learning and Tutorials: Measure surface tension using hand held surface tensiometer.

Unit II: Colloidal Nanoscience: Introduction to colloidal material, surface properties, origin of colloidal particles, preparation & characterization of colloidal particles. Applications of super hydrophilic hydrophobic surfaces, self-cleaning surfaces. Surface viscosity. Synthesis of hydrophobic and hydrophilic colloids and aerosol.

Self-learning and Tutorials: Brownian motion and Brownian Flocculation Unit III. Quantum Confined Materials: Inorganic semiconductors, quantum wells, quantum wires, quantum dots, quantum rings. Manifestation of quantum confinement: Optical properties nonlinear optical properties. Quantum confined stark effect. Dielectric confinement effect, super lattices. Core-shell quantum dots and quantum-dots-quantum wells. Organic Quantum-confined structures.

Self-learning and Tutorials: Applications of quantum confined structures

Unit IV: Nanoscience and Interface: Intermolecular Forces, Van der Waals forces (Kessorn, Debye, and London Interactions). Dynamic properties of interfaces. Contact angle. Brownian motion and Brownian Flocculation. Surface free energy.

Self-learning and Tutorials: Bio-nano interfaces

Unit 5: Nanotechnology in Chemical Industry: Nanocatalyts - Smart materi-

als – Heterogenous nanostructures and composites – Nanostructures for Molecular recognition (Quantum dots, Nanorods, Nanotubes) – Molecular Encapsulation and its applications – Nanoporous zeolites – Self-assembled. Nanoreactors - Organic electroluminescent displays.

Self-learning and Tutorials: Applications of nanomaterials in chemistry.

Reference Books:

- 1. Principles of Colloid and Surface Chemistry, Paul C. Hiemenz, Marcel Dekker, any edition starting with the 2nd edition, 2011.
- 2. Physical Chemistry of Surfaces, Arthur W. Adamson, 5th edition, Wiley, 2012.
- 3. Foundations of Colloid Science, Robert J. Hunter, Clarendon, Oxford, Volume 1, 1989.
- 4. Colloidal Dispersions, W. B. Russel, D. A. Saville and W. R. Schowalter, Cambridge University Press, 2013.
- 5. Intermolecular and Surface Forces, Jacob N. Israelachvili, Academic Press, 2010 or later editions.
- 6. Interfacial Forces in Aaqueous Media, Carel van Oss, Marcel dekker or Taylor & Francis, 2010

Paper 6. Properties of Nanomaterials 4 Credits

Course Objectives: Teach and train students to have in-depth fundamental knowledge in nanomaterials and have the capability to design and synthesis new nanomaterials. Learning objectives for this course will focus on developing a fundamental understanding of properties of nanomaterials

Course Outcomes: This paper introduces the students to the properties of nanomaterials. The students study the optical, magnetic, mechanical, electronic and surface properties of nanomaterials. At the end of the course, the student will be able to appreciate the unique properties at the nanoscale.

Unit I. Nano-optics: Absorption: direct and indirect bandgap transitions, Emission: photoluminescence and Raman Scattering, Chemiluminescence and electroluminescence, Shape dependent optical properties, quantum size effects in semiconductor quantum dots and nanowires. Optical absorption and emission, Surface Plasmon resonance (SPR), Surface enhanced Raman scattering (SERS).

Self-learning and Tutorials: Principles of nano-photonics

Unit II: Nanomagnetism: Introduction, fundamental concepts of magnetic materials – dia, para and ferromagnetism, magnetic phenomena in ferromagnetic materials, magnetic anisotropy, magnetic domains, hysteresis small particle magnetism, single domain particles, coercivity of single domain particles, supraparamagnetism, coercivity of small particles, review of some issue in nanoscale magnetism

Self-learning and Tutorials: Spontaneously formed magnetic composites

Unit III: Nanoscale Mechanics: Introduction, Mechanical properties with examples. Elasticity of bulk and nanomaterials. Plastic deformation of nanomaterials,

physical basis of yield strength, crystals and crystal plasticity, crystal plasticity to polycrystal plasticity. Nanocatalysis.

Self-learning and Tutorials: Nanoscale mechanics and cellular decision making.

Unit IV: Surface Properties of Nanomaterials: Surface to volume ratio, scaling effects of nanoparticles, Intermolecular forces at the surface, effect of surface properties on flocculation, and wetting and self-assembly in biological and synthetic systems.

Self-learning and Tutorials: Surface chemistry in nanomaterials

Unit V: Nanoelectronics: Electrical properties at the nanoscale, electrical properties of nanowires and CNTs, Semiconductor junctions; field-effect transistors, MOS-FET, electroactive polymers. Coulomb Blacked effect, single electron transistor, Resonate Tunneling Diodes.

Self-learning and Tutorials: Nanoelectronics application

Reference Books:

- Nanostructures & Nanomaterials: Synthesis, Properties & Applications, Guozhong Cao and Ying Wang, World Scientific (2011), ISBN: 13 978-981-4324-55-7 (pbk).
- 2. Nanomaterials: Mechanics and Mechanisms, K. T. Ramesh, Springer London, 2012, ISSN: 978-0-387-09782-4.
- 3. Nanoscale materials in chemistry, Kenneth J. Klabunde, John Wiley & Sons Ltd, New Jersey, 2009, ISSN: 978-0-470-22270-6.
- 4. 4. Nanoscopic materials; Size dependent phenomena, Emil Roduner, Royal Society of Chemistry, UK, 2016, ISSN: 978-0-85404-857-1.
- 5. 5. Optical properties and spectroscopy of nanomaterials, Jin Zhong Zhang, World Scientific, USA, 2011, ISSN: 978-981-283-664-9.
- 6. 6 Nanoelectronics and nanosystems K. Goser, P. Glösekötter and J. Dienstuhl, Springer New York, 2018, ISSN: 3-540-40443-0.

Paper 7. Nanobiology 4 Credits

Course Objectives: The objective of the course is to familiarize the learner with the underlying principles that governs the structure and function of biomolecules and to harness these unique properties of biomolecules for novel applications. The topics that are to be covered are: Self-assembly in biological systems Organic & Inorganic Templates in Biological Systems Biogenic nanoparticles Stealth nanoparticles Smart Nanosystems Targeted nano delivery systems – The Trojan horse concept Stem cells & Nanotechnology – Stimulating tissue regeneration.

Course Outcome: This course will educate on the interdisciplinary areas of bionanotechnology/nanobiotechnology and nanobioengineering, including micro/nanofludics principles and inherent technological applications. The goal of this chapter is to help students understand the science concepts on which nanobiotechnology is based and explore some of the many career possibilities in this exciting field. It also is intended to provide a snapshot of some of the leading nanobiotechology research. **Unit I. Introduction to Nanobiology**: Bio-mineralised Inorganic Nanomaterials – Nanostructures and Dynamics of Biocompatible surfactant monolayers and bilayers – Bio-interface, Bio-conjugation, Bio-matrix based on bioinspired phospholipids polymers. Self-assembly of ionic-complementary peptides and their applications in nano-biotechnology –from nanocluster assays to optical biochips for nano-biotechnology –bioactive nanomaterials in bone grafting and tissue engineering- inorganic /polymer nano composites for dental restoration and bone replacement applications

Self-learning and Tutorials: Bio-mineralized inorganic nanoparticles

Unit II. Protein and DNA Based Nanostructures: Protein and DNA based nanostructures. DNA based Nanostructures: DNA based nanostructures- Properties of DNA- Proteins – Hybrid conjugates of gold nanoparticles- DNA oligomers- Use of DNA molecules in nanomechanics and Computing. Protein based nanostructures-Proteins as transducers and amplifiers of biomolecular recognition events.

Self-learning and Tutorials: DNA Origami

Unit III. Nanocomposites: Introduction to nanocomposites, advantage of composite materials, mechanical properties, thermal properties. Ceramic metal nanocomposites – ceramic based nano-porous composites, metal matrix nanocomposites, natural nano-bio-composites, bio-mimetic nanocomposites, biologically inspired nanocomposites. Polymer nanocomposites and natural nanocomposites. Bio-ceramic for implant coatings.

Self-learning and Tutorials: Nanocomposite with antibiofilm activities or in-suit polymerization

Unit IV. Stem Cell Nanotechnology: Basics, properties, classification and types of stem cells. Cell sources, stem cell differentiation and proliferation. Extracellular matrix, cell-cell interactions, Nanomaterials for controlling the differentiation of stem cells. Nanotechnology in the regulation of stem cell behavior.

Self-learning and Tutorials: Nanotechnology for mesenchymal stem cell therapies

Unit V. Tissue engineering and Regenerative medicine: History and fundamentals of tissue engineering. Biomaterials for tissue engineering, Biodegradable materials. Bioreactors, Tissue dynamic and migration. Tissue engineering examples: Bone & Cartilage Tissue Engineering. Applications of nanotechnology in regenerative medicine.

Self-learning and Tutorials: Nanotechnology and Regenerative medicine

Reference Books:

- 1. Encyclopedia of Nanoscience & Technology, Edited by H.S. Nalwa, American Scientific Publishers (2015).
- 2. Bionanotechnology: Lessons from Nature, David Goodsell, John Wiley & Sons (2010).
- 3. Nanoscience: Nanobiotechnology and Nanobiology, P. Boisseau, P. Houdy and M.
- 4. Lahmani, Springer, New York, 2010, ISSN: 978-3-540-88632-7.

- 5. Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology, 2014. Wiley Publishers.
- 6. Hari Singh Nalwa, American Scientific Publishers, USA, 2009, ISSN: 1588830349.
- 7. Nanobiotechnology, C.M.Niemeyer, C.A. Mirkin, Wiley VCH, 2004, ISSN: 3-527-306587.
- 8. Nanocomposite Science & Technology, Ajayan, Schadler & Braun, Wiley VCH, 2012,
- 9. ISSN: 3527605177.

Paper 8. Synthesis and Surface Modification of Nanomaterials 4 Credits

Course Objectives: Surface modification is a sub-discipline of Materials Science and deals with the surface of a solid and its modifications. The primary goal of surface modification of nanomaterials is to modify the properties of surface of nanomaterials to improve its electrical and thermal properties, and to improve the compatibility of nanomaterials with some matrix when they are used as reinforcing fillers in composites for high performance applications.

Course Outcome: This paper covers the various synthesis methods and surface modification methods used for nanoparticles. The topics covered include physical method, chemical method, biological method, surface modification, targeting strategies. By the end of the course, the students will have an excellent grasp on all the concepts involved in synthesis of nanoparticles and their surface modification.

Unit I. Physical Methods: Fabrication of Nanomaterials by Physical Methods: Inert gas condensation, Arc discharge, RF-plasma. Plasma arc technique, Ion sputtering, Laser ablation, Laser pyrolysis, Molecular beam epitaxy (MBE), Lithography techniques-Photolithography–Electron Beam lithography – Extreme UV- lithography – X-ray Lithography – Focused ion beam Lithography (FIB). Etching, Types of etching - Reactive ion etching (RIE) - Wet chemical etching - Isotropic etching -Anisotropic etching- electrochemical etching.

Self-learning and Tutorials: Imprint Technology

Unit II. Chemical Methods: Chemical precipitation and co-precipitation, polyol, and borohydrate reduction methods. Colloidal hydrolysis sonochmical methods, colloidal precipitaton techniques. Sol-Gel synthesis; Microemulsions synthesis; Hydrothermal, Solvothermal- control of grain size. Microwave assisted synthesis; Sonochemical assisted synthesis, synthesis of core-shell nanostructure, organic-inorganic hybrid methods and nanocomposites, quantum dot (QDs) synthesis. Electrodeposition - electrospinning technique. Arc method-carbon nanotubes- other nanotubes and nanorods –nanosprings –rings chemical routes for nanotubes and nanorods – ion beam induced nanostructures

Self-learning and Tutorials: Synthesis of mesoporous nanomaterials

Unit III. Mechanical methods Grinding – high energy ball milling – types of balls – WC and ZrO2 - material – ball ratio – medium for grinding –limitations in getting required grain size for low melting point materials – typical systems –severe plastic deformation – melt quenching and annealing

Self-learning and Tutorials: High energy ball milling process and its applications

Unit IV. Biological Methods: Green Synthetic Methods for Functionalized Metal Nanoparticles, Greener Preparations of Semiconductor and Inorganic Oxide Nanoparticles, green synthesis of Metal nanoparticles.

Self-learning and Tutorials: Bio-catalytic reactions

Unit V. Surface modification and functionalization: Surface modification of inorganic nanoparticles by organic functional groups, Development of photocatalyst inserted into surface of porous aluminosilicate - Dispersion control of nanoparticles in solvents - development of biodegradable PLGA nanospheres and application. Design of nanoparticle platforms for targeted and temporal delivery and optimal nanoparticle designs-biological targeting, antibody targeting, protein targeting, aptamer binding and cell surface receptor binding.

Self-learning and Tutorials: Surface modification of nanomaterials and controlled drug delivery

Reference Books:

- A.S.Edelstein and R.C.Cammarata Ed. Nanomaterials: Synthesis, Properties and Applications, Institute of Physics Publishing, Bristol and Philadelphia 2011
- 2. Guozhong Cao, Nanostructures & nanomaterials, Imperial College Press, London, 2014
- 3. Gregory Timp Ed., Nanotechnology, AIP Press, Springer 2014
- 4. J.H.Fendler Ed., Nanoparticles and Nanostructured Films, Wiley-VCH 2014

Practical 2: Synthesis of Nanomaterials/ nanoparticles. 6 Credits

- 1. Synthesis of TiO2 nano particles by sonochemical method
- 2. Synthesis of ZnO nano particles by sonochemical method
- 3. Synthesis of CdS nano particles by sonochemical method
- 4. Synthesis of SrTiO3 nano particles by sonochemical method
- 5. Biogenesis of Iron nano-particles –for development of Microbial Emulsion
- 6. Photocatalytic degradation of hazardous compounds by UV irradiation
- 7. Photocatalytic degradation of hazardous compounds by VIS irradiation
- 8. Photocatalytic degradation of hazardous compounds by IR irradiation
- 9. X-ray diffraction determination of structure, composition and estimation of particle size
- 10.Nanomicrobial degradation of various xenobiotics (e.g. pesticides, organochlorines, pyretheroids, PAH)
- 11.Immobilization bacterial cells for bioremediation of heavy metals using micronano-filtration process.
- 12.Hands on experience for Surface tension measurements of prepared nanoemulsions.

Elective 2

Elective 2a. Cancer Nanotherapeutics 4 Credits

Course Objectives: This course mainly aims on highlighting the advances in nanotherapeutics. The main objective of this course is to impart knowledge on cancer developmental stages, Drug Delivery Concepts in Nanoscience, latest advances in cancer nanotherapeutics, nanotechnology aided imaging and diagnostics.

Course Outcome: The course provides insights into the cancer development, stages in development, aberrant signaling mechanisms in cancer, angiogenesis and expression of oncogenes. The course covers topics for current therapies for cancer and their limitations. It highlights the advancements made in the field of nanotechnology for the treatment of cancer, precision tools for diagnosis of cancer. This course will largely depend on Research Papers and class room discussion for references.

Unit I: Biology of cancer development: Different forms of cancer, principles of carcinogenesis, and principles of cancer metastasis and clinical significance. Metastatic cascades, basement membrane disruption. Three step theory of invasion. Signaling mechanism and tumor microenvironment. Oncogenes and identification of oncogenes. Cell cycle and its regulation, apoptosis, DNA damage and repair mechanism, cell death, epigenetic regulation of gene expression. Types of cancer therapies, Mutations and drug resistance.

Self-learning and Tutorials: Cancer development and wound healing process

Unit II: Nanotechnology based precision tools for cancer diagnosis and imaging: Nanotechnology based biochips, nanofludics and microarrays, Mems, Bionanosensors, nanoscale single scale identification and cancer theranostics.

Self-learning and Tutorials: Optical image guided nanotherapies or MEMS based ultra sound device for cancer detection

Unit III: Nanotechnology based therapies: Enhanced Permeation and Retention based therapies. Passive and active targeting in solid tumors and cancer. Pathophysiological principles and physicochemical aspects of delivery systems. Multifunctional nanoparticles for cancer therapy and neutron capture therapy of cancer: nanoparticles and high molecular weight boron delivery agents. Investigational and approved nanomedicine products. Doxil and abrexane formulation, mechanism of action, internalization and pharmacokinetics. Cancer nanotherapeutics in clinical trials. Molecular-targeted nanotherapies for cancer - Nanoparticles based siRNA therapies and Immunotherapies.

Self-learning and Tutorials: Targeted nanotherapies for metastatic and solid tumors.

Unit IV: Nanotechnology in Hyperthermia based cancer therapy: Over view of hyperthermia, whole body hyperthermia, basics of hyperthermia cancer treatment, nanoparticle mediated hyperthermia in cancer therapy. Gold and magnetic nanoparticles for hyperthermia. Neel and Brownian relaxation in magnetic nanoparticles.

Self-learning and Tutorials: Duality of iron oxide nanoparticles in cancer therapy

Unit V: Chemo and radio sensitization using nanotechnology: Chemo/radio-sensitive and resistant, tumors, novel approaches to sensitize tumors, thermal chemo-sensitization, chemo and radio sensitization strategies, radio-sensitizing chemotherapy. Nanoparticles in radiotherapy, nanoparticles based brachytherapy spacers, hydrogel spacers, and smart brachytherapy spacers for combined chemo-radiotherapy and drug eluting brachytherapy spacers. Animal models in cancer nanotherapeutics.

Self-learning and Tutorials: Synergistic administration of photothermal and chemotherapy

Reference Books:

- 1. Cancer Chemotherapy. Dr. Rajat Kheri. Edition 2011, VDM, Verlag Publishers.
- 2. Nanoparticle-Based Medicines: A Review of FDA-Approved Materials and Clinical Trials to Date. 2016, A review.
- 3. George C. Prendergast, 2015, Molecular Cancer Therapeutics: Strategies for Drug Discovery and Development. Wiley.
- 4. Rajaventhan Srirajaskanthan, Victor R. Preedy, 2017 Nanomedicine and Cancer. CRC Press
- 5. Anshu Mathur, 2016 Nanotechnology in Cancer, 1st Edition. Elsevier

Elective 2b. Applied Nanotechnology 4 Credits

Course Objectives: This objective if this course is to provide an understanding and importance about nanotechnology for students in various areas. The course will give an over view about the use of nanotechnology in textile, food, agriculture and other industries.

Course outcomes: This course is application oriented. Students will learn the overview of wide range of applications of nanotechnology in various industries – electronic industries, textile, cosmetic, security systems, food and packaging. This course will largely depend on Research Papers and class room discussion for references.

Unit I: Nanotechnology in electrical and electronic industry: Advantages of nano electrical and electronic devices- Electronic circuit chips. Nanosensors and actuators, Optical switches. Diodes and Nano-wire transistors. Memory storage – Lighting and displays – Filters (IR blocking) – Quantum computers – Energy devices – Medical diagnosis – Conductive additives - Lead-free solder –Nanocoatings –EMI shielding.

Self-learning and Tutorials: Nanotechnology shaping electronic industry

Unit II: Nanotechnology in Textiles and Cosmetic industry: Textiles: Nanofiber production - Electrospinning – Controlling morphologies of nanofibers – Nano-fillers embedded polypropylene fibers – Bionics – Swim-suits with shark-skin effect, Soil repellence, Lotus effect - Nano finishing in textiles (UV resistant, anti-bacterial, hydrophilic, self-cleaning, flame retardant finishes) – Modern textiles (Lightweight bulletproof vests and shirts, Color changing property, Waterproof and Germ proof clothes), Nano-polymers in medical textiles. Cosmetics: Formulation of Gels, Shampoos, Hair-conditioners (Micellar self-assembly and its manipulation) – Sun-screen dispersions for UV protection using titanium oxide – Color cosmetics.

Self-learning and Tutorials: Potential use of nanotechnology in cosmetic dermatology

Unit III. Nanotechnology in Defense: Military applications of Nanotechnology - Artificial intelligence materials – Propulsion. Vehicles - Propellants and Explosives – Camouflage distributed sensors – Amour protection - Conventional weapons - Soldier systems - Implanted systems, Body manipulation - Autonomous systems - Mini-/Micro robots - Bio-technical hybrids – Small satellites and Space launchers - Nuclear weapons - Chemical weapons – Biological weapons - Chemical/Biological protection. Mirage effect using carbon nanotubes

Self-learning and Tutorials: Nanotechnology and National security

Unit IV: Nanotechnology in Agriculture and Food Technology: Nanotechnology in Agriculture - Precision farming, Smart delivery system –Nano-fertilizers: Nano-urea and mixed fertilizers, Nano-fertigation – Nano-pesticides, Nano-seed Science. Nanotechnology in Food industry – Nano-packaging for enhanced shelf life - Smart/Intelligent packaging - Food processing and food safety and bio-security –Electrochemical sensors for food analysis and contaminant detection.

Self-learning and Tutorials: Increasing shelf life of food and packing using nanomaterials.

Unit V: Nanotechnology for Environmental safety: Environmental pollutants in air, water, soil, hazardous and toxic wastes - Application of Nanotechnology in remediation of pollution in Industrial and waste water treatment. Drinking water and Air/Gas purifications using nanomaterials.

Self-learning and Tutorials: Multilayer nanoporous graphene membranes for water desalination

Reference Books:

1. Nanotechnology in Industrial waste water treatment by Arup Roy and Jayanta Bhattacharya. 2015. ISBN 9781780406879. International Water Association publishers.

III SEMESTER

Paper 9. Nanotechnology Product Development 4 Credits

Course Objectives: The course will focus on the nanotechnology based drug development process. It will discuss the development of nanoparticles drug formulation from conception in a lab to production, patenting, patent laws in India. The course will also give an insight into entrepreneurship development, startups, economics and manufacturing and production stages.

Course Outcomes: This course discusses the strategies needed for successful commercialization of nanoscale products. The students learn about business development, capital generation for business, IP rights, Patent aspects and economics of product development. At the end of the course, the student will be able to demonstrate a command on all aspects involved in commercialization of nanotechnology-based product.

Unit I. General introduction to Nanotech & Biotech industries: Scope, Trends and key issues in industry. Organization, financing, policy, trends, problems and issues in the healthcare, pharmaceutical, Agri and other biotech industries. Introduction, types of nano-businesses, ease of entry, intellectual property, ethics, risks/dangers, standardization, investors and commercialization centers, business applications, social aspects of nanotechnology

Self-learning and Tutorials: Over view of manufacturing industries

Unit II. Business Development: Market landscape, tools to map, understand and segment the nanotechnology marketplace, end-users and applications, global market for products, academy industry relationship, University and employee's inventions.

Self-learning and Tutorials: Patent Policies

Unit III: Capital Market for product development: Types of funding, diluting vs non-diluting sources, government and foundations, angel investments, venture capital, private equity, other financing options.

Self-learning and Tutorials: Logistics systems management

Unit IV. Intellectual Property and Regulatory Aspects: Indian and international IP perspectives, various mechanisms for protection, US PTO, Indian PTO, International IP flavors, Regulatory framework for developing nanotechnology marketplace, incentives for commercial applications, critical impact of regulation of nanotechnology – environmental, health and safety.

Self-learning and Tutorials: Product development in manufacturing industries.

Unit V. Economics of product development: Comparison and projection of yield, manufacturing output, labor and equipment expenses to calculate and estimate costs, identification of equipment, facilities and overheads, specific manufacturing methods, tools to estimate the economics of process, addressing the effect

of overall system costs and its benefits.

Self-learning and Tutorials: Marketing of services to educational institutions

Reference Books:

- 1. W.R. Cornish, Intellectual Property, Sweet & Maxwell, London (2016)
- 2. P. Narayana, Patent Law, Wadhwa Publication.
- 3. Patent Law and Policy: Cases and Materials, Robert Patrick Merges, Lexis-Nexis Matthew Bender, 2011, ISSN: 1422480305
- 4. A Practical Guide to Patent Law, Brian C. Reid, Sweet & Maxwell, 2014, ISSN: 9780421656307.
- 5. Global Patent Litigation, Strategy and Practice, Prof. Willem Hoyng, 2016, Kluwer Law. International, 2016, ISSN: 978-9041124609.
- 6. The Law of Patents with a special Focus on Pharmaceuticals in India, Feroz Ali Khader, LexisNexis Butterworths, Nagpur, 2017, ISSN: 8180381501, 9788180381508.
- 7. Principles of Intellectual Property, N.S. Gopalakrishnan and T. G. Agitha, Eastern Book Company, Lucknow, 2014, ISSN: 8170121574, 9788170121572.

Paper 10. Biopharmaceutics and Pharmacokinetics 4 Credits

Course Objectives: Biopharmaceutics and pharmacokinetics is a cross-disciplinary course. Biopharmaceutics is a subject that introduces the absorption, distribution, metabolism and excretion of medicine in the body, and illuminates the interrelationship among preparation, biology and drug treatment. The primary aim of the course is to help students grasp the basic theories and basic skills of biopharmaceutics and pharmacokinetics, develop the students 'ability to analyze and solve problems. All these work will construct steady base for the students who are mainly dedicated to pharmaceutical research.

Course Outcomes: After completion of the course students are expected to: 1. Understand the basic concepts of pharmacokinetics and biopharmaceutics. 2. Describe the different pharmacokinetic models. 3. Determine the basic pharmacokinetic parameters that describe drug absorption and disposition. 4. Differentiate between compartmental and non-compartmental analysis. 5. Identify the physiological, physicochemical and dosage form-related factors that affects drug absorption from different dosage forms. 6. Evaluate the in vitro-in vivo correlation for different drug products.

Unit I. Absorption of Drugs: Drug Absorption from the Gastrointestinal Tract, mechanism of drug absorption, Factors affecting drug absorption, pH–partition theory of drug absorption. Dissolution rate, dissolution process, Noyes–Whitney equation and drug dissolution, Factors affecting the dissolution rate. Permeability-Solubility-Charge State and the pH Partition Hypothesis. Properties of the Gastrointestinal Tract (GIT), pH Microclimate Intracellular pH Environment, Tight-Junction Complex, and Solubility. Experimental methods, Permeability: in-vitro, in-situ and in-vivo methods

Self-learning and Tutorials: ADMET principles

Unit II. Protein and tissue binding: Tissue distribution and permeability. Factors affecting protein binding, kinetics of protein binding, determination of rate constant and different plots (direct and reciprocal). Implication of protein binding on pharmacokinetic parameters. Kinetics of proteins binding, clinical significance of protein-drug binding. Drug interactions: introduction, the effect of protein binding interactions, the effect of tissue-binding interactions, cytochrome p450-based drug interactions and drug interactions linked to transporters.

Self-learning and Tutorials: Rationale for using protein and tissue binding data for drug design

Unit III. Drug disposition: Site of drug disposition, total body clearance, renal clearance, mechanism of clearance, clearance ratio, factors affecting renal clearance, hepatic clearance, volume of distribution and its significance. Role of bio-transformation in drug disposition. Role of biotransformation in drug disposition, first pass effect, microsomal mixed function oxidase system- phase I reactions, phase II reaction, factors affecting drug metabolism, principles of therapeutic drug monitoring.

Self-learning and Tutorials: Spleen microanatomy and emerging role of spleen in pharmacokinetics of monoclonal antibodies and nanoparticles

Unit IV. Bioavailability and Bioequivalence: purpose of bioavailability studies. Absolute and relative bioavailability, in vitro nanoparticle dissolution models, in vitro-in vivo correlations, methods to enhance bioavailability. Methods for assessing bioavailability. Bioequivalence studies, design, evaluation of bioequivalence studies. Bioequivalence example.

Self-learning and Tutorials: Nanoformulations to increase bioavailability of poorly water/lipid soluble drugs OR ionized drugs and their solubility.

Unit V. Pharmacokinetics: Basic considerations, Pharmacokinetic models, Compartment modeling: One compartment model - IV bolus, IV infusion, Extravascular; Multi Compartment models; Two compartment model - IV bolus, IV infusion. Application of Pharmacokinetics in new drug development and designing of dosage forms and Novel drug delivery systems. Drug levels in blood, pharmacokinetics models – compartment models and non-compartment models.

Self-learning and Tutorials: Pharmacokinetics problem solving

Reference Books:

- 1. Industrial Pharmaceutical Biotechnology, Heinrich Klefenz, Wiley Publication, Germany, 2012, ISSN: 3527299955, 9783527299959.
- 2. Pharmaceutical Biotechnology, Daan Crommelin, Robert D Sindelar, 2002, Tailor and Francis Publications, New York, 2012, ISSN: 415285003.
- 3. Hand book of Pharmaceutical Biotechnology, Jay P Rho, Stan G Louie, and Haworth press, New York, 2013, ISSN: 789016354.
- 4. Theory and practice of industrial pharmacy, Lachman L Lieberman, HA, Kanig, J, 2011, 3rd edition, Varghese publishing & Co, New Delhi, 2000, ISSN: 0812109775, 9780812109771.
- 5. Remington's Pharmaceutical sciences, Joseph Price Remington, 18th edition, Mack publishing & Co., Easton, 2012.

Paper 11. Advanced Drug Delivery Systems 4 Credits

Course Objectives: This course covers all the aspects in the design of various drug delivery platforms for nano-based therapeutics. The areas covered include oral, ocular, transdermal and mucoadhesive-based nano-drug delivery systems. By the end of the course, the student will demonstrate the ability to design novel drug delivery system based on the application.

Course Outcomes: After successful completion of the course student will be able to understand the concepts and applications of Advanced Drug Delivery Systems and apply knowledge gained in developing various novel formulations as per requirements. The student will also be able to analyze various evaluation parameters for oral, parenteral, topical etc. drug delivery systems and formulate industrially feasible, cost effective strategy for development of new dosage forms.

Unit I. Routes of Drug Administration on the design of sustained and controlled release systems I: Rationale for controlled drug delivery, physiochemical properties and biological factors influencing the design and performance of sustained/controlled release products.

Per-oral controlled-release delivery: Design and fabrication of oral systems, dissolution controlled release, diffusion controlled release, diffusion and dissolution controlled release, ion-exchange resins, pH-independent formulations, osmotically controlled release, altered density formulations, Case studies.

Parenteral drug delivery: Major routes of parenteral administration; selection, design and development, biopharmaceutics of sustained/controlled release parenteral drug products, polymer microspheres and their biocompatibility and dispersed DDS.

Self-learning and Tutorials: Compare oral/parental and inhalation routes of delivery.

Unit II. Routes of Drug Administration on the design of sustained and controlled release systems II: Transdermal/skin drug delivery system Principles of skin permeation, factors affecting percutaneous absorption of drugs, sorption promoters, absorption enhancement by energy input - iontophoresis, sonophoresis and electroporation, pharmacokinetics of skin permeation, development and evaluation of transdermal devices, Case studies.

Implantable Therapeutic Systems: Introduction, Historical Development, Approaches to development of Implantable therapeutic systems, Benefits of controlled drug administration via implantation, Medical aspects of Implantation.

Self-learning and Tutorials: Transdermal route for protein drugs

Unit III. Drug targeting: Different levels of targeting-first order, second order and third order targeting, active and passive targeting, EPR effect, receptor medi-

ated endocytosis, prodrug based drug targeting, brain targeting, tumor targeting. Overview of different carrier systems for drug delivery: Microparticles, liposomes, niosomes, polymeric nanoparticles, solid lipid nanoparticles, carbon nanotubes, stimuli responsive nanoparticles. Protein/peptide drug delivery systems: Enzyme, epithelial/endothelial barriers, pharmacokinetics, different routes of delivery, practical considerations.

Self-learning and Tutorials: Compare sustained and targeted drug delivery

Unit IV. Drug release kinetics: Theory of controlled release drug delivery systems and Mathematical modelling -zero order kinetics, first order kinetics, Higuchi, Hixson crowell cube root law and Korsmeyer-peppas theory of diffusion from polymers and other matrix.

Self-learning and Tutorials: Drug release kinetics problem solving

Unit V. Design of nanoparticles based carriers for drug delivery: Fabrication methods and nanoparticle types. Self-assembled nanoparticles and hydrogels. Modelling applications in drug delivery and nanoparticles device design. Challenges in nanoparticles drug development.

Self-learning and Tutorials: Nanoparticle production scale.

Reference Books:

- 1. Nanoparticles as Drug carriers, Vladimir P Torchilin, Imperial College Press, USA, 2006. ISSN: 1860946305, 9781860946301.
- 2. Nanomedicine, Parag Diwan and Ashish Bhardwaj, Oscar Publications, India, 2006, ISSN: 978-8182741394.
- 3. Nanobiotechnology, C.M.Niemeyer, C.A. Mirkin, Wiley VCH, 2004, ISSN: 3-527-306587.

Paper 12. Biomedical Applications of Nanomaterials 4 Credits

Course Objectives: The objective of this course is to provide the students with an insight into the various applications of nanomaterials in the biomedical area. Biomedical nanotechnology is rapidly developing field which includes a diverse collection of disciplines. The applications of nanotechnology are gaining overwhelming response in almost all the fields. Tremendous development has taken place in health care sector. In the future years, cancer diagnosis and therapy, medical implants, tissue engineering are known be influenced by this area.

Course Outcomes: The learning outcomes of the course are to understand how nanomedicines can be personalized. The students will understand the problems and possibilities for drug delivery and target therapies and relate theory with practice to describe, explain and discuss relevant topics on the field of nanomedicine. To understand basic targeting strategies of nanomedicines for different therapies. To understand the need, obstacles and solutions for polymeric and nanoporous drug delivery systems. To be aware of the toxicological aspects of nanosized surfaces and particles. To improve the research skills on nanomedicines and to apply the scientific techniques for own research.

Unit I. Microfludics and Nanofludics: Introduction to Micro/nanofluidics and

Lab-on-a-Chip, principle, pressure driven liquid microflow, Laminar flow, Special considerations of flow in small channels, mixing, microvalves, micropumps and hydrodynamics. Approaches toward combining living cells, microfluidics and 'the body' on a chip, Chemotaxis, cell motility. Fabrication techniques for Nanofluidic channels – Biomolecules separation using Nanochannels - Biomolecules Concentration using Nanochannels – Confinement of Biomolecules using Nanochannels Functions and applications in life sciences. Lab-on-a-chip for Biochemical analysis and BioMEMS

Self-learning and Tutorials: Microfluidics for synthesizing nanoparticles

Unit II. Bionanosensors: History, Clinical Diagnostics, generation of biosensors, Biological elements, Performance factors of Biosensors, immobilization of Biological components, Screen Printing Electrode, applications of Biosensors, Types of transducer technology, conducting Polymer based sensor, DNA Biosensors, Biochips and biosensors for detection of pathogens and allergens.

Self-learning and Tutorials: Target detection and tracking by bionanosensors

Unit III. Nanomaterials for in vivo imaging: Principles of molecular imaging, different imaging modalities - MRI, SPECT, PET, CT, non-invasive imaging modalities. Applications of nanotechnology in radiotherapy and radio-sensitization.

Self-learning and Tutorials: NIR fluorescent nanoprobes for in vivo optical imaging

Unit IV. Implants and Inserts: Types of implants, Osmotic pumps, design and evaluation methods, types of inserts, design and evaluation methods, medical prosthetics and their applications.

Self-learning and Tutorials: Non-degradable versus a degradable polymer for an implantable drug delivery system

Unit V. Nanomaterials for Gene Delivery: Carbon nanotubes for gene delivery, protein and peptide nanomaterials for gene delivery, lipid based nanomaterials for gene delivery, polymer based nanomaterials for gene delivery. Use and design of nanoparticles for gene therapy and barriers in gene delivery.

Self-learning and Tutorials: Production and clinical development of nanoparticles for gene delivery

Reference books:

- 1. Malsch, N.H., "Biomedical Nanotechnology", CRC Press. (2005).
- 2. Mirkin, C.A. and Niemeyer, C.M., "Nanobiotechnology II: More Concepts and Applications", Wiley-VCH. (2007).
- 3. Kumar, C. S. S. R., Hormes, J. and Leuschner C., "Nanofabrication towards Biomedical Applications: Techniques, Tools, Applications, and Impact", WI-LEY -VCH Verlag GmbH & Co. (2005).
- 4. Lamprecht, A., "Nanotherapeutics: Drug Delivery Concepts in Nanoscience", Pan Stanford Publishing Pte. Ltd. (2009).
- 5. Jain, K.K., "The Handbook of Nanomedicine", Humana press. (2008).

Practical 3. Biopharmaceutics and Pharmacokinetics 6 Credits

- 1. Dissolution study of Nano drug delivery systems by Dialysis method or by using Dissolution apparatus.
- 2. In vivo and ex vivo comparative absorption study for API and Nanocrystals.
- 3. Determination of Lymphatic absorption (In vivo, for lipid Nano formulations).
- 4. Diffusion study of Nano emulsion/suspensions using biological membrane.
- 5. Bio distribution of drug loaded nanoparticles.
- 6. Protein binding behavior of Nano suspension and API.
- 7. Study on blood components (Hemolysis) of Nano delivery systems.
- 8. Comparative metabolism study of API & Nano formulations Via GIT.
- 9. Relative Bio availability of conventional and Nano formulations.
- 10.Elimination behavior of polymeric Nano formulations with reference to t-half, Ke, MRT.

Elective 3

Elective 3a. Environmental Nanoscience 4 Credits

Course Objectives: This course describes both the advantages and disadvantages of nano products to the environment.

Course Outcomes: By the end of the course, the students have an appreciation for the benefits of nanotechnology in improving the environment. After the successful completion of this course, the student will be able to: 1. Understand the basic and essential elements of battery materials 2. Explain the mechanism of harnessing solar energy. 3. Discuss the fabrication of solar cell structures. 4. Define and design how hydrogen energy can be stored 5. Describe the working principle of various fuel cells and model it. 6. Analyze the safety and precautionary issues in handling nanomaterials

Unit I. Environmental pollution: Environmental fate and transport of Nanomaterials, physical-chemical interactions, aggregation and deposition, definition of air pollution, water pollution and ground pollution, contribution of nanoparticles in aggravating pollution.

Self-learning and Tutorials: Pollution control using Nanotechnological strategies

Unit II. Nanotoxicology: Exposure and risk assessment, dose-response, mechanisms of toxicity, definition of eco-toxicity, routes of entry of nanomaterials into the environment, cytotoxicity of nanomaterials.

Self-learning and Tutorials: Immunotoxicity of silver nanoparticles

Unit III. Health effects of nanoparticles: Sources of nanoparticles, epidemiological evidence, entry routes into the human body – Lung, Intestinal Tract, Skin, effect of nanoparticle size and charge, effects of nanoparticles on - cardiovascular, liver and gastrointestinal and nervous system, coagulation and thrombosis, bloodbrain barrier. Impact of CNT's on respiratory systems.

Self-learning and Tutorials: Nanoparticles – pros and cons

Unit IV. Environmental application of nanomaterials: Environmental Remediation, nanoparticles reactivity, fate, and lifetimes in the subsurface, ground water remediation with nanoparticles, nanomaterials for water and wastewater treatment.

Self-learning and Tutorials: Nano-remediation

Unit V. Nanotechnology for controlling air pollution: Nanomaterials for sensing toxic gases. Gas sensing materials and devices. Techniques used for gas sensing (resistance, capacitance and electrochemical), Sensor properties, advantages of nanomaterials, synthesis and characterization of nano-metal oxides (tin oxide, zinc oxide, indium oxide), mixed oxides, nanoscale materials for sensors (quantum dots, CNTs, nanotubes, wires and belts), colloidal silver and gold, magnetic nanoparticles, application of nanomaterials in sensors, CNT-based sensors,

Graphene-based sensors, active devices based on Nanostructures. Remediation and monitoring.

Self-learning and Tutorials: Graphene oxide nanomaterials for gas sensing

Reference Books:

- 1. 1. Environmental Biotechnology, Alan Scragg, Pearson Education Limited, England, 2007, ISSN: 0199228612, 9780199228614.
- 2. 2. Environmental Biotechnology, S.N. Jogdand, Himalaya Publishing House, Bombay, 2006.
- 3. 3. Wastewater Engineering Treatment, Disposal and Reuse, Metcalf and Eddy, Inc., Tata Mc Graw Hill, New Delhi, 2013, ISSN: 0073401188, 9780073401188.
- 4. 4. Environmental chemistry, A.K. De, Wiley Eastern Ltd, New Delhi, 2009, ISSN:
- 5. 8122426174, 9788122426175.
- 6. 5. Introduction to Biodeterioration, D. Allsopp, C. Gaylarde and K.J. Seal, ELBS/Edward
- 7. Arnold, 2004, ISSN: 0-521-821355, 0521528879.
- 8. 6. Biotechnology for Wastewater Treatment, P Nicholas Cheremisinoff, Elsevier Science,
- 9. 2013,ISSN: 0080946453, 9780080946450
- 10.7. Biotechnological Methods of Pollution Control, SA Abbasi and E Ramaswami,
- 11. Universities Press, India, 1999, ISSN: 8173710988.
- 12.8. Environmental Biotechnology, Concepts and Applications, Hans-Joachin Jordening and JosefWinter, Winter-VCH, 2005, ISSN: 3-527-30585-8.

Elective 3

Elective 3b. Nano-toxicology 4 Credits

Course Objectives: The student will understand the toxicology of nanomaterials and his/her responsibility when using nanotechnology

Course Outcomes: After the successful completion of this course, the student will be able to 1. Identify different types of nano materials and its applications. 2. Explain problems and issues of Bio nano materials. 3. Understand the patent of research article. 4. Define the safety and handling of nano materials. 5. Describe the toxic and hazards of Nanomaterials 6. Discuss the experimental issues of Nano materials.

Unit I. Nanotoxicology and sustainable nanotechnology: Size-specific behavior of nanomaterials – nanotoxicology challenges – carbon nanotubes in practice – postproduction processing of carbon nanotubes – physicochemical properties of nanomaterials as mediators of toxicity – characterization of administered nanomaterials during toxicity studies – nanomaterial characterization after administration experiment.

Self-learning and Tutorials: Renewable energy using nanotechnology

Unit II. Nanoparticle exposure: Physicochemical determinants in particle toxicology – nanoparticles vs. micron-size particles – nanoparticle toxicity comparison to larger counterparts – requirement for appropriate model particles – exposure assessment, exposure pathways and their significance – documenting the occurrence and nature of exposures – bio-distribution of nanoparticles – localization of particles in tissues – relevance of drug targeting to nanotoxicology.

Self-learning and Tutorials: Health effects of nanoparticles exposure

Unit III. Nanoparticle interaction with biological membranes - Interaction of nanoparticles with lipid bilayers – cell-level studies of nanoparticle-induced membrane permeability – internalization of cation nanoparticles into cells – placental biological barrier model for evaluation of nanoparticle transfer – transport across placental barrier – assessment of placental transfer - Biological mechanism of nanoparticle disposition – outline of gene-cellular interactions of nanomaterials – overview of dermal effects of nanomaterials – toxicity of nanoparticles in the eye.

Self-learning and Tutorials: Permitted toxicity levels of nanoparticles

Unit IV. Approaching the Nano-age -Scientists as moral agents – the business community and corporations as moral agents – policy makers and regulators as moral agents – ethical and societal implications – the public interface of science and human values – origins of the precautionary principle – the citizen as moral agent – the language of ethics – meta-ethics and normative ethics. **Self-learning and Tutorials: Bioethics in nanotechnology**

Unit V. The Ethical Agenda for Nanotechnology - The visions of nanotechnology – scenarios in the nanotech marketplace – clarifying purpose – the principle of respect for communities – the principle of the common good – the principle of social justice – utilitarian priorities The pressing questions – the players – the funders – the thinkers – the communicators – the arenas combined – the role of fore-sighting – ethics applied to the practical – citizenship in the nano-age – the value of the skeptical optimist.

Self-learning and Tutorials: Future of nanotechnology.

Reference Books:

- 1. Nanotoxicology Interactions of Nanomaterials with Biological Systems by Yuliang Zhao and Hari Singh Nalwa. ISBN: 1-58883-088-8.
- 2. Case Studies in Nanotoxicology and Particle Toxicology. Antonietta M. Gatti and Stefano Montanari. ISBN 978-0-12-801215-4. 2015.

SEMESTER IV

Project Work 12 Credits Summer Internship – 2 Credits MSc dissertation – 12 Credits

Nanoscience Journal Club

This journal club will expose graduate students to recent advances in nanoscience literature and to improve their skills in writing abstracts, giving presentations, and thinking critically. Students will be given a recent research nanoscience topic unfamiliar to them and will be asked to write an abstract synthesizing a small collection of peer-reviewed publications, present the topic, and respond to questions from fellow students and faculty. Additionally students are requested to register on online for SWAYAM, NPTEL and other online educational resources to gain knowledge

M.Sc. in Nutrition and Dietetics

General Course overview

It is now well-established that many disorders can be treated / prevented with appropriate nutrition. Therefore, appropriate management of nutrition is key to the success of keeping once own health in good condition. Keeping this in mind, the JSS AHER has started a new Master's degree course in Nutrition and Dietetics, which provides in depth knowledge in general nutrition, clinical nutrition, and management of various nutritional disorders while covering the fundamentals of biochemistry, statistical models in biology and application of computer knowledge in the management of nutrition and dietetics. The semester-based course begins with fundamentals of food science, which introduces various aspects of vegetarian and non-vegetarian diets.

Next, the student is exposed to various aspects of nutritional biochemistry, to get acquainted with the structure and function relationships of nutritional biochemicals. The course continues with the basic aspects of human physiology, biochemical techniques and statistical methods for biology (as an elective). In the second semester, the student studies the advanced nutrition, community nutrition, human nutrition and diet therapy subjects to better understand the concepts of nutrition and the role of nutrition in the treatment / prevention of disorders

In the Semester-3, the student studies the metabolism of nutrients, the safety aspects of nutrition, and medical nutrition and management. Additionally, student also studies the use of computer applications in the implementation and design of nutrition and dietetics studies.

The fourth semester provides an opportunity to student to get exposed to modern research labs. The student performs experiments under the supervision of an expert research guide and submits his report as dissertation thesis. In addition, the student can also present his/her research findings in national/international seminars; publish work in high impact peer reviewed journals. In total, the student gets a chance to shape his/her career in nutrition and dietetics research. In conclusion, the M.Sc. in nutrition and dietetics course offered under Faculty of Life Sciences, JSS Academy of Higher Education & Research is a well-designed master's program for shaping a student's career in modern research and teaching.

Eligibility: A graduate in Science (B.Sc.) from an UGC recognized University with biology as a major subject.
Course Curriculum

	Semester I	Credits
Paper 1	Fundamentals of Food Science	4
Paper 2	Nutritional Biochemistry and Biochemi- cal Techniques	4
Paper 3	Human Physiology	4
Paper 4	Life Cycle Nutrition	4
Elective 1	Statistical Methods for Biology	4
Practical 1	(Nutritional Biochemistry (Practical 1	6
		26
Paper 5	Advanced Nutrition-1	4
Paper 6	Principals of Diet Therapy	4
Paper 7	Human Nutrition	4
Paper 8	Medical Nutrition Management-1	4
Elective 2a 2b 2c	Nutraceuticals and Functional Foods Food preservation and Food Microbiolo- gy Diet for Endocrine Disorders	4
Practical 2	(Clinical Nutrition (Practical 2	6
		26
	Semester III	
Paper 9	Advanced Nutrition 2	4
Paper 10	Medical Nutrition and Management-2	4
Paper 11	Community Nutrition	4
Paper 12	Food Safety and Food Service Manage- ment	4
Elective 3a 3b 3c	Nutrition for Sports and Exercise Sensory Evaluation and Culinary Sci- ence Food Security	4
Practical 3	Menu Planning and hospital internship	6
		26
	Semester IV	
	Summer Project	2
	Thesis and viva voce examination	12
		14
	Total Credits	92

SEMESTER I

Paper I. Fundamentals of Food Science 4 Credits

Objectives- The paper deals with the nutritive value of all food groups. The factors effecting the cooking of different food groups will be taught and also the sensory attributes of the food products is covered.

Outcome: By the end of the semester the student will understand the concept of food groups and factors affecting their cooking quality and acceptability.

Unit I: Classification of food, cereals

- Concept of food and classification of food.
- Cereals –Rice, Wheat and Millets (Ragi, Maize, Barley & Oats) –structure, composition and nutritive value.
- Starch Chemistry, sources, gelatinization, retrogradation, and factors affecting of gelatinization and starch gel.
- Flour Types, properties, rheological properties of dough. Functional properties of flour.
- Sugar cookery Principles and stages of sugar cookery, preparation of crystalline and non-crystalline candies.

Unit II: Pulses, Legumes, Nuts and Oil seeds

- Pulses and legumes- Composition, nutritive value, anti-nutritional factors, physical & chemical properties of proteins, pulses cookery
- Nuts and oil seeds composition, nutritive value, role of nuts and oil seeds in cookery.
- Fats and oils Physical and chemical properties of fats and oil, rancidity and prevention and its uses.

Unit III: Fruits, Vegetables, Spices and Condiments

- Fruits and vegetables Composition, nutritive value, structure, Texture, pigments and flavor component, changes during cooking and processing and browning reaction.
- Spices and condiments Composition, Spice principles, their role in cookery.

Unit IV: Meat, Poultry and Marine foods

- Meat Structure, composition, cuts of meat, post mortem changes, methods of cooking, tenderness of meat.
- Poultry Composition, market forms, selection factors and methods of cooking.
- Marine foods- Types, composition, cooking.

Unit V: Egg, Milk, Water and Sensory evaluation of foods

- Egg Structure, composition, coagulation, foam formation and its role in cookery.
- Milk Composition, types, nutritive value, physical and chemical properties, coagulation of milk protein, and preparation of milk based beverages.
- Water- properties, water as medium of cooking- blanching, boiling, steaming, poaching, simmering, reducing.
- Sensory evaluation of foods -a) Sensory characteristics of foods Appearance, Colour and Flavor, b) Types of sensory test, sensitivity test and objective evaluation

- 1. Potter, N.N. (2007) Food Science, AVI publishing company INC West Port Connecticut.
- Vickie A. Vaclavik, Elizabeth W. Christian, Essentials of Food Science Springer, Science & Business Media 2013 –.
- 3. Srilakshmi (1998) Food Science, AVI publishing company, Connecticut.
- 4. Swaminathan, M. (1998) Food Science and Experimental Foods, BAPCO Bangalore.
- 5. Marion and Banion (1998) Food Science, Mac Millon Company, London.
- 6. Jones & Bartlett Learning, 16-Jan-2018 Food Science.
- 7. Shobha Kumari, Handbook of Food Science and Technology, Oxford Book Company, 2014

Paper II. Nutritional Biochemistry and Biochemical Techniques

Objectives: Students will learn detailed cell structure and its components functions in this paper. All macronutrients, nucleic acids and enzyme classification, physicochemical properties and methods of estimation will be taught. Some of the basic biochemical techniques will be learned during the course period.

Outcome: At the end of the course, students will be able to estimate macro and micro nutrients by using biochemical techniques.

Unit I: Cell & Nucleic acids

- Cell Structure and Function: Components, cell membrane composition, fluid mosaic model, membrane lipids, proteins and carbohydrates, membrane receptors, functional role of sub cellular organelles and membrane systems.
- Nucleic acids: Components, structure and level of organization, Physico chemical properties, biological importance, DNA replication and enzymes in DNA replication.

Unit II: Amino acids & Proteins

- Amino acids- Classification and structure, properties, reactions and identification techniques. Formation of peptide linkages.
- Proteins- Structure and organization, physico-chemical properties, classification and functional diversity of proteins, techniques of protein purification.

Unit III: Carbohydrates

- Carbohydrates: Classification, structural features, stereoisomerism and optical activity, chemical properties.
- Inter conversion of hexoses, sugar derivatives of biomedical importance, hetero-glycans. Methods to estimate sugars and starch.

Unit IV: Lipids & Enzymes

- Lipids: Classification, chemical structure and properties of fatty acids, Triglycerides, phospholipids, biological functions of lipids, glycolipids, Lipoproteins: Types, Structure and physicochemical properties.
- Enzymes: Classification, nomenclature, general properties of enzyme,, kinetics and mechanisms action, regulation of enzyme activity.
- Coenzymes and cofactors, Enzyme inhibition, isoenzymes, immobilized enzymes

Unit V: Biochemical Techniques

- Spectroscopic techniques: Principles of colorimeter, spectrophotometer, fluorimeter. Beer-Lambert's Law and its limitations.
- Separation techniques: Centrifugation, Ultra centrifugation, Chromatography-Principles, methods and applications.
- Electrophoretic techniques: Types and application.

- 1. Textbook of Medical Biochemistry 8th Edition, M N Chatterjea, Rana Shinde, 2011. Jaypee Brothers Medical Publishers
- 2. Murray, R.K., Granner, D,K., Mayes, P.A. and Rodwell, VW. (2000) : 25th Ed. Harpers Biochemistry, Macmillan Worth Publishers.
- 3. Nelson D.L. and Cox, M.M. (2017) : seventh Ed. Lehninger's Principles of Biochemistry, Macmillan Worth Publishers.
- 4. Devlin, T.M. (2010): 7th Ed. Text book of Biochemistry with Clinical Correlations, Wiley Liss Inc.
- 5. Stryer, L. (1998): 4th Ed. Biochemistry, W.H. Freeman and Co.
- 6. Conn, E.E., Stumpt. P.K. Bruening, G. and Doi, R.H. (2001): 5th Ed. Outlines of Biochemistry, John Wiley and Sons.
- 7. Voet, D. Voet, J..G and Prat, C.W,, (2015) : Fundamentals of biochemistry. 4th Ediiton.

Paper 3- Human Physiology 4 Credits

Objectives: The paper covers the working of internal organs and organ system. The students will be exposed to anatomy of different organs and will help the students to understand the physiological functions of the biological systems **Outcome:** At the end of the course the students will be able to appreciate the anatomical and physiological aspects of the human body system

Unit I: Cell physiology, Biochemical aspects of muscle tissue & nerve tissue

- Cellular basis of Physiology Body fluid compartment, membrane potential, Intercellular communication - Homeostasis.
- Biochemical aspects of muscle tissue structure, chemical composition, mechanism and energetics of muscle contraction, muscle fatigue.
- Biochemical aspects of nerve tissue structure, composition & functions of nerve tissue.

Unit II: Endocrinology

- Endocrinology Anatomy of endocrine glands, Hypo- and Hyper- functions of the glands.
- Hormones Mode of action, functions of hormones of the endocrine glands
 Pituitary, Adrenal, Thyroid, Gonadal hormones, Pancreas, Pineal body and Parathyroid.

Unit III: Respiratory Tract & GI tract

- Respiratory tract: Oxygen requirement for nutrients, composition of inspired and expired gas, partial pressure of gas, diffusion gradient and gas flow, transport of oxygen and CO2, Hemoglobin affinity for O2 and dissociation.
- Gastro Intestinal Tract: Anatomy and function of Gastrointestinal Tract, secretion of gastric juice.
- Hunger, Appetite, Satiety physiological and psychological factors affecting food intake, circadian rhythm in GI tract secretions.

Unit IV: Blood Circulation, Renal functions and Reproduction

- Circulation: Blood composition, functions of formed elements of blood and plasma proteins, blood pressure, origin and conduction heartbeat.
- Renal functions: Formation of urine, characteristics of urine, normal and abnormal constituents of urine, acid base balance.
- Reproduction-Anatomy and functions.

Unit V: Sensory organs & Immunity

- Sensory organs-Nose, eyes, ears, skin, tongue,: anatomy and functions.
- Immunity Properties, natural and acquired Immunity, features of immune responses, antigen - antibodies - types, properties, antigen - antibody interaction, allergy.

- 1. K Sembulingam Physiology, 2017,
- 2. Textbook of Physiology, AK Jain, Volume-2, 2017, Avichal Publishing Company.
- 3. Human physiology by CC Chatterjee, Vol I & II,CBS Publishers & Distributors PVT Ltd.

- 4. Text book of Human Physiology, Gerald R Graham,
- 5. Essential Of Medical Physiology, Anil Baran Singha Mahapatra, Current Books International, 2014.
- 6. Human Physiology: The Mechanisms of Body Function, Vander, Sherman, Luciano. 1998, William C Brown Pub

Paper 4: Life Cycle Nutrition 4 Credits

Objectives: The paper covers the importance of nutrition along with RDA of nutrients throughout the different stages of human life. The students would also be taught about various nutritional problems associated with the different stages of life cycle

Outcome: At the end of this course the students will be able to appreciate not only the significance of nutrition but also understand the various nutritional problems associated with the various stages of life cycle and ways to overcome them.

Unit I: RDA & Dietary Guidelines

- RDA- ICMR and WHO: their uses and limitations;
- Basis for computing nutrient requirements, latest concepts in dietary recommendations.
- Dietary guidelines-ICMR

Unit II: Nutrition during Pregnancy

- Importance of nutrition prior to pregnancy
- Nutrition during Pregnancy Stages of gestation, maternal physiological adjustments, nutritional problems, Maternal Anemia - types, causes, symptoms and treatment and dietary management.

Unit III: Nutrition during Lactation

- Nutrition during Lactation Physiology of lactation, hormonal control and reflex action, efficiency of milk production, problems of breast feeding.
- Nutritional composition of breast milk, nutritional concerns during lactation, special foods during lactation.

Unit IV: Nutrition in Infancy, Preschool & school children

- Nutrition in Infancy Infant feeding, nutritional needs, premature infant and their feeding, feeding problems, weaning foods. infant formulae, lactose intolerance
- Nutrition in preschool: Feeding and factors to be considered. Packed lunch.
- Nutrition in school children Feeding school children and factors to be considered. Feeding problems, packed lunch.

Unit V: Nutrition during Adolescence, Adult and Elderly

- Nutrition during Adolescence Changes in growth and development, hormonal influences.
- Age at menarche factors affecting age at menarche, psychological problems, body image, disordered eating behavior, nutritional problems.
- Nutrition in Adult and Elderly -Menopausal and post-menopausal women, hormonal changes, nutritional requirement.
- Physiological changes in aging Psycho-social and economic factors af-

fecting eating behavior, social situation, knowledge and belief, institutionalization, common health problems, nutritional requirement, feeding old people.

Reference Books:

- 1. Bennion, H. (1979) Clinical Nutrition, New York Harper and Raw Publishers
- 2. Brown, J. E. (1998). Nutrition Now, West/Wadsworth: International Thomson Pub. Co.
- 3. Brown, J. E., Sugarman, I. J. (2002). Nutrition through the Life Cycle, Wadsworth Thomson Learning.
- 4. Goodhart, R. S. S. and Shils, M. E. (1998). Modern Nutrition in Health and Disease. Philadelphia: Lea and Febiger.
- 5. Groff, J. L and Gropper, S. S. (1999). Advanced Nutrition and Human Metabolism, Belmount CA: Wads worth/Thomson Learning.
- Jackson, M. S., Rees, Jane, M., Golden, Neville, H.; Irwin Charles, E. (ed) (1997). Adolescent Nutritional Disorders.New York: The New York Academy of Science.
- 7. Mahan L. K. & Stump S.E. (13th ed.) (2012) Krause's Food Nutrition and diet Therapy Saunders USA: Elsevier.
- 8. Wardlawy, G. M. Insel, P. M. and Seyler M. F. (1994). Contemporary Nutrition; Issues and Insights St. Lopuis Masby.
- 9. Warthington, R., Vermeersch J. and Willams, S. (1985). Nutrition in Pregnancy and Lactation St. Louis Times Mirror. Mosby College Publishing.
- 10.Ziegler, E. E. and Filer L. J. (1996). Present Knowledge in Nutrition, Washington D.C.: International Life Science institute.
- 11.Life Cycle Nutrition An evidence based approach, Sari Edelstein, Second Edition.2014.

Elective 1: Statistical Methods for Biology (common paper) 4 Credits

(Biochemistry/ Molecular Biology/ Nanoscience & Technology/ Nutrition& Dietetics/ Geo- informatics/ Environmental Sciences/ Cognitive Neurosciences/Cosmetic Science)

Course Objectives: To train the students intensively in both theoretical and practical aspects of statistics, to bring them in contact with basic concepts and methods and to create a problem-solving attitude with the aid of statistical methodology.

Course Outcomes: It provides an introduction to selected important topics in Biostatistical concepts and reasoning. This course represents an introduction to the field of data and data types. The students learn specific topics including tools for describing central tendency and variability in data; methods for performing inference on population means and proportions via sample data; statistical hypothesis testing and its application to group comparisons; issues of power and sample size in study designs; random sample and other study types.

Unit I. Numerical Methods to Represent Variation:

Importance and Scope of Statistics, Data Types, Frequency Distribution, Graphical Representation Methods (Histogram, Bar Charts, Pie Charts), Measures of Center Tendency (Mean, Median, Mode,) and Dispersion (Standard Deviation, Variance)

Advantages and Disadvantages, Co-Efficient of Variance.

Unit II. Probability:

Basic Terminology, Definition of Probability, Basic Laws of Probability, Types of Probability,

Additional Rule of Probability and Multiplication Rule of Probability, Probability Distribution-Bernoulli Distribution, Binomial Distribution, Poisson distribution and Normal Distribution-Simple Problems.

Unit III. Sampling Methods:

Collection of Data, Census Method, Concept of Population, Sample, Sampling, Sample Size, Sampling Error, Advantages and Disadvantages of Sampling Method, Necessity of Sampling, Types of Sampling Methods, Types of Random Sampling Methods – SRS, Stratified Random Sampling, Systematic Random Sampling and Cluster Sampling.

Unit IV. Testing of Hypotheses:

Statistical Hypotheses-Null and Alternative, Level of Significance, Type I and Type II Error, Critical Region, Power of the Test, P Value, Degrees of Freedom, Chi-Square Test for Independence of Attributes and Goodness of Fit, Student's t Test: One Sample t Test and Paired t Test, F Test.

Unit V. Regression and Analysis Of Variance:

Simple Linear Regression, Multiple Linear Regression (Definition, Assumptions, Applications, and Examples), Analysis of Variance –Introduction, Definition of ANOVA, Assumption, Test of ANOVA, Types of ANOVA, Construction of One Way Analysis of Variance.

Reference Books:

- 1. Fundamentals of Biostatistics. Veer Bala Rastogi. Publisher: ANE Books. 2nd Edition, 2009.
- 2. Fundamentals of Mathematical Statistics, S.C. Gupta and V. K. Kapoor, Publisher: Sultan Chand & Sons (2014).
- 3. Fundamentals of Statistics. S.C.Gupta. Publisher: Himalaya Publishing House Pvt. Ltd.Edition.7th Edition, 2012
- 4. Introductory Statistics for Biology. R. E. Parker. Publisher: Cambridge University Press 2nd Edition, 1991.
- 5. Statistics for behavioral science. Chintamani Kar. Publisher: Dominant Publishers & Distributors (P) Ltd. (2015).

Practical 1: Nutritional Biochemistry 6 Credits

Objectives: To estimate the proximate composition, and analyze the micronutrients in food samples using different techniques

Outcome: At the end of the semester, student will be able to estimate and analyze various components in food samples by using the techniques such as colorimetry, spectrophotometry and chromatography.

Proximate composition

- 1. Determination of moisture, Ash total, acid soluble and insoluble.
- 2. Determination of Protein in foods by micro-Kjeldahl method.
- 3. Determination of Fat Crude fat.
- 4. Carbohydrates glucose, starch
- 5. Vitamin estimation Ascorbic acid, β carotene.

Colorimetry-Demonstration of Beer Lambert's law.

- 1. Quantitative estimation of proteins by spectrophotometric method.
- 2. Mineral estimation-, iron, phosphorous.
- 3. Enzyme activity assays Amylase

Paper Chromatography

- 1. Ascending and descending separation of amino acids and sugars.
- 2. Separation of plant pigments by column chromatography.

- 1. Food analysis laboratory manual, Suzanne Nielsen, 2010, Springer.
- 2. Biochemical methods a concise guide for students and researchers, a. Pingoud; c. Urbanke; j. Hoggett and a. Jeltsch
- 3. Principles and Techniques of biochemistry and molecular biology, Wilson/ walker, 2010.
- 4. A Laboratory Manual of Food Analysis, Shalini Sehgal, 2016.IK International Publishing House.
- 5. Basic methods for the biochemical lab; holtzhauer martin, 2006. Springer.

SEMESTER II

Paper 5- Advanced Nutrition-1 4 Credits

Objectives: The paper covers the bioavailability of the micronutrients –minerals and vitamins.

The paper deals with the causes, symptoms and treatment of the deficiency of micronutrients. The paper deals with the RDA and Estimation of the micronutrients.

Outcome: By the end of the course the students will be able to understand the significant role of micronutrients in our regular life.

Unit I: Understanding Nutrition

Understanding Nutrition –Introduction, Nutrition Science, History of Nutrition-Identification of food factors and Discovery of other essential nutrients, The Indian Nutrition Scenario, Basic terminology in relation to nutritional requirements.

Unit II Fat soluble Vitamins

Vitamins - Discovery of water soluble vitamins, Numbering and naming of vitamins, units and measurement of vitamins, factors influencing the utilization of vitamins.

Fat soluble Vitamins: Vitamin A, Vitamin D, E & K. - Digestion, absorption and transport and excretion, functions, interaction with other nutrients (if any), RDA, Deficiency and toxicity, major source and nutritional assessment.

Unit III. Water soluble vitamins

Water soluble vitamins: Vitamin C, Thiamine, Riboflavin, Niacin, Pantothenic acid, Biotin, Folic acid, Vitamin B12, Vitamin B6 - Digestion, absorption and transport and excretion, functions, interaction with other nutrients (if any), RDA, Deficiency and toxicity, major source and nutritional assessment.

Unit IV. Macro minerals

Calcium, Phosphorus Magnesium, Sodium, Potassium, chlorine.- Digestion, absorption and transport and excretion, functions, homeostasis, interaction with other nutrients (if any), RDA, Deficiency and toxicity, major sources, Assessment of nutriture and methods of estimation in food materials.

Unit V. Micro minerals

Iron, Zinc, copper, selenium, chromium, iodine, manganese, Molybdenum and fluoride: Digestion & absorption, Functions, Toxicity, interaction with other nutrients, RDA and food sources.

- 1. Modern Nutrition in Health and Disease , Robert J. Cousins PhD (Author), Katherine L. Tucker Ph.D. (Author), Thomas R. Ziegler M.D., 11th Edition, 2014.
- 2. Understanding Normal and Clinical Nutrition, Eighth Edition, Sharon Rady Rolfes, Kathryn Pinna, Ellie Whitney. Wadsworth, Cengage Learning 2009.
- 3. Advanced Nutrition and Human Metabolism, Sareen S. Gropper, Jack L. Smith, James L. Groff. , 2009
- 4. Mahan, L.K., Arlin, M.T., (2012): Krause's Food, Nutrition and Diet Therapy, 13th Ed. W.B. Saunders Company, London.

5. Srilakshmi B, Nutrition Science, 5th Edition, New age International Publishers. 2018.

Paper-6 Principals of Diet Therapy 4 Credits

Objectives: With this paper the students will understand the concept of clinical nutrition, diet planning and dietitian and their responsibilities. The paper deals with types of diets and dietary management in various diseased conditions and mal nutritional status. The paper deals with importance of nutrition in sports.

Outcome: At the end of the semester the students will understand the dietitian responsibilities and their role in nutrition care process and diet planning.

Unit I. Introduction to clinical nutrition and dietetics, dieticians

- Introduction to clinical nutrition and dietetics: Definition and history of dietetics, Interrelationship between food, nutrition and health. Factors affecting food choices. Concepts of a desirable diet for optimum health. Rationale for nutritional support in an institution, the food guide.
- Role and responsibility of dieticians: Factors in patient care, team approach in patient care, psychological considerations, interpersonal relationships with patients, importance of nutrition education, medical ethics, Hospital dietary-scope and importance, types of food service, quality management.

Unit II Nutrition Care Process & Basic principles of diet planning

- Nutrition Care Process (NCP) Nutritional assessment, History taking, Nutrient intake analysis, anthropometry, usefulness of nutrition laboratory data, assessment of protein – energy status, Nutrition counseling: definition, concept, role of clinical dietician, the recipient and counseling environment and goals of counseling.
- Basic principles of planning a normal diet- characteristics of normal diet, meeting nutrient requirement of individuals family and institutions, applications of dietary guidelines for the community, interrelationship between food nutrition and health, factors affecting food choices and regulation of food intake- huger, satiety and role of neurotransmitters.

Unit III. Types of diet and feeding methods

- Regular diet and rationale for modifications in energy and other nutrients, texture, luid, soft diets. Analysis of dietary intake, Food and nutrient delivery.
- Enteral and parenteral feeding: principles, types, methods of administration, monitoring and complications

Unit IV Eating disorders, Underweight and Obesity.

- Eating disorders: causes, symptoms, types-Anorexia Nervosa, Bulimia Nervosa, and Binge Eating Disorder, Pharmacological treatment.
- Types of obesity, Assessment of obesity, Health risks, Regulation of body weight. Causes of obesity, Dietary Management of obesity Dietary Modification: past and present approach, Psychology of weight reduction.
- Underweight / Excessive Leanness

Unit V Sports Nutrition

• Sports Nutrition -Introduction , Evolution and growth of sports nutrition

as a discipline, Anthropometric and physiological measurement, Various techniques for measuring body composition, Work capacity, Physical fitness, Parameters of fitness, Fitness tests, Nutritional demands of sports and dietary recommendations

Reference Books

- 1. Robinson, C.H., Lawler, M.R., Chenoweth, W.L., and GarMck, A.E. (1986) Normal and Therapeutic Nutrition. 17th Ed., MacMillan Publishing Co.
- 2. Williams, S.R. (2013); Basic Nutrition and Diet Therapy, 14th Ed. Times Mirror/Mosby college publishing St. Louis.
- 3. Raheena, Begum (1989): A Textbook of foods, nutrition and dietetics. Sterling publishers, New Delhi.
- 4. Joshi, S.A. (1992): Nutrition and Dietetics, Tata McGraw Hi 11 Publications, New Delhi.

Paper 7 Human Nutrition 4 Credits

Objectives: This paper deals with understanding the metabolism of macronutrients viz, carbohydrates, proteins and lipids. The students are also exposed to concepts affecting the metabolism especially the digestion and utilization of the nutrients. The students are also exposed to recent concepts like fetal origins of diseases.

Outcome: At the end of this course the students will have a clear understanding of the metabolism of the macronutrients and factors affecting their utilization and digestion.

Unit I: Introduction of human nutrition, Bioavailability, body composition

- Introduction of human nutrition- Concept of Food groups, five and seven main groups.
- Concept of Bioavailability and Bio accessibility Bioavailability of macro and micro nutrients.
- Methods of studying body composition- underwater weighing, air displacement technique, DXA (dual X-ray absorptiometry), skin fold caliper, bio-impedance.

Unit II: Carbohydrate metabolism

- Carbohydrates Food Sources, RDA, physiological functions, Digestion and Absorption of dietary carbohydrates.
- Metabolism of carbohydrates- Glycolysis, TCA cycle, Pentose Phosphate pathway
- Dental caries, artificial sweeteners.
- Dietary Fiber Definition, sources, types of fiber, role in digestion, Interaction with other nutrients.
- Factors influencing metabolism of carbohydrates and their metabolic disorders

Unit III: Protein metabolism

- Proteins Food Sources, RDA, physiological functions, Digestion and absorption, Concepts of essential and non-essential amino acid, Factors affecting protein
- Bioavailability plant and Animal sources.
- Nitrogen balance concept. Methods for evaluating protein quality 2h

Unit IV: Lipid metabolism

- Fats and lipids- Food Sources, RDA, physiological functions, Digestion and absorption, lipid transformation in the liver, lipotrophic factors, deposition of fat in the body,
- Lipids Concepts of visible and invisible fats. EFA, SFA, MUFA, PUFAsources and physiological functions.
- Role of lipoproteins, triglycerides in health and disease.

Unit V: Current concepts in human nutrition

- Nutrigenomics- definition, nutrient gene interaction, nutrigenomics and non-communicable diseases, Impact of nutrigenomics on nutrition research, nutrition therapy,
- Fetal origins of adult disease-nutritional basis and genetic link-intrautirine nutrition-birth weight maternal nutrition, Barker's hypothesis.

Reference Books

- 1. Modern Nutrition in Health and Disease , Robert J. Cousins PhD (Author), Katherine L. Tucker Ph.D. (Author), Thomas R. Ziegler M.D., 11th Edition, 2014.
- 2. Understanding Normal and Clinical Nutrition, Eighth Edition, Sharon Rady Rolfes, Kathryn Pinna, Ellie Whitney. Wadsworth, Cengage Learning2009.
- 3. Advanced Nutrition and Human Metabolism, Sareen S. Gropper, Jack L. Smith, James L. Groff. , 2009
- 4. Mahan, L.K., Arlin, M.T., (2012): Krause's Food, Nutrition and Diet Therapy, 13th Ed. W.B. Saunders Company, London.
- 5. Srilakshmi B, Nutrition Science, 5th Edition, New age International Publishers. 2018.
- 6. Nutrigenomics and Nutrigenetics in Functional Foods and Personalized Nutrition Lynnette R. Ferguson, 2013, CRC Press.

Paper 8 Medical Nutrition and Management –I 4 Credits

Objectives: The paper deals with the concept of nutrition care for the patients under medical supervision or hospitalized patients. The paper deals with the nutrient and drug interaction. The paper covers the nutrition therapy for GI tract, pancreas, pulmonary, and liver diseases under medical supervision.

Outcome: By the end of the semester the students understand what type of nutritional care process should be followed for the subjects with various disease conditions under medical supervision.

Unit I Nutritional care of hospitalized patients

- Hospital malnutrition, impetus for improved nutritional care of patients,
- Nutritional screening and assessment of the critically ill.
- Preparation of nutritional care plan.

• Differentiate between basic modified diets -sodium, diabetic, renal, and different dietary consistencies.

Unit II: Diet, Nutrient and Drug Interaction

- Drugs and pharmaceutical compounds-natural and synthetic
- Effect of drugs on ingestion, Digestion, Absorption and metabolism of nutrients.
- Effect of foods, nutrients and nutritional status on drug dosage and efficacy.

Unit-III Medical Nutrition Therapy for Upper Gastrointestinal tract Disorders

- Oesophagus; oesophagitis, , Gastroesophagial reflux, (GERD) Hiatus hernia
- Disorders of stomach: Indigestion, Gastritis, H. pylori infection , Gastric and duodenal ulcers, dietary management.
- Disorders of Small and Large intestine Mal absorption syndrome (sprue, ulceratice colitis, crohn's disease, inflammatory bowel syndrome, Celiac (Gluten –induced), Flatulence, constipation, haemorhoids, diarrhoea, steatorrhoea, dietary management.
- Intestinal surgery: Short bowel syndrome, Ileostomy, Colostomy, Rectal surgery, dietary management.

Unit IV Medical nutrition therapy in Pulmonary & Liver diseases

- Pulmonary diseases: Chronic obstructive Pulmonary disease, cystic fibrosis, pneumonia, tuberculosis; causes, pathology, effect of malnutrition, dietary management.
- Liver diseases: Liver function tests, Hepatitis (A,B,C, Fulminant,) alcoholic liver disease and cirrhosis, Cholecystisis, Cholelithiasis, cholangitis, cholestatic liver disease, inherited disorders, dietary management.

Unit V Medical nutrition therapy in Pancreas disorder & Rheumatic disorders

- Pancreas disorder: pancreatitis, Functional tests and dietary management.
- Rheumatic disorders: Osteo arthritis, rheumatic arthritis, scleroderma, systemic lupus erythematosis Gout: Symptoms, causes, treatment, prevention, dietary management.

Reference Books

- Anderson, L., Dibble, M.V., Turkki, P.R., Mitchall, H.S., and Rynbergin, H.J.(1982) Nutrition in Health and Disease, 17thEd., J.B.Lippincott Co.Philadelphia.
- 2. Aiitia, F.P. (2001): Clinical Dietetics and Nutrition '4th Edition, Oxford University press, Delhi.
- 3. Mahan, L.K., Arlin, M.T., (2012): Krause's Food, Nutrition mid Diet Therapy, 11thEd. W.B.Saunders Cotnpany, London.
- 4. Robinson, C. H., Lawler, M. R., Chenoweth, W. L., and (Iiiiwick, A.E. (1991) Normal and Therapeutic Nutrition, 17thEd., MacMillan Publishing Co.
- 5. Williams, S.R. (2016): Nutrition and Diet Therapy, 15th Ed Times Mirror/ Mosby college publishing,
- 6. Raheena, Begum(2011): A Textbook of foods, nutrition and dietetics. Sterling publishers, NewDelhi.
- 7. Joshi, S.A. (1 992):Nutrition and Dietetics, Tata McGr Hill Publications, New Delhi

Elective 2a: Nutraceuticals and Functional Foods 4 Credits

Objectives: The paper deals with the concept of nutraceuticals and functional foods, their role in disease prevention and management. Paper also covers the role of phytochemicals in preventing metabolic disorders.

Outcome: At the end of the semester the students will be able to appreciate the significance of nutraceuticals in maintaining health and to incorporate them as functional ingredient in food formulations for disease prevention.

Unit I: Nutraceuticals History and Classification

- Functional foods and nutraceutical Introduction Defining, the concept Review of the history of functional foods teleology of nutraceuticals.
- Classifying Nutraceuticals
- Organizational models for nutraceuticals- a) Food source and b) Animal

Unit II: Plant metabolites as Nutraceuticals

- Primary and secondary metabolites in plants general teleology a) Carotenoids b) Conjugated linolenic acid c) Flavonoids d) Amino acid e) Omega – 3 PUFA g) Terpenoids.
- Mechanism of action Anticancer, positive influence on blood lipid profile, anti-oxidation, anti-inflammatory, osteogenetic

Unit III: Functional properties of foods and water

- Physico-chemical (Functional Properties) properties of foods_ Organic food components, colloids, food dispersions (sols, gels, emulsion, foam), types of solutions.
- Role of water-functional properties, water activity and intermediate moisture foods.

Unit IV: Nutraceuticals-safety quality assurance and cost

- Proteins, modified proteins, Starch, cellulose, hemicelluloses, hydrocolloids and gums.
- Nutraceuticals- safety quality assurance and cost bioavailability: definition, factor affecting, chemical measurement and physical testing and micro- biological testing- functional foods and in vitro studies.

Unit V: Pharmacology of nutraceuticals

• Pharmacology and nutraceuticals — pharmacology of chemical components derived from plant source and the therapeutic derived from plant source and the therapeutic efficiency of functional food ingredients.

Reference Books

1. Physical-Chemical Properties of Foods, 1st Edition, Aïchatou Ndob Malik

Melas André Lebert, Elsevier, 2015.

- 2. Natural Antioxidants in Human Health and Disease, Balz Frei, Elsevier, 2018.
- 3. Handbook of Nutraceuticals and Functional Foods, Robert E C ed Wildman, 2016.CRC press.
- 4. Functional Foods and Nutraceuticals, Aluko Rotimi Aluko, 2012, New India Publishing Agency.
- 5. Handbook Of Nutraceuticals Yashwant Vishnupant Pathak, 2011, CRC Press.
- 6. Nutraceuticals and Functional Foods in Human Health and Disease Prevention, Debasis Bagchi, Harry G. Preuss, Anand Swaroop, 2015., CRC press.

Elective 2b- Food preservation and Food Microbiology 4 Credits

Objectives: Students in this course will learn about microbes in food and spoilage of food. The students will learn about various preservation techniques of food. Students will also learn about the importance of packaging in food preservation.

Outcome: At the end of the course, the student will be able to appreciate the microbiology of food and the various preservation techniques.

Unit I History of microbiology and classification of micro-organisms.

- History of microbiology of food. Microbial growth pattern, physical and chemical
- factors influencing destruction of micro-organisms.
- Types of micro-organism normally associated with food-mold, yeast, and bacteria. Micro-organisms in natural food products and their control.
- Classification of food in relation to shelf life-Spoilage in food and its control: spoilage caused by microorganism (bacteria, fungi and virus), enzymes, pets and rodents.

Unit II Techniques of Food Preservation

- Food dehydration and concentration: methods of drying and concentration, types of dryers.
- Heat processing : Mechanism of action, methods of application to foods (Equipments),
- Cold preservation; Mechanism of action, methods of application to foods (Equipments),
- Food irradiation: technology, application and safety assessments, effects on food and microorganisms
- Chemicals in food preservation, safety of preserved foods.

Unit III Methods of Packaging and packaging material

- Food Packaging- Objectives and functions of food packaging. Requirement for effective food packaging. Selection of packaging forms and materials.
- Various methods of packaging canning, aseptic packaging, retort pouches etc.
- Special problems in packaging of food stuff, consideration in the packaging of perishables and processed foods.
- Evaluation of packaging material and package performance, packaging equipment, package standards and regulation.

Unit IV Food Microbiology

- Contaminants of foods-stuffs, vegetables, cereals, pulses, oilseeds, milk and meat during handling and processing.
- Biochemical changes caused by micro-organisms, deterioration of various types of food product.
- Food poisoning and microbial toxins, microbial food fermentation, standards for different foods.

Unit V

- Intrinsic and extrinsic parameters of food that effect microbial growth
- Microbiology of processed foods.
- Rapid microbiological detecting methods.

Reference Books

- 1. Modern Food Microbiology, Jay, James M., Loessner, Martin J., Golden, David A, 2005, seventh edition.Springer, US
- 2. Branen A.L.and Davidson, P.M. 1983. Antimicrobials in Foods. Marcel Dekker, New york.
- 3. Handbook of Food Preservation, Second Edition, M. Shafiur Rahman, 2007, CRC Press
- 4. Fundamental Food Microbiology, Bibek Ray, 3rd Edition.2004, CRC Press.
- 5. Robinson, R.K. Ed. 1983. Dairy Microbiology. Applied Science, London.

Elective 2c. Diet for Endocrine disorders 4 Credits

Objectives: The paper deals with hormones and basic anatomy and functions of endocrine glands. The basic concept of the paper is to make the students understand the role of endocrine glands in health and disease. Also the paper covers the dietary management in endocrine disorders.

Outcome: By the end of the semester the students will understand causative factors of endocrine disorders and their dietary management.

Unit I. Hormones

Hormones: Introduction to endocrinology, messengers- neuronal and chemical signals. General characteristics - Neuroendocrine relationship, mechanisms of hormonal action, control of hormone secretion.

Unit II. Endocrine Glands anatomy and functions: Adrenal glands, Hypothalamus, Ovaries, Islet cells in the pancreas:, parathyroid, Pineal gland, Pituitary gland, Testes, Thymus ,Thyroid

Unit III. Hormonal systems: Classification – Basis and types of classification. Paracrine, Autocrine, Intracrine, Anatomical.Chemical nature.

Unit IV. Endocrine disorders: Causes of endocrine disorders and types of endocrine disorders.

Diagnostic tests and indicators of endocrine disorders.

Unit V. Treatment and Dietary management in endocrine disorders: Endocrine Cancers Treatment for endocrine disorders. Diet planning for endocrine disorders

Reference Books:

- 1. Hormones and the Endocrine System: Textbook of Endocrinology, Book by Winfried G. Rossmanith, 2016, Springer.
- 2. Principles of Endocrinology and Hormone Action, Belfiore, Antonino, Le-Roith, Derek, 2018, Springer.
- 3. Laboratory Investigation of Endocrine Disorders, M. R Wills, 2nd Edition, Butter worth publications
- 4. Endocrine Disorders, Donald, 1984, Informal Healthcare.
- 5. Therapeutic Outcome of Endocrine Disorders: Efficacy, Innovation and Quality of Life, Barry B Bercu Bercu Stabler, 2013, Springer New York.

Practical 2: Clinical nutrition and Dietetics 6 Credits

Objectives: To analyze the biochemical parameters in serum and urine samples: To compare the analyzed with the reference values and diagnose the condition. To standardize the raw and cooking the weight of basic food ingredients used in cooking process.

Outcome: By the end of the semester the student will be able to analyze the biochemical parameters and diagnose the physiological condition. Food exchange list is made by comparing the raw and cooked weight measures

1. Analysis of blood:

- 1.1. Glucose
- 1.2. Hemoglobin Cyanmethhaemoglobin method
- 1.3. Iron Wong's method
- 1.4. Total cholesterol and Triglycerides
- 1.5. Serum A/G ratio and total protein
- 1.6. Serum Vitamin C
- 1.7. Serum alkaline phosphatase
- 1.8. Serum creatinine
- 1.9. Serum Urea
- 1.10. SGOT and SGPT

1.10.1. Analysis of Urine for -Creatinine,Urea, Albumin ,

2. Dietetics- Development of a Ready Reckoner for calculating nutrient content of various foods, portion size and volume.

Conversion of cooked to raw equivalent of various foods and food exchange list.

Reference Books:

- 1. Hormones and the Endocrine System: Textbook of Endocrinology, 2016, Winfried G. Rossmanith, Springer International publishing.
- 2. Greenspans Basic and Clinical Endocrinology, David G Gardner, M D and Dolores M. Shoback, 2007, Appleton & Lange publisher
- 3. Principals og endocrinology and hormone action, 20018, Springern, anthropometry

SEMESTER III

Paper 9. Advanced nutrition -2 4 Credits

Objectives: The paper covers the role of vitamin like molecules and ultra-trace elements in health status. The paper coves the energy metabolic process and its requirement and expenditure. The paper deals with the interaction of drugs with nutrients.

Outcome: By the end of the course the students will understand the energy metabolism, drug and nutrient interaction in human body

Unit 1- Vitamin like molecules & Ultra trace minerals

Vitamin like molecules: Choline, carnitine, inositol, taurine, flavonoid, pangamate, laetrile PABA - chemistry, metabolism, source. Deficiency, excess.

Ultra-trace minerals: Arsenic, Boron, Nickel, Silicon, Vanadium & cobalt: Digestion & absorption, Functions, Toxicity, interaction with other nutrients. RDA and food sources.

Unit II Energy metabolism

Energy metabolism: Energy content of foods, Basal and resting metabolisminfluencing factors. Methods to determine energy requirements & expenditure. Thermo genesis, adaptation to altered energy intake, latest concepts in energy requirements and recommendations for different age groups.

Unit III Water

- Introduction, Water: An essential but overlooked nutrient
- Functions of water in the body
- Water distribution and compartments of body water
- Forces influencing water distribution
- Water Balance -
 - ✓ Water intake
 - ✓ Water output (Losses of body water)
 - \checkmark Regulation of water balance
 - ✓ Requirements of water
 - ✓ Disturbances in fluid balance
 - ✓ Dehydration
 - ✓ Edema

Unit IV Food components other than essential nutrients

- Bioactive substances from plant food phytochemicals.
- pro and prebiotics, Phenolic compounds-their health benefits
- Other dietary factors with anti-nutritional effects
- Health benefits of other dietary factors with anti-nutritional effects

Unit V Drug-nutrient interactions

Drug-nutrient interactions – effect of drugs on ingestion, digestion, absorption and metabolism of nutrients, effects of dietary composition, effect on nutritional status, effect on organ function, drug dosage and efficacy. Drug abuse and drug assistance.

- 1. Modern Nutrition in Health and Disease , Robert J. Cousins PhD (Author), Katherine L. Tucker Ph.D. (Author), Thomas R. Ziegler M.D., 11th Edition, 2014.
- 2. Understanding Normal and Clinical Nutrition, Eighth Edition, Sharon Rady Rolfes, Kathryn Pinna, Ellie Whitney. Wadsworth, Cengage Learning 2009.
- 3. Advanced Nutrition and Human Metabolism, Sareen S. Gropper, Jack L. Smith, James L. Groff. , 2009
- 4. Mahan, L.K., Arlin, M.T., (2012): Krause's Food, Nutrition and Diet Therapy, 13th Ed. W.B. Saunders Company, London.
- 5. Srilakshmi B, Nutrition Science, 5th Edition, New age International Publishers. 2018.

Paper 10 Community Nutrition 4 Credits

Objectives: The paper deals with nutritional problems prevailing in community. The paper covers intervention programs and nutritional policies implemented by government to overcome the nutritional problems. The organizations working concerned with food and nutrition in India and globally.

Outcome: At the end of the semester the students will be educated on nutritional problems, nutritional education, nutritional assessment and policies followed in preventing nutritional problems.

Unit I: Common nutritional problems and mal nutrition

- Relationship of nutrition to development -In terms of socio economic, industrial and agricultural development.
- Consequences of malnutrition and prevalence of common nutritional problems - PEM, vitamin A deficiency disease, anemia, iodine deficiency disorders and fluorosis.
- Etiological factors leading to malnutrition, Synergism between malnutrition and infection. Measures to overcome malnutrition.
- Epidemiology of communicable disease: Factors responsible for the spread of communicable diseases, mode of transmission chicken pox, typhoid fever, malaria, leprosy, filariasis.

Unit II: Nutrition Education

- Nutrition Education: Its importance to the community. Qualities of training workers in nutrition education programs, integration of nutrition with education and extension work.
- Methods of education, when to teach, whom to teach.
- Principles of planning, executing and evaluating nutrition education programs, problems of nutrition education.

Unit III: Methods of Assessment of nutritional status

- Direct method Anthropometry, biochemical, biophysical and clinical assessment.
- Indirect method Dietary Survey, Vital statistics.

Unit IV: Nutrition Intervention programs & National Nutrition policy

• Nutrition Intervention programs in India: Genesis objectives and operation

of National Anemia Control Prophylaxis Program, National Goiter Control Program, Vitamin A Prophylaxis Program, School Lunch Program.

- CMNMP, ICDS, TINP.
- National Nutrition policy thrust areas and implementation at national level Impact of national policy on food security.
- Primary health center (PHC) Concept, organization, current status in India and delivery of service, Taluk level hospital, and employees state insurance (ESI) and immunization.

Unit V: National & International organization concerned with food and nutrition

- National ICMR, CHEB, CSWB, SSWB, NIN, NNMB, CFTRI, DFRL, NIPCCD, ICAR -objectives and functions.
- International FAO, WHO, UNICEF, World Bank, FFHC, UNESCO, DANIDAobjectives and functions.

- 1. Vinodini Reddy, Pralhad raj. Gowrinath sastry, J find Kashinath, K.C. (1993), Nutrition Trends in India, NIN, Hyderabad.
- 2. Park and park (1995), Text book of preventive and social medicine, Banarsidas published by Jabalpu.
- 3. Jellifee, D.D and Pathes (1989), Assessment of Nutritional status of community, WHO, Geneva.
- 4. Proceeding of the Nutrition society of India (1999), Vol (35,42,43,44,46 and 47), NIN, Hyderabad.
- 5. Sarah Gopalam (1996. Towards better Nutrition for women and children problems and programs, Development of women and child development Government of India.
- 6. Bagehi, K (1987), Evaluation of nutrition education nutrition monitoring and assessment, Editors - Gopaldas, T and Seshadris, Oxford University press.

Core paper 11 Medical Nutrition and Management –II 4 Credits

Objectives: The paper deals with the nutritional management of CVD, diabetic, neurological and metabolic disorder subjects under medical supervision. The paper deals with the nutritional support for critically ill subjects.

Outcome: By the end of the semester the students understand what type of nutritional care process should be followed to the subjects with various metabolic diseases under medical supervision.

Unit I. Medical nutrition therapy of cardiovascular diseases:

- Role of specific nutrients in cardiac efficiency, CVD bio markers and interpretation.
- Metabolic syndrome, long-term and short-term treatment in Coronary disease. Myocardial infarction, cerebral infarction (atherosclerosis as one of the causative factor)
- Other acute and chronic conditions: congestive heart failure, hypertension, stroke, dyslipidemia (genetic hyperlipidemia).

Unit II: Medical Nutrition therapy in Diabetes mellitus:

- Classification, therapy, diagnostic/monitoring criteria,
- Long term and short-term management. Drugs in diabetes, calorie counting.
- Ketoacidosis,
- Hypoglycemia of non-diabetic origin.

Unit III Medical nutrition therapy in Metabolic stress, Febrile condition & deficiency diseases

- Metabolic stress: Sepsis, trauma, burns, surgery, oral and dental health.
- Febrile condition
- Short duration Typhoid, Influenza, Malaria,
- Long duration Tuberculosis.
- Deficiency diseases PEM, Vitamin A, Anemia.
- Allergy Common food allergens, test for allergy Skin test and Elimination diet and Treatment for allergy.

Unit IV: Medical nutrition therapy in Neurological diseases

- Epilepsy, migraine, Alzheimer's Parkinson's, trauma myasthenia graviscauses, effect of malnutrition, feeding problems, role of nutrients early recovery.
- Special diets for metabolic disorders: Phenylketonuria (PKU); Maple Syrup Urine Disease (MSUD); Lactose intolerance; Galactosemia; disorders of fatty acid oxidation.

Unit V. Assessment of the critically ill

- Nutritional support systems and other life saving measures for the critically ill
- Monitoring nutrient intake and providing nutrition support service.
- Role of immuno enhancers, conditionally essential nutrients, immuno suppressants and special diets.

- 1. Anderson, L., Dibble, M.V. Turl-ki, P.R., Mitchall, H.S., and Ryntceruili, H.J. (1982) Nutrition in Health and Disease, 17th Ed., J.B. Lippincott Co. Philadelphia.
- 2. Antic, F.P. (1973): Clinical Dietetics and Nutrition, Second Edition, Oxford University press, Delhi.
- 3. Mahan, L.K., Arlin, M.T., (1992): Krause's Food, Nutrition and Diet Therapy, 8th Ed. W.B. Saunders Company, London.
- 4. \Robinson, C.H., Lawler, M.R., Chenoweth, W.L., and GarMck, A.E. (1986) Normal and Therapeutic Nutrition. 17th Ed., MacMillan Publishing Co.
- 5. Williams, S.R. (1989); Nutrition and Diet Therapy, 6th Ed. Times Mirror/ Mosby college publishing St. Louis.
- 6. Raheena, Begum (1989): A Textbook of foods, nutrition and dietetics. Sterling publishers, New Delhi.
- 7. Joshi, S.A. (1992): Nutrition and Dietetics, Tata McGraw Hi 11 Publications, New Delhi.

Paper 11 Food Safety and Food Service Management 4 Credits

Objectives-The paper covers the importance of understating the concept of food service management, The students will be exposed to the concepts of menu, its planning, working and design of food service kitchens. Students will also be exposed to the various laws associated with food service management.

Outcome: At the end of this course the students will be able to appreciate the working of various food service institutes, various components of food service institutes like menu, kitchen plan, laws governing etc.

Unit I: Food service industry in India

 Food service industry in India - acts and responsibilities, note on eating preference and misinformation, reliable information, source of reliable information, government information and regulations on healthful food program.

Unit II Food processing and menu palnning

- Projecting and preserving nutrients during production, purchase, storage, cooking and serving.
- Types and function of menu, planning a menu according to food service type, recipes and special menu for food service.

Unit III. Kitchen management Principles of layout, determination of equipment:

Kitchen management Principles of layout, determination of equipment - factors affecting the selection, criteria for selection, types of equipment, basic materials used in manufacture of equipment, installation and care of equipment's, fuel saving techniques. Physical planning - architectural features, floor, walls, lighting, plumbing and ventilation.

Unit IV: Laws governing food service institutions

• Food service - Service areas, methods and styles, table winding up, set-

ting, presentation techniques, clearing and customer relations.

• Laws governing food service institutions -food laws, labor laws, laws concerning hygiene and safety.

Unit V. Environmental hygiene and sanitation

- Environmental hygiene and sanitation: Hygiene in food, plant hygiene, safety handling, and personal hygiene, to prevent procedure followed in food service establishment to prevent accidents, facilities and benefits to workers in each establishment.
- Indices of food and water field of catering establishment biological criteria of foods, testing and control measures.
- Management of food waste and waste-water.

Reference Books

- 1. Sethi, M. and Matha, S. Catering Management An integrated approach, Wiley Eastern Ltd., New Delhi, II Edition 1993.
- 2. Branson, J.C. and Lennon, M.Hostel and Hospital Housekeeping, EILBS (Publication) V Edition 1992.
- 3. Palacio J.P. Harger . V., Shugart G. and thesis, M. West introduction to food service, Mac Millan publication Co., New york XVII Edition 1994.
- 4. Kotscheva.r, and. Teerell, M.E., Food service planning; layout and equipment, MacMillan Publication Co., New York, III Edition, 1985.
- 5. Splaver, B.R .Successful catering, Van Norstrand Reinhold, New York, II Edition.
- 6. Kinton, R. and Cesarani, V., The Theory of catering ELBS, VII Edition, 1992.
- 7. Lillicap, D.R. and Cousins, J.A. Food and Beverage Service, ELBS, IV Edition, 1994.
- 8. Marris, M.McCreery, C and Brighton, R. Introduction to Catering, Blackwell Scientific Publication, London, 1993.
- 9. Delfakis, H, Scanion, W.C. and Van Burch, J.B. Food service Management, South Western Pubilication Co., Cincinatti, Ohia, 1992.
- 10.Cracknell, H.C. and Nobis, G. Mastering Restaurant Service, Macmillan Master Service, Macmillan Education Ldt., (pub) London, 1989.

Elective 3a. Sensory Evaluation and Culinary Science 4 Credits

Objectives: The paper deals with learning the sensory evaluation, sensory analysis and sensory assessment of the food samples. The paper also covers the culinary aspects of food.

Outcome: At the end of the course student understand the importance of sensory and culinary attributes in product development.

Unit 1. Sensory evaluation, sensory analysis and sensory panel

- Introduction to Sensory evaluation, sensory analysis and sensory panel
- Basic tastes, threshold tests for basic tastes
- Requirements for sensory analysis and different types of sensory tests
- Sensory panel, type, selection and training,

Unit II Sensory Assessment and methods

- Application of sensory evaluation methods to assess sensory qualities of foods including taste, texture, appearance and flavor.
- Sensory assessment of food products
- Using sensory techniques for new product development
- Subjective and objective sensory evaluation

Unit III Culinary arts

- Introduction to culinary arts and culinary history
- List of culinary (common and basic) terms,
- Culinary equipment

Unit IV Culinary science and Cooking

- Origin of modern cooking,
- Aims and objectives of cooking food,
- Principals of cooking and role of food components in culinary science
- Methods of cooking food
- Effect of cooking on culinary properties

Unit V Culinary skills

- Culinary skills
- Food ingredients and their nutritional values Culinary applications in food industry and product development

Reference Books

- 1. Lawless , Harry T, Heymann, Hildegarde, Sensory Evaluation of Food, 2010.
- 2. Vickie Vaclavik, Elizabeth W Christian, Essentials of Food Science, Kliwer Academic Publishers, 2003.
- 3. Splaver, B.R .Successful catering, Van Norstrand Reinhold, New York, II Edition.

PRACTICAL 3: Menu Planning and internship in hospital during semester 6 Credits

- 1. Calculation of nutrient requirement based on nutritional status.
- 2. Diet Therapy: Routine hospital diet, Regular diet, Light diet, Soft diet, Full liquid diet, Bland diet, Formula diets available in markets. Write suitable recipes for the above modified diets
- 3. Diet in fevers and infections Typhoid, Malaria and Tuberculosis
- 4. Diet in deficiency diseases Anaemia, vitamin A and PEM
- 5. Preparing nutrient dense -high calorie and high protein recipes and Preparing high fiber low calorie recipes
- 6. Planning diet for Obesity and underweight individuals.
- Planning and preparation of diet for –dyslipidemia, Peptic Ulcer, Hepatitis, cirrhosis, pancreatitis, Diabetes mellitus, acute renal failure, chronic renal failure, dialysis

M.Sc. Medical Statistics

Overview

JSS AHER, Department of Faculty of Life Sciences introduces an innovative career oriented program **M.Sc. Medical Statistics** with CBCS scheme, which allows for greater flexibility for the students to enhance their learning experience, The MSc in Medical Statistics is a flexible degree programme blending theoretical and applied statistical disciplines ideal for training in medical statistics, This course aims to train students from a variety of academic backgrounds to work as statisticians in various sectors.

Medical Statistics is a fundamental scientific component of health research, deals with Applications of statistics to medicine and the health sciences, including epidemiology, public health, demography and clinical research. Medical Statistics is a sub discipline of statistics. "It is the science of summarizing, collecting, presenting and interpreting data in medical practice and using them to estimate the magnitude of associations and test hypotheses". It has a central role in medical investigations.

The course is designed to cover modern statistical theory and methods providing a good foundation for research in Medical Statistics. The emphasis throughout is on applying and adapting it to real-life circumstances. The course provides opportunity to develop skills for data analysis and the individual project work provides field experience and hands-on training.

The course also aims at providing students scope for professional development in understanding and use of statistical software packages including SPSS, R, MAT-LAB and Excel, problem based learning, Introducing concepts through real examples, discussion oriented teaching.

Eligibility: Any Undergraduate Science degree recognized by UGC with Mathematics as one of the subject in second PUC or 10+2 or its equivalence.

Job Opportunities

Medical Statisticians typically work in collaboration with scientists and physicians. They may work in hospitals, in the pharmaceutical and biotech industries, market research organizations, public health and utility providers, government departments, universities and technical institution.

The key tasks a medical statistician is likely to undertake include:

- Meeting with medical researchers to identify and understand their needs.
- Selecting an appropriate study design to address the medical questions being researched.
- Selecting and applying appropriate statistical techniques for analyzing medical data.
- Analyzing and managing statistical data using a range of software packages.
- Interpreting results.
- Keeping up-to-date with new developments in medical statistics.

Medical statisticians, also called Biostatisticians, work in a variety of medical and public health fields. They conduct statistical research to advance medical knowledge, track or prevent diseases and improve medications and treatments. There are several opportunities for a student of medical statistics with good computing techniques.

Job opportunities are varied. A Statistician may:

- Consult in the design and analysis of clinical studies, evaluating new pharmaceutical agents.
- Design experiments for agricultural, ecological, environmental, or energy-related studies.
- Determine mortality, morbidity, and accident rates for an insurance company.
- Develop theories of learning and behaviour in conjunction with psychologists.
- Determine optimal combinations and evaluate performance of various chemicals in industrial setups.
- Conduct reliability and quality control studies in various industries.
- Develop econometrics, time series, and forecasting models for determining the cause and effects of various socio-economic variables on the society.

Course Curriculum

	Semester I	Remarks
Paper 1	Basic Medical Statistics	4
Paper 2	Statistical Epidemiology	4
Paper 3	Fundamentals of Mathematics	4
Paper 4	Population and Health Data Management	4
Elective 1	Statistical Computing Using Excel and SPSS	4
Practical 1	Practical –I	6
		26
	Semester II	
Paper 5	Basics of Clinical Trial	4
Paper 6	Linear Regression and Robustness	4
Paper 7	Documentation and Research Methodology	4
Paper 8	Time Series and Spatial Statistics	4
Elective 2	`Statistical Model Using `R	4
Practical 2	Practical -II	6
		26
	Semester III	
Paper 9	Generalized Linear Models	4
Paper 10	Multivariate Analysis	4
Paper 11	Survival Data Analysis	4
Paper 12	Advanced Epidemiology	4
Elective 3	Data analysis Using MATLAB	4
Practical 3	Practical -III	6
		26
	Semester IV	
	Summer Project	2
	Thesis and viva voce examination	12
	Total Credits	92

Paper1: Basic Medical Statistics 4 Credits

Course Objectives: To enhance students in order to bring in contact with the different ways in which statistics is used in medical discipline.

Course Outcomes: This introductory course gives an overview of medical staa tistics. The area covered includes types of measurement, quantitative aspects of medical decisions, sample survey methods, significance and methods of rank order. By the end of the course, the students are able to appreciate the importance of statistics in research and prepare them for a career in health care.

Unit I: The Scope of Medical Statistics

Definition and Scope of Medical Statistics, Types of Measurement : Nominal , Metric and Ordinal Scales ,Discrete and Continuous Variables, Construction of Statistical Table and Frequency Distribution, Graphical Representation of Data, Measures of Central Tendency : Mean, Median, Mode, Dispersion: Range, Quartile Deviation, Mean Deviation, Standard Deviation, Variance, Coefficient of Variation, Skewness And Kurtosis.

Unit II Quantitative Aspects of Medical Decisions: Probability

Random Experiment, Sample Space ,Event ,Trial , Outcomes ,Mutually Exclusive and Exhaustive ,Events, Independent Events, Types of Probability, Axiomatic Approach to Probability ,Application of Principles of Probability to Biological Problems, Additional Rule of Probability, Conditional Probability, Generalization of Multiplicative Law of Probability, Probability Distribution: Binomial, Poisson and Normal Distribution-Properties and simple problems

Unit III: Architecture of Medical Statistics: Sample Survey Methods

Population and Sample, Need for Sampling, Census and Sample Surveys, Sampling and Non Sampling Errors, Advantages and Disadvantages of Sampling Method, Types of Sampling Method Random Sampling: SRSWR, SRSWOR, Systematic Sampling, Stratified Sampling, Cluster Sampling, Non Probability Sampling.

Unit IV: Test of Significance

Hypothesis ,Errors, Level of Signification ,P Value ,One and Two Tailed Tests ,Critical Region Degrees of Freedom , Fisher Z Transformation and its Application ,Student t Test ,Chi-Square Test, F Test ,Relation Between t , Chi-Square F and Z Test.

Unit V: Methods based on rank order

Non Parametric Test, Kolmogorov - Smirnov One Sample And Two Sample Test, Runs Test, Wilcoxon Signed Rank Test, Mann-Whitney U Test, Median Test for Three or More Samples, Kruskal-Wallis Test and One Way and Two Way ANOVA.

- 1. Martin Bland: An Introduction to Medical Statistics, Oxford Medical Publications, 3rd Edition.
- 2. Abhaya Indrayan Sanjeev, B.Sarmukaddam: Medical Biostatistics, CRC Press Inc.Volume7.
- 3. P. Armitage and G. Berry: Statistical Methods in Medical Research, Third Edition.
- 4. Gurumani N: An Introduction to Biostatistics, MJP Publisher; 2 Editions.
- 5. Cochran W.G : Sampling Technigues, Wiley; Third edition (2007).

- 6. Murthy M.N: Sampling Thorey and Methods, Alpha Science International Ltd; 2nd Edition.
- 7. S C Gupta and V K Kapoor: Fundamental of Mathematical Statistics, Sultan Chand & Sons (2014)

Paper 2: Statistical Epidemiology 4 Credits

Course Objectives: To bring more statistical rigour to bear in the field of epideb miology.

Course Outcome: The topics covered include probability, tools of epidemiology, measures of disease-exposure association, principles of measurements; infectious disease epidemiology. At the end of the course, the student will have a greater appreciation on the role of statistics in understanding epidemiology.

Unit I: Introduction and Tools of Epidemiology

Historical aspects of Epidemiology and evolution, Definition and understanding -Natural history of disease, Tools of Epidemiology: measuring disease Frequency (Prevalence, incidence, morbidity rates and attack rates).

Unit II: The Role of Probability in Observational Studies

- Probability and the incidence proportion
- Inference based on an estimated probability
- Conditional probabilities
- Independence of two events
- Example of conditional probabilities—Berkson's bias

Unit III: Measures of Disease-Exposure Association

- Relative risk
- Odds ratio
- The odds ratio as an approximation to the relative risk
- Symmetry of roles of disease and exposure in the odds ratio
- Relative hazard
- Excess risk
- Attributable risk

Unit IV: Principles of Measurements

- Types of measures
- Reliability
- Validity
- Accuracy
- Questionnaire construction
- Diagnostic tests
- Measurement issues
- Assessing Significance in a 2x2 Table and Estimation and Inference for Measures of Association - Population-based designs, Role of hypothesis tests and interpretation of p-values

Unit V: Infectious disease Epidemiology, Chronic disease Epidemiology

- Epidemiology of policy, public health programme, Health services etc.
- Roles of Genetic and Environmental Factors in Disease Causation.

Reference Books:

- 1. Gordis L, Epidemiology, 2004, Elsevier Saunders.
- 2. Nicholas P.Jewell, Statistics for Epidemiology, CHAPMAN & HALL/CRC A CRC Press Company

Paper 3: Fundamentals of Mathematics 4 Credits

Course Objectives: To increase the student's ability in deductive reasoning and critical thinking to solve problems.

Course Outcomes: The purpose of this course is to introduce the students to basics in mathematics as relevant to medical statistics program. The students learn trigonometry, elementary mathematics, matrices, and numeral methods and vector algebra. At the end of the course; the student is well versed in the necessary mathematics components to understand the field statistics.

Unit I: Trigonometry and Analytical Geometry

Trigonometric functions, trigonometric ratios of standard angles, allied angles, compound angels Cartesian rectangular coordinate system, distance formula, section formula, straight lines, slopes, types of straight lines. Application in solving life science problems

Unit II: Elementary Mathematics

Solutions of simultaneous linear equations, quadratic equations, progressions, permutations and combinations,

Unit III: Matrices & Determinants

Introduction to Matrix, Transpose of a Matrix, Elementary row and column operations of Matrix, determinants, Properties of determinants (Without Proof) Rank of a Matrix, Minor and Co-factors Inverse of a matrix.

Unit IV: Numerical Method

Gauss Jordan, Jacobi and Gauss sidle methods, Newton-Raphson method. Transcendental function- Logarithmic and exponential functions, Application in solving Biological science problems

Unit V: Vector Algebra

Definition, Types of Vectors, two and three dimensional vectors, Scalar (dot) and Vector (cross) product . Application in solving Biological science problems

- 1. T.B : SCHAUM Series books of calculus , vectors, statistics & matrices
- Pharmaceutical Mathematics with Application to Pharmacy PharmMed Press, A Unit of BSP Books Pvt Ltd, 4-4-309/316, Giriraj Lane, Sultan Bazar, Hyderabad – 500 095 - Panchaksharappa Gowda D.H.
- 3. Introduction to Mathematics for life scientist Publisher- Springer (India)

Pvt. Ltd- Edward Batschelet Paper 4: Population and Health Data Management 4 credits

Course Objectives: To enable students to demonstrate knowledge in the use of statistics in interpreting population and health data.

Course Outcomes: The course highlights the importance of statistics in population and health data management. The students are taught demography and measures of population, vital statistics, life table, population growth models and development statistics.

Unit I: Demography and Measures of population:

Introduction to demographic data: Census, vital events, registration, survey, Application of Demography, Static Demography, Dynamic Demography, Collection of Demographic Data, Measures of population, Growth of population ,Population Density, population distribution by age and Sex in India.

Unit II: Vital Statistics:

Basic concept of Vital Statistics, Uses and Advantages of Vital Statistics, Application, Measures of Vital Statistics, Measures of fertility, Fertility rates, Reproduction rate, Measures of Martial Status, Measures Of Morbidity, Measures of Mortality, Crude Death rate ,Standardized death rates, Specific Death rates, Monitoring of Family Planning Programme .

Unit III: Life Table:

Basic Concept and Definition of a life table, construction of a life table, types of life table ,Basic Assumptions for preparing a life table, Uses and Application of Life Table, Force of Mortality and Expectation of life, Population projection using logistic curve.

Unit IV Population growth models:

Models for population growth: exponential, logistic, Gompertz models, Deterministic models, birth and death processes, logistic growth, Competition between populations, growth rate, stable population analysis, population projection by component method and using Leslie matrix.

Unit V: National income and Development statistics:

Estimation of National Income - product approach, income approach and expenditure approach. Population growth in developing and developed countries, basic concept of National income –GNP,GDP, Uses of National income, problems in estimating National income, Methods of estimating National income, CSO,NSSO and Its activities, National accounts statistics of CSO, Measuring inequality of incomes, Gini coefficient.

- 1. Mahajan B.K.: Methods in Biostatistics,7th edition.
- 2. Spiegelman H: Introduction to demography, Harvard University press.
- 3. UNESCO: Principles of Vital Statistics Systems, Series M-12.
- 4. Keyfitz, N. Mathematical Demography
- 5. Pollard, J.H.: Mathematical Models for the growth or human population, Cambridge University press.

Elective1: Statistical computing using Excel and SPSS 4 credits

Course Objectives: To enhance students' ability to use software, computer simulations and statistical techniques to find solutions to problems arising in planning and decision-making.

Course Outcomes: Students in this course study a wide variety of statistical and graphical techniques, including linear and nonlinear modelling, classical statistical tests. The course will impart training to students who seek to acquire and refine their skills relating to data analysis and manipulation.

Unit I: Introduction to Excel

Workbooks and Worksheets, Cell Addresses, Entering and Editing Data, Savings Files, Importing/Accessing Data, Mathematical Operators in Excel, Creating Formulas and Functions, Data Analysis ToolPak: Installing the Analysis ToolPak, Using the Analysis ToolPak, Practice Problems.

Unit II: Creating Tables, Charts and Descriptive Statistics Using Excel Functions

Creating and Formatting Tables, Frequency Distribution Tables, Histograms and Bar Charts, Pie Chart, Scatter Diagram, Descriptive Statistics Using Excel Functions, Practice Problems.

Unit III: Statistical Functions in Excel Analysis Tool Pak

Creating an XY Plot of Data, Using The Regression Function to Fit a Straight Line, Correlation, ANOVA, t-Test and F Test.

Unit IV: SPSS For Windows: An Introduction

Overview and Scope of SPSS, Starting SPSS, Typing in Data, Loading Data, Starting SPSS for Windows, Entering Data, Importing a File ,Defining The Variables, Missing Values, Saving Your Data, Help, Exiting SPSS.

Unit V: Writing / Performing Programs Using SPSS On Problems From The

Following Topics: Frequencies, Bar Chart, Pie chart, Box plot, Descriptive Statistics, One and Two Sample Parametric and Nonparametric Tests, Chi-Square Tests, Regression and Correlation Analysis, Analysis of Variance and Kruskal-Wallis Test.

- 1. Essentials Of Biostatistics Workbook Statistical Computing Using Excel: By Lisa M.Sullivan (Second Edition)
- 2. An Introduction To Statistics Using Microsoft Excel: By Dan Remenyi George Onofrei Joe English
- 3. Practical Statistics Using SPSS Authors Nicola Spiers, Brad Manktelow, Michael J. Hewitt
- 4. A Handbook Of Statistical Analyses Using SPSS By Sabine Landau And Brian S. Everitt

SEMESTER II

Paper 5: Basics of Clinical Trial 4 credits

Course Objectives: To provide necessary statistical background for designed to test a hypothesis about a treatment and prospective experiments in medical treatments.

Course Outcomes: The students in this course are introduced to the basics in designing experiments for clinical trials, alternative trial designs, designing studies of medical tests, addressing ethical issues and classification of clinical trials. The student after completion of the course will be well versed in all aspects involved in the design, implementation and execution of a successful clinical trial.

Unit I: Designing an Experiment: Clinical Trials

Selecting the participants, Measuring Baseline variables, Applying the interventions, Follow-up and adherence to the protocol, measuring the outcomes, analyzing the results, Alternatives to the randomized blinded trials

Randomization in Clinical Trials

Definition, Types of bias in randomization, Selection bias, Accidental bias Fixed allocation randomization

- Simple randomization
- Block randomization
- Stratified randomization

Adaptive randomization

- Biased coin method
- Baseline adaptive (minimization)
- Outcome adaptive

Unit II: Alternative Trial Designs and Implementation Issues

Factorial design, Group or Cluster Randomization, Non-Randomized Between-Group designs, Within – Group designs (Time series and Cross – Over), Trial for regulatory approval of New interventions, Pilot Clinical trial, Conducting a clinical trial – Follow-up and Adherence to the Protocol, Adjudicating outcomes, Adaptive design, Analyzing the results

Unit III: Designing Studies of Medical Tests

Determining whether a test is useful , Studies of test reproducibility ,Studies of the accuracy of tests ,Studies of the effect of test results on clinical decisions ,Studies of feasibility, costs and risks of tests, Studies of the effect of testing on outcomes ,Pitfalls in the design or analysis of diagnostic test studies

Unit IV: Addressing Ethical Issues

Ethical Principles, Additional Protection for Research Participants, Responsibilities of Investigators, Ethical Issues specific to certain types of research, other issues **Unit V: Classification of Clinical Trials:** Phase-I, Phase-II, Phase-III and Phase – IV, Sample size determination for Phase-I, Phase-II, Phase-III and Phase-IV Clinical Trials. Bioavailability and Bioequivalence Studies

Reference Books:

1. Designing Clinical Research – Third Edition – Stephen B.Hulley Pub: Lip-

pincott Williams and Wilkings, a Wolters Kluwer business, 530 Walnut Street, Philadelphia, PA 19106 USA, LWW.com

2. Introductory Biostatistics - CHAP T.LE - PUBLISHED BY John Wiley and Sons, Inc., Hoboken, New Jerse

Paper 6: Linear Regression and Robustness 4 credits

Course Objectives: To prove basic linear model theory, multiple linear regressions models and apply methods of robust regression and interpret the models.

Course Outcomes: In this course, students study linear regression, multiple regression, logistic regression, non-linear regression and robust regression. By the end of the course the students will be able to demonstrate the role of regression in the identification and characterization of relationships among multiple factors in medical data.

Unit I: Simple linear regression:

assumptions, inference related to regression parameters, standard error of prediction, tests on intercepts and slopes, extrapolation, diagnostic checks and correction: graphical techniques, tests for normality, uncorrelatedness, homoscedasticity, lack-of-fit testing, polynomial regression, transformations on Y or X (Box-Cox, square root, log etc.), method of weighted least squares, inverse regression.

Unit II: Multiple regressions:

definition, general purpose of Multiple regression ,examples, multiple regression model, assumption of Multiple regression, application of Multiple regression analysis, estimation, testing linear hypothesis, confidence interval, confidence region, prediction of new observations, prediction interval, Polynomial regression in one variable, use of orthogonal polynomials, use of dummy variables, Introduction to non-linear models.

Unit III: Logistic Regression:

Explanation, types of Logistic Regression, Logit transformation, ML estimation, Tests of hypotheses, Wald test, LR test, multiple logistic regression, forward, backward method, interpretation of parameters, relation with categorical data analysis, multicollinearity.

Unit IV: Non Linear Regression (NLS):

main features of nonlinear regression, Non Linear equation, comparison of linear and Non Linear Regression. Linearization transforms, their uses & limitations, examination of non-linearity, iterative procedures for NLS, Newton-Raphson, Marquardt's methods, Additive regression models, Introduction to nonparametric regression methods.

Unit V: Robust regression:

Influential observations, outliers, methods of detection of outliers and influential observations, M-estimators: Median, Trimmed and winsorized mean. Influence curve for M-estimators, Robust regression with rank residuals, Resampling procedures for regression models, methods and its properties (without proof), Jackknife techniques and least squares approach based on M-estimators.

Reference Books:

- 1. Lehmann. E and Romano, J. P.(2010). Testing Statistical Hypotheses, Springer
- 2. Kendall, M. G. & Stewart, A. The Advanced Theory of Statistics, Vol. 2
- 3. Mood, A. M & Gray bill, F. A.(2009). Introduction to the theory of statistics, Tata Mc GrawHill
- 4. Rao, C. R(2002). Linear Statistical Inference and its Applications, John Wley & Sons, Newyork
- 5. Siegal.(). Nonparametric methods
- 6. Zacks, S. (1971). Theory of Statistical Inference (Probability & Mathematical Statistics), John Wiley & Sons.
- 7. Huber, P. J. and Ronchetti, E. M (2011) Robust Statistics, Wiley, 2nd Edition.

Paper 7: Documentation and Research Methodology 4 Credits

Course Objectives: To enable students to develop and understanding of basic concepts of research and research process

Course Outcomes: The outline of the course is to introduce the students to research methodology, precision and accuracy, cohort studies and quality control. At the end of the course the students will be able to apply their learning to design experiments, meeting the international guidelines..

Unit I: Introduction to Research:

Need for Research, Designing the methodology, Protocol Writing, Report Writing and Presentation of data, Sample size determination and Power of study

Unit II: Getting Started: The Anatomy and Physiology of Research

What it is made of, How it works, Designing the study,

Conceiving the Research Question: Origins of a research question, Characteristics of a good research question, Developing the research question and study plan, Choosing Study Subjects: Basic terms and concepts, Selection criteria, Sampling, Recruitment of study subjects

Unit III: Planning the Measurements: Precision and Accuracy

Measurement scales, Precision, Accuracy, Other features of measurement approaches,

Measurements on stored materials

Case Study: Types of case studies, Design and Analysis of study

Unit IV: Designing a Cohort Studies

Prospective cohort studies, Retrospective cohort studies, Nested Case-Control and Case-Cohort studies, Multiple-cohort studies and External Controls , Planning a cohort study

Designing an Observational Study: Cross sectional studies, Case control studies, Choosing among observational designs, Enhancing Causal Inference in Observational Studies: Spurious associations, Real associations other than cause effect, coping with confounders in the design phase, coping with confounders in the analysis phase.

Unit V: Unit 5: Implementing the Study and Quality Control

Assembling Resources - Space, Research team, Leadership and Team- Building, Institutional Review Board Approval, Operational Manual and Forms Development, Database Design,

Finalizing The Protocol: Pre-test and Pilot Studies, Substantive Protocol Revision once Data Collection has begun, Quality Control During The study : Good Clinical Practice, Quality Control for Clinical Procedures, Quality Control for Laboratory Procedures, Quality Control for Data Management,

Reference Books:

- 1. Designing Clinical Research Third Edition Stephen B. Hulley. Pub: Lippincott Williams and Walking's, a Wolters Kluwer business, 530. Walnut Street, Philadelphia.USA.
- 2. Introductory Biostatistics CHAP T. LE Published by John Wiley and Sons, Inc., Hoboken. New Jersey

Paper 8: Time Series and Spatial Statistics 4 credits

Course Objectives: To enable students to understand the basic concepts of time series and Spatial statistics.

Course Outcomes: Students in this course study the components of time series, stationary processes and spectral analysis. Students upon completion of this course will be able to apply this knowledge in spatial statistics.

Unit I: Components of time series, additive and multiplicative models, measurement of trend by moving averages and by least squares, Time series as discrete parameter stochastic process, auto-covariance and auto-correlation functions and, their properties, Partial autocorrelation function, Exploratory time series analysis, test for trend and seasonality.

Unit II: Detailed study of the stationary processes: Autoregressive(AR), Moving Average(MA), Autoregressive Moving Average, ACF and PACF plots of these processes, Non-stationary time Series models: ARIMA and Seasonal ARIMA Models.

Unit III: Estimation of mean, auto covariance and autocorrelation functions under large sample theory (statement only). Choice of AR and MA periods, Estimation for ARIMA model parameters

Unit IV: Spectral analysis of weakly stationary process, Periodogram and correlogram Analyses, Spectral decomposition of weakly AR process and representation as a one sided MA process – necessary and sufficient conditions, Implication of spectral decomposition in prediction problems

Unit V: Basic concept and definition of spatial statistics, spatial statistics in current use and application of spatial statistics, Spatial statistical techniques: point pattern data, spatially continuous data, area data and interaction data, modelling spatial data: Basic concepts, statistical models, hypothesis testing, spatial data modelling, parameter estimation, geographically weighted regression, Software for spatial statistics
Reference Books:

- 1. Abraham, B and Ledolter, J.C(1983). Statistical Methods for Forecasting, Wiley
- 2. Box, G. E. P. and Jenkins, G. M(1970). Time Series Analysis, Forecasting and Control Holden-Day.
- 3. Brockwell, P. J and Davis, R.A(1987), Time Series. Theory and Methods, Springler-Verlag
- 4. Bailey .T.C and Gatrell, A.C.(1995) Interactive spatial data analysis. Longman, Harlow
- 5. Anderson, T. W(1971). Statistical Analysis of Time Series, Wiley
- 6. Fuller, W. A(1978). Introduction to Statistical Time Series, John Wiley.
- 7. Kendall, M. G(1978). Time Series, Charler Graffin
- 8. Tanaka, K(1996). Time Series Analysis, Wiley Series

Elective 2: Statistical Model Using `R 4 Credits

Course Objectives: To train the students to use R tools to fit the models and interpret the R output in both theoretical and practical aspects

Course Outcomes: Students in this course study a wide variety of statistical and graphical techniques, including linear and nonlinear modelling; classical statistical tests. The course will impart training to students to use the statistical software package R to fit statistical models.

Unit I: Introduction to statistical software R:

Downloading and Installing R, Essentials, Advantages and objects, Functions and arguments, Manipulating vectors, Factors, Matrix operations: addition, subtraction, multiplication, Lists, Importing of files, Data frame, Getting Help: The functions help(), help.search() and example().

Unit II: Descriptive statistics and Graphics in R:

Measure of central tendency and measure of dispersion (Mean, median, standard deviation, variance, quartiles, fivenum summary), Measure of skewness and kurtosis, R-Graphics- Bar Graph, Pie chart, Box-plot, Stem and leaf plot and Histogram,

Unit III: Introduction to Probability and Probability Distribution using R functions:

Sample spaces, Events, Set Union, Intersection, and Difference, Basic probability problems in R, Conditional probability, Fitting of distributions to given data with R –Binomial distribution, Poisson distribution and Normal distribution, Simulation from discrete and continuous distribution.

Unit IV: Using R functions for standard statistical tests and Programming in R:

One and two sample t-tests, Chi-squared tests, F- test for equality of variance and non-parametric test, Kruskal-Wallis Test, Programming in R: for/while/loops.

Unit V: R functions in Liner modeling:

Correlation, correlation coefficient, Simple linear regression, multiple linear regressions, Logistic regression, one way ANOVA and two way ANOVA.

Reference Books:

- 1. Purohit S.G., Gore,S.D. and Deshmukh,S.R.(2008) Statistics Using R, Alpha Science.
- 2. Peter Dalgaard: Introductory statistics for R ,Springer.
- 3. Statistical Methods Using R Software : V. R. Pawagi and Saroj A. Ranade
- 4. Verzani, J. (2005). Using R for Introductory Statistics, Chapman and Hall, London.
- 5. Introduction to Probability, and Statistics Using R,G. Jay Kerns, First Edition

Paper 9: Generalized linear models 4 Credits

Course Objectives: Able to perform statistical modelling of relationships between continuous and categorical variables with an emphasis on practical and theoretical considerations

Course Outcomes: Understand the foundation theory of Generalised Linear Models. Summarise data with an appropriate statistical model. Use models to describe the relationship between a response and a set of explanatory variables. Interpret the results of the modelling.

Unit I: Basic concept and definition of generalized linear models, Assumptions of Generalized linear models, Concept of estimability, linear estimation: Gauss-Markov model, Least squares estimation, Distributional properties of least squares estimators, Gauss-Markov theorem.

Unit II: BLUE, Variances and covariance's of BLUEs, Error space, Estimation space, Tests of hypothesis in general linear models, ML estimation of parameters, Likelihood ratio tests for various hypotheses including independence, Marginal and conditional independence.

Unit III: Analysis of binary and grouped data by using logistic models, large sample tests about parameters, Goodness of fit, analysis of deviance, Variable selection, Introduction to poisson regression, Generalized Linear model: link functions such as Poisson, binomial, inverse binomial, inverse Gaussian.

Unit IV: The Generalized Linear Mixed Model, including both fixed and random effects, Log linear model for two and three dimensional contingency tables, Interpretation of parameters, comparison with ANOVA and regression.

Unit V: Family of Generalized Linear Models: Exponential family of distributions, Formal structure for the class of GLMs, Likelihood equations, quasi likelihood, Link functions, important distributions for GLMs, Power class link function.

Reference Books:

- 1. Searle, S.R.(1971): Linear Models, John Wiley.
- 2. Alvin C. Rencher (2000): Linear Models in Statistics, John Wiley & Sons, New York
- 3. Guttman, I (1982): Linear Models An Introduction , John Wiley
- 4. Dobson A J and Barnett A G, An Introduction to Generalized Linear Models, Chapman and Hall. (3rd Edition) 2008.
- 5. Lindsey J K, Applying Generalized Linear models, Springer, 1997.

6. McCullagh P and Nelder J A, Generalized Linear Models, Chapman and Hall, (2nd Edition), 1989.

Paper10: Multivariate Analysis 4 Credits

Course Objectives: Provide students to identify and apply the multivariate statistical techniques in health research.

Course Outcomes: Students in this course learn principle component analysis, clustering, applications in test on mean vectors and MANOVA to understand the assumptions underlying their use, and appreciate the strengths and limitations of these methods. Knowledge of these methods is particularly helpful for gaining employment in statistical consulting.

Unit I. Multivariate Data in Biological Sciences, Examples, Multivariate Normal Distribution, Maximum Likelihood Estimators of Parameters, Multivariate Linear Regression Model, Estimation of Parameters, Testing Linear Hypothesis about Regression Co-Efficients.

Unit II. Principal Component Analysis, Factor Analysis –Orthogonal Factor Model, Factor Loadings, Estimation Factor Loadings, Factor Scores, Applications, Canonical Correlations and Canonical Variable - Definition, Use, Estimation and Computation.

Unit III. Classification and Clustering, Linear Discrimination, Classification Trees, Hierarchical Clustering, K-Means Clustering, Multidimensional Scaling.

Unit IV: Application in Test on Mean Vectors for Single and Several Multivariate Normal Populations, Hotelling's T2 -Statistic and its Distribution, Relationship with Mahalanobis D2 Statistic, Applications of Hotelling's T 2-Statistic.

Unit V: Methods and Applications of MANOVA, Structural Equation Modelling and Path Analysis.

Reference Books:

- 1. Anderson, T. W.(1984) Introduction to Multivariate Analysis (John Wiley)
- 2. Kshirsagar, A. M. (1983) Multivariate Analysis (Marcel Dekker)
- 3. Morrison, D.F.(1990) Multivariate Statistical Methods (McGraw Hill Co.)(3rd ed.)
- 4. Rao, C. R.(1995) Linear Statistical Inference and its Applications. (Wiley Eastern Ltd.)
- 5. Johnson R.A. & Wichern, D.W. (1988) Applied Multivariate Statistical Analysis
- 6. H["]ardle, W. and Simar, L. (2003). Applied Multivariate Statistical Analysis. Springer.
- 7. Mardia, K.V., Kent, J.T. and Bibby, J.M. (1979). Multivariate Analysis. Academic Press.

Paper 11: Survival Data Analysis 4 Credits

Course Objectives: Recognize or describe the type of problem addressed by a survival analysis.

Course Outcomes: Describe survival data, and the roles played by censoring, and survival and hazard functions. Graph survival data, and the Kaplan - Meier curve. Specify and fit the Cox Proportional Hazards model, define and interpret a survivor function and a hazard function, and describe their relation

Unit I: Introduction, Basic functions and models. Censoring and Truncation, Parametric univariate estimation: Exponential, extreme value, gamma, Pareto, logistic, normal and log – normal, Survival function, hazard rate, cumulative hazard function, and mean residual life. Censoring mechanisms: type I, type II and random censoring.

Unit II: Nonparametric univariate estimation: Actuarial, Kaplan-Meier and Nelson-Aalen Estimators, Tests of equality of survival functions: Gehan's and Mantel-Haenszel tests. Treatment of ties(Peto's method).

Unit III: Semi parametric regression models: Cox proportional hazard model-estimation, tests, Diagnostics. Graphical methods: Hazard plots and Survival plots, Regression for grouped data: Life table, logistic and proportional hazards approaches.

Unit IV: Additive Models. Accelerated Models, Competing Risk and Multivariate Survival models, Frailty Models. Ageing classes - IFR, IFRA, NBU, NBUE, HNBUE .

Unit V: understand Cox PHM, estimate coefficients from first principles on computer, test equality of coefficients using the likelihood-ratio(LR) test, fit model and do LR test on a computer.

Reference Books:

- 1. R.G.Miller : Survival Analysis
- 2. P.J.Smith : Analysis of Failure and Survival Data
- 3. J.D.Kalbfleisch&R.L.Prentiice: The Statistical Analysis of Failure Time Data, 2nded.
- 4. J.P.Klein&M.L.Moeschberger: Survival Analysis : Techniques for Censored and Truncated Data
- 5. D.J.Kleinbaum and M.Klein: Survival Analysis A Self-Learning Text

Paper 12: Advanced Epidemiology 4 Credits

Course Objectives: To enhance students in interpreting and assessing the evidence quality of a range of study designs and to apply appropriate statistical techniques in the analysis of public health data.

Course Outcomes: The aim of the course is to provide in-depth expertise in epidemiologic methods across different topics like infectious and chronic disease and for diverse population. Students after successful completion of this course will be able to Design and interpret epidemiological studies.

Unit I: Experimental studies and Qualitative research

Experimental Studies -The Randomized Control trial, Allocation alternative, Maneuver, Measurement including blinding, Compliance, contamination, co intervention, adverse events, Stopping rules, Analysis, Diagnostic tests, Measurement issues, Qualitative research - Mixed designs, Ecological Studies, Space time cluster studies, Familial aggregation studies

Unit II: Regression Models Relating Exposure to Disease

- Some introductory regression models -The linear model Pros and cons of the linear model
- The log linear model The probit model The simple logistic regression model

Unit III: Estimation of Logistic Regression Model Parameters

- The likelihood function
- The likelihood function based on a logistic regression model
- Properties of the log likelihood function and the maximum likelihood estimate
- Null hypotheses that specify more than one regression coefficient
- Logistic regression with case-control data
- Confounding and Interaction within Logistic Regression Models
- Assessment of confounding using logistic regression models
- Introducing interaction into the multiple logistic regression model
- Collinearity and centering variables

Unit IV: Matched Studies

- Frequency matching
- Pair matching
- Mantel-Haenszel techniques applied to pair-matched data
- Small sample adjustment for odds ratio estimator
- Confounding and interaction effects
- Assessing interaction effects of matching variables
- Possible confounding and interactive effects due to nonmatching variables
- The logistic regression model for matched data

Unit V: Alternatives and Extensions to the Logistic Regression Model

- Flexible regression model
- Beyond binary outcomes and independent observations
- Introducing general risk factors into formulation of the relative hazard—the Cox model
- Fitting the Cox regression model
- When does time at risk confound an exposure-disease relationship?
- Time-dependent exposures
- Differential loss to follow-up

Reference Books:

- 1. Gordis L, Epidemiology, 2004, Elsevier Saunders.
- 2. Nicholas P. Jewell, Statistics for Epidemiology, CHAPMAN & HALL/CRC A CRC Press Company.

Elective 3: Data Analysis Using MATLAB 4 Credits

Course Objectives: Provides hands-on experience for performing statistical data analysis with MATLAB.

Course Outcomes: This course explores the use of the MATLAB software in data analysis. The students in this course are taught graphics, descriptive statistics, linear algebra and lineal methods, modeling. Upon successful completion of this course, the students will be able to demonstrate their skills in applying the MATLAB software to address a variety of biomedical problems that involve large volumes of data.

Unit I: Introduction to MATLAB

What is MATLAB, Advantages and Disadvantages, MATLAB Key Features, Getting Help in MATLAB, Importing and Exporting Data, Desktop Basics, Arithmetic Operations: Addition, Multiplication, Division, Powers, Log, Trigonometry, Exponential and Functions, Variables in MATLAB.

Unit II: MATLAB Graphics

2-D Plots And 3-D Plots, Formatting and Annotation ,Images ,Printing and Savings, Line Plots :Syntax, Description ,Examples ,Plot Multiple Lines ,Create Line Plot From Matrix ,Specify Line Style ,Colour and, Line Width ,Larker Size ,Marker Color, Add Title and Axis Labels, Plot Circle, Plotting

Unit III: Descriptive Statistics and Distribution

Functions for Calculating and Plotting Descriptive Statistics: Maximum, Minimum, Mean, Median, Mode, Standard Deviation, Variance and Statistics On Plots, Basic Visualization: Bar Diagram And Histogram, MATLAB Commands for Discrete Distribution and Continuous Distribution, Introduction to Simulation Using MATLAB.

Unit IV: Linear Algebra and Linear Methods.

About Matrices, Entering Matrices, Basics Matrix Operation: Matrix Addition and Scalar Multiplication, Matrix Multiplication, Matrix Algebra ,Matrix Inverses ,Powers

of a Matrix, The Transpose and Symmetric Matrices, Cross Product, Dot Product, System of Linear Equations, Inverse and Determinants, Eigen Values.

Unit V: Modelling Data

Linear Correlation, Correlation Co-Efficient, Linear Regression: Simple Linear Regression, Fitting Data with Cure Fitting Toolbox, Multivariate Data, M-Files, Parametric and Non Parametric Test.

Reference Books:

- 1. Understanding MATLAB by S.N. Alam (Author), S.S. Alam
- 2. Statistics in MATLAB: A Primer by MoonJung Cho, Wendy L. Martinez
- 3. Computational Statistics Handbook with MATLAB, Second Edition, Wendy L. Martinez, Angel R. Martinez

Semester IV

Summer project Thesis and viva vice examination M.Sc. BIOINFORMATICS 2 Credits 12 Credits

Course Overview

Objective

To have better understanding to correlate the fundamentals and advance concepts in biology, mathematics, pharmaceutics, medicine computationally.

Curriculum

The study of PG course of bioinformatics includes the areas of development of new computational methods for studying Organization and Evolution of Genes and Genomes, computational approaches to Macromolecular structure, dynamics and simulation, Comparative Evolutionary Genomics, Drug design and Discovery, Pharmacogenomics, Algorithm Development, Data base Development, Sequence Analysis, Data Mining, Prediction and Analysis of structure etc.

Course Description

The Course extends for a period of two years under Semester Pattern (Four semesters). The Program has been designed in a way to make the students understand the basic and fundamental concepts in bioinformatics and their kind of application in biological issues. Pharmaceutical and medical bioinformatics is a new discipline in the area of the genomics revolution. It is central to biomedicine with application in areas like pharmacy, medicine, biology and medicinal chemistry.

Outcome

The distinctiveness of the program is that every student can face the biological issues systematically.

Eligibility

A graduate in Science (B.Sc.) from an UGC recognized University with biology as a major subject.

Career opportunities

Graduates acquire a wide range of subject specific and transferable skills and gain extensive research experience. Around half of each class enrolls for PhD positions after the M.Sc., whilst others build upon their training to enter careers in biology and IT. The combination of Systems Biology and Bioinformatics addressed in this course reflects the current skills sought in academic and industrial (e.g. pharmaceutical) settings.

	Semester I	Credits				
Paper 1	Fundamentals of Biostatistics	4				
	Fundamentals of Computers and					
Paper 2	Programming Languages	4				
Paper 3	Biomolecules	4				
Paper 4	Molecular Biology for Bioinformatics	4				
Elective 1	Statistical computing using Excel and SPSS	4				
Practical 1	al 1 (Practical 1)					
		26				
	Semester II					
Paper 5	Protein structure and function	4				
Paper 6	Multivariate Techniques and Big Data Analytics	4				
Paper 7	PERL for Bioinformatics	4				
Paper 8	System Biology	4				
Elective 2	2(a)Molecular statistical model using 'R' Or 2(b)Object-Oriented Programming and Database Management	4				
Practical 2	Combination of all the above (Practical 2)	6				
	Semester III					
Paper 9	PYTHON for Bioinformatics	4				
Paper 10	Structural Bioinformatics	4				
Paper 11	CADD (Drug Designing)	4				
Paper 12	Immunoinformatics	4				
Elective 3	Bioinformatics tools in MatLab	4				
Practical 3	Combination of all the above (Practical 3)	6				
		26				
	Summer Project	2				
	Thesis and viva voce examination	12				
		14				
	Total Credits	92				

M.Sc. BIOINFORMATICS

SEMESTER I

PAPER 1: FUNDAMENTALS OF BIOSTATISTICS 4 CREDITS

Objectives:

- It provides an introduction to selected important topics in bio-statistical concepts and reasoning.
- This course represents an introduction to the field of data and data types.

Outcome:

- The students learn specific topics including tools for describing central tendency and variability in data;
- Statistical hypothesis testing and its application to group comparisons; issues of power and sample size in study designs; and random sample and other study types.

Unit I:

Introduction to Biostatistics- Definition of Biostatistics, Aims of Bio-Statistics, Role of Biostatistics in Modern research, Brief History, Limitations of Statistical Methods, Application and Uses of Biostatistics, Descriptive and Inferential Biostatistics .

Unit-II:

Representation of Bio- Metric Data- Types of Variables – Continuous, Discrete, Dependent and Independent Variables, Scales Of Measurements - Nominal, Ordinal, Interval And Ratio Scales, Frequency Distributions, Class Intervals, Working Rule To Prepare a Frequency Table, Pie Chart ,Bar Chart, Stem And Leaf, Dot Diagram, and Histogram, Measures of Central Tendency – Mean, Median and Mode, Measures of Variability – Standard Deviation and Variance, Coefficient of Variance.

Unit-III:

Probability- Trial, Event, Sample Space, Definition Of Probability, Mutually Exclusive Events, Independent Event, Laws Of Probability-Simple Problems, Binomial Distribution ,Poisson Distribution and Normal Distribution: Properties-Problems.

Unit-IV:

Fundamentals of Testing Of Hypotheses - Null and Alternate Hypotheses, Type I and Type II Errors, Tests Of Significance, Parametric And Non-Parametric Tests, Level Of Significance and Power Of The Test, 'P' Value And Its Interpretation, Statistical Significance And Clinical Significance, 'Z' Test, Student's 't' Test: Paired and unpaired, 'F' Test

Unit-V:

Analysis of Categorical Data- Analysis Of Variance-Introduction, Definition Of ANOVA, Assumption, Types Of ANOVA, Construction Of One Way And Two Way ANOVA ,Correlation , Types Of Correlation, Karl Pearson's Correlation Coefficient, Regression , The Method Of Least Squares, The Regression Of X On Y, Wilcoxon Test, Mann-Whitney U Test,

Reference:

- 1. An Introduction to Biostatistics: Gurumani N.
- 2. Fundamentals of Biostatistics: Veer Bala Rastogi
- 3. Biostatistics: Vinod kumar Bais
- 4. Fundamental of Mathematical Statistics: S C Gupta and V K Kapoor
- 5. Medical Biostatistics: Abhaya Indrayan Sanjeev B.Sarmukaddam

PAPER 2: FUNDAMENTALS OF COMPUTERS AND

PROGRAMMING LANGUAGES 4 CREDITS

Objectives:

- Students will demonstrate the ability to extend current knowledge and/ or skills to a computing environment or problem currently unknown to the student.
- Students will demonstrate the ability to solve problems in the discipline.
- Outcome:
- Upon successful completion of a basic in computer sciences, students will be able to: Demonstrate proficiency in problem-solving techniques using the computer. Demonstrate proficiency in at least basics of tools in computer science, two programming languages and experts' operating systems.

Unit – I:

Operating System Concepts and Linux Environment Introduction to O.S., types of O.S., O.S services, system calls, system components, system structures, virtual machines. Linux: Introduction to Linux, basic commands (Navigation and Directory Control Commands. File Maintenance Commands, Display Commands, Print Commands etc), working with the files, file attributes, pipes, wildcards, working with processes working with basic editors (vi, emacs). Basic regular expressions, string search applications using regular expressions.

Unit – II:

Computer Environment Introduction: What is a grid? -Infrastructure of hardware and software -Main Projects and Applications –The Open Grid Forum -International Grid Trust Federation. Grid Architecture - Overview of Resource Managers - Overview of Grid Systems - Application Management : Grid Application Description Languages –Application Partitioning -Meta-scheduling –Mapping – Monitoring - Web Services - Grid Portals - Clouds.Cluster computing at a glance – cluster classifications- cluster middleware – cluster applications – cluster setup and administration – multi path communication – distributed shared memory - representative cluster system: Biowulf – RWC PC cluster II- Parallel Processing on Linux Clusters. Java for HPC: java and different flavors of parallel programming models. HPC program optimization. API. Remote Desktop in Windows and linux operating systems.

Unit – III:

Awk / Shell Scripting Fundamentals Execution, Fields and Records, Scripts, Operations, Patterns, Actions, Associative Arrays, String Functions, String Functions, Mathematical Functions, User – Defined Functions, Using System commands in awk, Applications, awk and grep, sed and awk.Unix Session, Standard Streams, Redirection, Pipes, Tee Command, Command Execution, Command-Line Editing, Quotes, Command Substitution, Job Control, Aliases, Variables, Predefined Variables, Options, Shell/Environment Customization.

Unit – IV:

Introduction to Perl And Python An overview of Perl: Getting started, Statement blocks, ASCII, Unicode, Escape sequences, White spaces, Numerical data types, strings in Perl. Operators, Variables: special variables, regex (regular expression) variables, Input/output variables, Filehandle variables, error and system variables. Perl statements, Introduction to statements, Types - Input/Output statements, conditional statements, looping, andjumping statements. Python : Simple values – Booleans, Integers, Floats and Strings, Expressions – Numerical operators, Logical Operations, String Operations, Names, Functions and Modules – Assigning Names, Defining the functions – Function parameters, Comments and Documentation, Assertions, Default parameter values, Using Modules – Importing, Python Files.

Unit – V:

Introduction to R and MATlab Overview of the R language: Defining the R project, Obtaining R, Generating R codes, Scripts, Text editors for R, Graphical User Interfaces (GUIs) for R, Packages. R Objects and data structures: Variable classes, Vectors and matrices, Data frames and lists, Data sets included in R packages, Summarizing and exploring data, Reading data from external files, Storing data to external files, Creating and storing R workspaces. Manipulating objects in R: Mathematical operations, Basic matrix computation, Textual operations, Basic graphics. Introduction to MATLab and molecular forces; Bioinformatics ToolBox, Statistics ToolBox, Distributed computing server, Signal Processing ToolBox. The Matlab working environment.Variables, constants and reserved words. Arrays and matrices. Scripts. The debugger. Generating 2D and 3D Graphics. Simple statistical analysis. String manipulation. Boolean logic and if statements. Loops (while, for). Functions & Files. Program design. MATlab structures. Complexity.

References:

- 1. RajkumarBuyya, "High Performance Cluster Computing: Programming and Applications", Prentice Hall, 1999.
- 2. James D. Tisdall, "Beginning Perl for Bioinformatics", O'Reilly, 2001.
- 3. Unix and shell Programming Behrouz A. Forouzan, Richard F. Gilberg. Thomson
- 4. Michael J Quinn, "Parallel programming in C with MPI and OpenMP", Tata McGraw-Hill, 2003
- 5. Ahmar Abbas, "Grid Computing: A Practical Guide to Technology and Applications", Charles River Media, 2003.
- 6. Kevin Dowd, "High Performance Computing", O'Reilly, 1993.
- 7. Computer programming with C by E, Balaguruswamy.
- 8. Elements of Statistics by Gupta.

PAPER 3: BIOMOLECULES 4 CREDITS

Objectives:

• The course leads to the understanding of procedures that have been developed to exploit our knowledge of the replication and expression of genetic information.

Outcome:

- The paper helps the students to understand the processes involved to identify, isolate, amplify, analyze and express virtually any genetic material, whether it is DNA or RNA.
- It enables the detailed understanding of databases used in biological research.

Unit I:

Carbohydrates: Structure and classification of carbohydrates

Chemistry of monosaccharides: Pentoses, hexoses, deoxyglucose, amino sugars, muramic acid, neuraminic acid. Linkages in sucrose, lactose and maltose, trehalose and glycosides.

Structural elucidation of carbohydrates: graded acid hydrolysis, periodate oxidation, methylation, acetylation, GC-MS, IR and NMR.

Glycobiology: Glycoproteins; N- and O-glycosylation, lectins, carbohydrates in tissue engineering. Proteoglycans; agreecan, syndecan, and decorin.

Unit II:

Lipids: Classification of lipids; oils, fats, and waxes. Occurrence and physico-chemical properties of fatty acids, esters of fatty acids, cholesterol, phosopholipids, glycolipids, sphingolipids, cerebrosides and gangliosides.

Lipid mediators: Eicosanoids, prostaglandins, leukotrienes, prostacyclins, thrombaxanes, DAG and ceramide

Unit III:

Nucleic Acids- Nitrogenous bases, nucleosides, nucleotides, physicochemical properties. Purification of nucleic acids, physiochemical properties of nucleic acids, melting of DNA, Tm; factors affecting Tm, Cot curve, classification of DNA based on cot curve. Chemical reactions of DNA and RNA; Nucleotides as regulatory molecules, enzyme cofactors and mediators of chemical energy in cells.

Unit IV:

Introduction to Protein Structure and Function: Amino acids: Nomenclature, classification and buffering properties of amino acids, zwitter ionic structure, reaction of amino acids, unusual amino acids, non protein amino acids.Determination of amino acid compositions: Acid and base catalyzed hydrolysis, separation, quantification, determination of N and C terminal residues, determination of site of glycosylation and type of linkage (o-glycosyl and n-glycosyl).

Determination of protein structure: Sequencing strategies; N-terminal and C-terminal, sequencing methods. Automated sequanators. Determination of s-sbond position. Secondary structure of protein; a, β sheet, β -bend, β -turn and super secondary structures. Secondary structure prediction methods; Ramachandran plot, Chou and Fasman algorithm. Tertiary and quaternary structures

Unit-V:

Bioenergetics- Free energy concept: Molecular basis of entropy, concept of free energy, standard free energy and measurement of free energy, significance in metabolism. Application of first and second law of thermodynamics to biological systems. Energy rich bonds - ATP and interconversions of nucleotide phosphates. Phosphorylation potential. Nitrogen fixation: Biological fixation of nitrogen, symbiotic and non-symbiotic nitrogen fixation. Nitrogenase enzyme complex - azoferredoxin and molybdoferrodoxin.

Reference:

- 1. Bray A. D., Lewis J., Raff M., Roberts K. and Watson J.D. Moleucular Biology of the Cell. B. Garland Publishing, New York and London.
- 2. De Robertis E.D.P., De Robertis E.M.F. 2001. Cell and Molecular biology. Lippincott Williams & Wilkins. Bombay.
- 3. Freifelder D. 1990. Molecular biology. Narosa Publishing House, New Delhi
- 4. Gardner E J & D P Snustad 1996. Principles of genetics. John Willey, New York.
- 5. Alberts, B., Bray, D., Lewis, J., Raff, M, Roberts, K, and Watson, J. D. 5th Edition. 2007 Molecular biology of cell. Garland Publishing Inc., New York.
- Lodish, H., Berk A., Zipursky, S.L. Matsudaria, P. Baltimore, D. and Darnell, J.2003. Molecular Cell Biology, Media connected, W.H. Freeman and Company.
- 7. Celis J E (Ed). Cell biology. 1998. A laboratory handbook. Academic Press.
- 8. Darnell J, Lodish H, Baltimore D 1990 Molecular Cell Biology. 2nd ed. New York, Scientific American Books.
- 9. Cooper G M. The Cell: A Molecular Approach 2000 Sinauer Associates, Inc. Sunderland, Massachusetts.

PAPER 4: MOLECULAR BIOLOGY FOR BIOINFORMATICS 4 CREDITS

Objectives:

• It deals with understanding the molecular aspects of bioinformatics of the biology.

Outcome:

- It majorly emphasizes the concepts of central dogma of molecular biology spanning from DNA Replication till Protein Synthesis and Reverse transcription.
- It also helps in understanding the concepts of cellular function.

Unit I:

Fundamental of molecular biology- Structure of Nucleic acids, DNA-Protein interactions, Transcription in prokaryotes, Control of prokaryotic transcription, Transcription in Eukaryotes, Post transcriptional events, Transcriptional regulation, Translation and translational regulation, post translational modification, RNA and Protein export and its regulation.

Unit II:

Fundamentals of genetic Engineering, historical perspectives, tools of genetic engineering – modifying enzymes, cloning vectors – naturally occurring plasmids, cloning plasmids, virus as cloning vehicles, hybrid vectors, cloning host. Techniques in genetic engineering - Gene cloning, DNA libraries, Microarray techniques, DNA sequencing, Massively parallel sequencing (Next Generation sequencing), Data repositories.

Unit III:

Introduction to Bioinformatics - Overview of biological research. Publicly available

biological databases (NCBI, EBI and UniProt, HPRD *etc.*,). Biological databases, Plants databases, Fly databases, Genomics (TCGA, PSRA), Proteomics, Human Proteomic Atlas and Metabolomics (HMDB), Pathway database (KEGG, Netpath), dbSNP. Molecular evolution and phylogeny

Unit IV:

Pairwise and multiple sequence analysis (BLAST, Fasta, BLAT and ClustalW). Motif and domain assignments.

Unit V:

DNA and RNA sequence analysis, Protein sequence analysis- Sequence alignment homology, Structure and function prediction, Motif analysis, Domain and motifs, Localization of signal sequences for targeting proteins, Nuclear localization signal, DNA-RNA binding motifs, Gene expression analysis, Protein expression profiling, Protein modification.

Reference:

- 1. Principles of Gene Manipulation and Genomics(link is external) 7th Edition – Sandy B. Primrose, Richard Twyman – Blackwell Publishing
- 2. Gene Cloning and DNA Analysis: An Introduction(link is external) 6th Edition T. A. Brown John Wiley & Sons
- 3. An Introduction to Genetic Engineering(link is external) 3rd Edition -Desmond S. T. Nicholl - Cambridge University Press
- 4. Molecular Biotechnology: Principles and Applications of Recombinant DNA (link is external)- 4th Edition - Bernard R. Glick, Jack J. Pasternak, Cheryl L. Patten - ASM Press.

ELECTIVE 1: STATISTICAL COMPUTING USING EXCEL AND SPSS 4 CREDITS

Objectives:

Students in this course study a wide variety of statistical and graphical techniques, including linear and nonlinear modeling, classical statistical tests, time- series analysis, and classification and clustering.

Outcome:

The course will impart training to students who seek to acquire and refine their skills relating to data analysis and manipulation.

Unit I:

Introduction to Excel- Workbooks and Worksheets, Cell Addresses, Entering And Editing Data, Savings Files, Importing/Accessing Data, Mathematical Operators In Excel, Creating Formulas And Functions, Data Analysis Toolpak: Installing The Analysis Toolpak, Using The Analysis Toolpak, Practice Problems.

Unit II:

Creating Tables, Charts and Descriptive Statistics Using Excel Functions-Creating And Formatting Tables, Frequency Distribution Tables, Histograms And Bar Charts, Pie Chart, Scatter Diagram, Descriptive Statistics Using Excel Functions, Practice Problems.

Unit III:

Statistical Functions in the Analysis Toolpak- Creating an XY Plot of Data, Using The Regression Function to Fit A Straight Line, Correlation, ANOVA, t-Test

And F Test.

Unit IV:

SPSS For Windows: An Introduction- Overview And Scope Of SPSS, Starting SPSS, Typing in Data, Loading Data, Starting SPSS For Windows, Entering Data, Importing a File ,Defining The Variables, Missing Values, Saving Your Data, Help, Exiting SPSS.

Unit-V:

Writing / Performing Programs Using SPSS on Problems from The Following Topics: Frequencies, Bar Chart, Pie chart, Box plot, Descriptive Statistics, One and two Sample Parametric and Nonparametric Tests, Chi-Square Tests, Regression and Correlation Analysis, Analysis of Variance and Kruskal-Wallis Test.

References:

- 1. Essentials Of Biostatistics Workbook Statistical Computing Using Excel: By Lisa M.Sullivan(Second Edition)
- 2. An Introduction To Statistics Using Microsoft Excel: By Dan Remenyi George Onofrei Joe English
- 3. Practical Statistics Using SPSS Authors Nicola Spiers, Brad Manktelow, Michael J. Hewitt.

PRACTICAL 1: BIOCHEMICAL TECHNIQUES 6 CREDITS

- 1. Paper chromatography ascending and descending separation of amino acids and sugars.
- 2. Qualitative tests for the identification of amino acids and carbohydrates.
- 3. Thin layer chromatography of amino acids and lipids.
- 4. Column (GPC) chromatographic separation of proteins (albumin and trypsin).
- 5. Polyacraylamide Gel Electrophoresis and agarose gel electrophoresis of serum proteins.
- 6. Ion exchange chromatography of amino acids.
- 7. Absorption spectrum of chlorophyll extracted from green leaves.
- 8. Absorption spectrum of aromatic amino acids, purines and pyramidines. Determination of Molar absorption coefficient of tyrosine.
- 9. Optical rotation of sugars using polarimeter
- 10. Molecular weight determination of proteins by SDS-PAGE
- 11.Western blotting
- 12.Quantitative estimation of proteins by spectrophotometric method.
- 13. Demonstration of Polymerase Chain Reaction

SEMESTER II

PAPER 5: PROTEIN STRUCTURE AND FUNCTION 4 CREDITS

Objectives:

- It enables the students to appreciate structural and functional aspects of proteins.
- It also elaborates on the protein characterization methodology and studies of protein-drug and protein protein interaction.

Outcomes:

• At the end the student will gain thorough knowledge of fundamentals and applications involved in protein chemistry.

Unit I:

Protein synthesis: Biological and recombinant protein synthesis. Peptide synthesis. Post-translational modifications.Protein chemistry: inclusive peptide sequencing and chemical modification of proteins.

Unit II:

Biological protein degradation. Protein informatics: Databases for protein sequences, structure and function. Methods for protein informatics.

Unit III:

Protein structure: Protein folding. Determination of the three-dimensional structure of proteins: X-ray crystallography, NMR spectroscopy, microscopy. Protein structure modeling and analysis using molecular graphics Protein structure-function relationships. **Unit IV:** Functional genomics and proteomics: Directed evolution of proteins - Protein interactions: Protein ligand, protein-DNA and protein-protein interactions. **Unit V:**

Kinetic and thermodynamic characterization of interactions, methods and interpretations. Examples of protein function and applications:a.Enzymes.b.Membrane proteins, receptors, c.Protein-protein interactions, signal transduction, d.Multilprotein complexes, viruses.

Reference:

- 1. Hiroaki Kitano (editor). Foundations of Systems Biology. MIT Press: 2001. ISBN 0-262-11266-3.
- 2. CP Fall, E Marland, J Wagner and JJ Tyson (Editors). "Computational Cell Biology." Springer Verlag: 2002 ISBN 0-387-95369-8.
- 3. G Bock and JA Goode (eds). In Silico" Simulation of Biological Processes, Novartis Foundation Symposium 247. John Wiley & Sons: 2002. ISBN 0-47084480-9.
- 4. E Klipp, R Herwig, A Kowald, C Wierling, and H Lehrach. Systems Biology in Practice. Wiley-VCH: 2005. ISBN 3-527-31078-9.
- L. Alberghina and H. Westerhoff (Editors) Systems Biology: Definitions and Perspectives, Topics in Current Genetics 13, Springer Verlag (2005), ISBN 9783540229681.
- Z. Szallasi, J. Stelling, and V.Periwal (eds.) System Modeling in Cellular Biology: From Concepts to Nuts and Bolts (Hardcover), MIT Press: 2006, ISBN 0-262-19548-8.
 Schaum's Outline of Theory and Problems of Programming with Visual Basic (2001)By yron S. Gottfried, Published by McGraw-Hill Professional.

PAPER 6: MULTIVARIATE TECHNIQUES AND BIG DATA ANALYTICS 4 CREDITS

Objectives:

• Students in this course learn principle component analysis, clustering, applications in test on mean vectors and MANOVA.

Outcome:

• Outcome of this course is that it prepares the students to apply these methodologies to actual real world data.

Unit I:

Multivariate Data In Biological Sciences, Examples, Multivariate Normal Distribution, Maximum Likelihood Estimators Of Parameters, Multivariate Linear Regression Model, Estimation Of Parameters, Testing Linear Hypothesis About Regression Co-Efficients.

Unit II:

Principal Component Analysis, Factor Analysis –Orthogonal Factor Model, Factor Loadings, Estimation Factor Loadings, Factor Scores, Applications, Canonical Correlations and Canonical Variable - Definition, Use, Estimation and Computation.

Unit III: Classification and Clustering- Basic concept, Methods, Examples, Applications, K-Means Clustering, Hierarchical Clustering, Classification Trees, Multidimensional Scaling- Classical, Ordinal and Metrical Multidimensional Scaling, Linear Discrimination.

Unit IV:

Multivariate Analysis of Variance (MANOVA)-Description, Assumptions, Limitations, Applications, Methods and Formula for MANOVA. Test Statistics, Structural Equation Modelling (SEM)-General approach to SEM, Model Specification, Estimation of Parameters, Assessment of model and model fit, Software's used for SEM.

Unit V:

Big data analytics- characteristics, sources, tools and application, Data structures: Structured, unstructured, quasi structured data, semi structured data, data analytics life cycle,Data Mining- processes, model assessment and tools, machine learning - supervised and unsupervised techniques.

Reference:

- 1. George W. Collins, II, "Fundamental Numerical Methods and data analysis", George W. Collins, II Press, 2003.
- 2. Hildebrand. F.B,"Introduction to Numerical Analysis", McGraw- Hill book Co, 1956.
- 3. Householder A.S., "Principles of Numerical Analysis", McGraw Hill Book Co; 1953.
- 4. Hamming, R.W, "Numerical methods for scientists and engineers", Mc-Graw Hill Book Co; 1962.
- 5. Daniel W.W., "Biostatistics a Foundation for Analysis in the Health Sciences", John Wiley & sons, 2000.
- 6. Warren J. Ewens, Gregory R. Grant, "Statistical methods in Bioinformatics: An Introduction", 2 nd edition, Springer 2004.

PAPER 7: PERL FOR PROGRAMMING 4 CREDITS

Objectives:

• The course provides the introduction to PERL scripting language and its use in bioinformatics.

Outcomes:

• At the end of the course, the students are able to utilize the power of PERL for disease diagnostics and therapy

Unit I:

Introduction to Perl Scripting language. Interpreted Language. About Perl. Why Perl for Bioinformatics?, CPAN. Basic structure of Perl language – print command – First Perl program – Executing your code. Variables in Perl: Scalars, Arrays and Hashes. Package and Lexical Variables. Reading from the Keyboard – using chomp.

Unit II:

Data Structures in Perl Literals: Numbers and Strings, Operators, Scalar data, Array data, Hash data. Manipulation of Data Structures: Scalar Variable: (Function list - chomp, chop, length, chr, oct, hex, oct, ord, index, rindex, substr, uc, ucfirst, lc, lcfirst). Array Variable: Creating an array, Use of range operator in an array, Adding and removing elements, getting the number of elements in an array, Accessing elements in an array. (Function list - reverse, sort, join, split, pop, push, shift, unshift, grep, map). Hash Variable: Printing hash data, accessing and removing elements (Function list - keys, values, delete, each, exists)

Unit III:

Control Structures and Regular Expressions Control Structures: if, else, elsif, switch, unless, while, until, do...while, for and for...each. (Statements associated with loops – next, last, redo, goto, continue) Regular expressions: Simple string comparisons, Matching, Substitutions, and Translations. Special characters in patterns. Storing and reusing portions of patterns. Escape characters.

Unit IV:

File and Directory Manipulations. File opening modes (read, write, append), File variable, Die – terminating a program, Reading a file line by line, Closing a file. File test operators (d, e, l, r, s, w, x, B, T). File Manipulation Functions – select, eof, seek, tell, read, sysread, syswrite, link, unlink, rename, truncate. Directory Manipulation functions – mkdir, chdir, opendir, readdir, closedir, telldir, seekdir, rewinddir, rmdir. System variables.

Unit V:

Object Oriented Programming Sub routines, references, OOPs in Perl – Introduction to modules, Classes in Perl, Methods, Constructors, Destructors, Inheritance, Polymorphism, Operator overloading. BioPerl – basics. CGI, DBI, LWP.

Reference:

- 1. Beginning Perl for Bioinformatics by James Tisdall, O-Reilly.
- 2. Developing Bioinformatics Computer Skills by Cynthia Gibas, Per Jambeck, OReilly
- 3. Learning Perl by Randal L. Schwartz, Tom Phoenix, O-Reilly.
- 4. Programming Perl by Larry Wall, Tom Christiansen, Jon Orwant, O-Reilly.
- 5. Programming the Perl DBI by Alligator Descartes, Tim Bunce, O-Reilly.
- 6. Advanced Perl Programming by Sriram Srinivasan, O-Reilly.

PAPER 8: SYSTEMS BIOLOGY

4 CREDITS

Objectives:

• The paper enables the students to learn the basic concepts, models, and measures to characterize the properties of analyzing metabolic networks.

Outcomes:

• It helps the students to understand the integrating aspects of multi-omics datasets and thereby understandingthe biological systems

Unit I:

General introduction to systems biology– overview of molecular mechanism and molecular functions, Molecular networks. Mathematical models vs. computational analysis vs. statistics.

Unit II:

Integrating multi-omics datasets and understanding biological systems – Genomics, proteomics, transcriptomics, metabolomics and phenomics. Understanding genomics and proteomics into biology in-silico. Omics analysis tools.

Unit III:

Concept of gene expression, Comparative Genomics and chromatin. Genome sequencing, genome assembly and finishing, genomic annotation, comparative genomics, and chromatin.

Unit IV:

Computational systems biology - Computational modeling to understand a) the fundamental properties of biochemical networks, and b) the properties of specific biochemical systems. Use of systems biology software to construct and analyses biochemical network models.

Unit V:

Human Molecular genetics: Genetic mapping of human chromosomes, detection of mutations in human genes, determining gene function, human gene therapy, prodrug activation therapy, Predicting the effect of mutations on protein function-SIFT Polyphen.

Reference:

- 1. Hiroaki Kitano (editor). Foundations of Systems Biology. MIT Press: 2001. ISBN 0-262-11266-3.
- 2. CP Fall, E Marland, J Wagner and JJ Tyson (Editors). "Computational Cell Biology." Springer Verlag: 2002 ISBN 0-387-95369-8.
- 3. G Bock and JA Goode (eds). In Silico" Simulation of Biological Processes, Novartis Foundation Symposium 247. John Wiley & Sons: 2002. ISBN 0-47084480-9.
- 4. E Klipp, R Herwig, A Kowald, C Wierling, and H Lehrach. Systems Biology in Practice. Wiley-VCH: 2005. ISBN 3-527-31078-9.
- L. Alberghina and H. Westerhoff (Editors) Systems Biology: Definitions and Perspectives, Topics in Current Genetics 13, Springer Verlag (2005), ISBN 9783540229681.
- Z. Szallasi, J. Stelling, and V.Periwal (eds.) System Modeling in Cellular Biology: From Concepts to Nuts and Bolts (Hardcover), MIT Press: 2006, ISBN 0-262-19548-8.

ELECTIVE 2

2 (a) MOLECULAR STATISTICAL MODEL USING `R` 4 CREDITS

Objectives:

• Students in this course study a wide variety of Molecular statistical and graphical techniques, including linear and nonlinear modeling, classical statistical tests, time-series analysis, and classification and clustering.

Outcomes:

• The course will impart training to students who seek to acquire and refine their skills relating to data analysis and manipulation.

Unit I:

Introduction to statistical software R Downloading and Installing R, Essentials, Advantages and objects, Functions and arguments, Manipulating vectors,

Factors, Matrix operations: addition, subtraction, multiplication, Lists, Importing of files, Data frame, Getting Help: The functions help(), help.search() and example().

Unit II:

gene expression studies and data visualization, Functional Genomics 2: SNP arrays, cDNA, EST, SAGE, MPSS, RNA expression and DNA microarray (Gene Expression Omnibus (GEO), ArrayExpress): database and basic tools, DNA microarray: design of microarray chip, understanding of microarray data, visualization of data, normalizing microarray data, detecting differential gene expression, correlation of gene expression data to biological process and computational analysis tools (especially clustering approaches - Kmeans technique), algorithmic approaches to clustering gene expression data and applications, Methods and tools for identification of disease associated genes in molecular diagnostics (molecular markers).

Unit III:

Descriptive statistics and Graphics in R Measure of central tendency and measure of dispersion (Mean, median, standard deviation, variance, quartiles, fivenum summary), R-Graphics- Bar Graph, Pie chart, Box-plot, Dot diagram, Stem and leaf plot and Histogram,

Unit IV:

Introduction to Probability and Probability Distribution using R functions Sample spaces, Events, Set Union, Intersection, and Difference, Basic probability problems in R, Probability Mass Functions with Mean, Variance, and Standard Deviation in R, Fitting of distributions to given data with R –Binomial distribution, Poisson distribution and Normal distribution.

Unit V:

R functions in Liner modelling and standard statistical tests Correlation, correlation coefficient, Simple linear regression, one way ANOVA and two way ANOVA, One and two sample t-tests, Chi-squared tests, F- test for equality of variance and non parametric tests: Kruskal-Wallis Test.

Reference:

- 1. Purohit S.G., Gore, S.D. and Deshmukh, S.R. (2008) Statistics Using R, Alpha Science.
- 2. Peter Dalgaard: Introductory statistics for R ,Springer.
- 3. Statistical Methods Using R Software :V. R. Pawagi and Saroj A. Ranade
- 4. Verzani, J. (2005). Using R for Introductory Statistics, Chapman and Hall, London.
- 5. Introduction to Probability, and Statistics Using R,G. Jay Kerns, First Edition
- 6. Andrew R. Leach (2001) "Molecular Modeling Principles and Applications"; Second Edition, Prentice Hall, USA
- 7. Gasteiger Johann (2003) Chemoinformatics: A Textbook, Wiley, John & Son, ISBN13
- 8. Schaum's Outline of Computer Graphics by Zhigang Xiang and Roy A. Plastock Second Edition, Mc Graw Hill, USA

Elective- 2 (b): Object-Oriented Programming and Database Management

Objectives:

• Designing database for different applications is an important area of program development and C++ as tools for solving problems.

Objectives

- Using C++ introduce the concept of object oriented programming
- Describe the concepts of Classes, objects and overloading using C++
- Introduce the Database management architecture and languages
- Description of Database models using ER model as an example
- Description of Structured query language

Unit I

OBJECT ORIENTED PROGRAMMING (OOP)- OOP concepts (Using C++): data hiding, encapsulation, inheritance, overloading, polymorphism.

Unit II

CLASSES AND OBJECTS, OVERLOADING - Classes and objects (Using C++); constructor and destructor, Inheritance: single, multiple, multilevel- overloading: Function overloading, Operator overloading.

Unit III

DBMS ARCHITECTURE, LANGUAGES - DBMS Architecture & Data Abstraction, DBMS Languages, DBMS System Structure.

Unit IV

ENTITY RELATIONSHIP MODEL- ER Model: Objects, Attributes and its Types, Entity and Entity Set, Relationship & Relationship Set. Design Issues in choosing attributes or entity set or relationship set: Constraints, Super Key, Candidate Keys, Primary Key, ER Diagram Notations.

Unit V

STRUCTURED QUERY LANGUAGE- SQL: Overview, the Form of Basic SQL Query, UNION, INTERSECT, and EXCEPT- Nested Queries- Aggregate Functions- Null Values.

Reference:

- 1. Herbert Schildt, "The Complete Reference C++", Tata McGraw Hill, 2001.
- 2. Robert Lafore, "Object Oriented Programming in Microsoft C++", Galgotia Publications, 2002.
- 3. Abraham Silberschatz, Henry F. Korth, S. Sudarshan, "Database System Concepts", McGraw-Hill, 4th edition, 2002.
- 4. Elmashri&Navathe, "Fundamentals of Database System", AddisonWesley Publishing, 3rd edition, 200.

PRACTICAL 2: INFORMATICS LABORATORY 6 CREDITS

- 1. Building databases
- 2. Data retrieval from data bases.
- 3. Real life data from biomedical sciences-Finding significant observation using statistics.
- 4. Perturbation to biosystem and its implication on cell and organ function.
- 5. RNA and DNA sequence alignment, Exome and whole genome alignment.
- 6. Building gene and protein networks.
- 7. Characterize Putative protein sequences.
- 8. Identification of the pathogens.
- 9. Motif identification.

10.Usage of Bioinformatics tools.

SEMESTER III

PAPER 9: PYTHON FOR BIOINFORMATICS 4 CREDITS

Objectives:

- Read and understand the Python syntax.
- Be familiar with Python's fundamentals and develop simple applications.
- Apply the principles and techniques of object-oriented programming.
- Use sophisticated techniques and Python modules that are particularly useful for bioinformatics programming.
- Build new Python software tools for life science research.

Outcomes:

• It helps the students to understand the summary of text patterns using regular expressions, apply different strategies for error handling of applications and write applications in one of the most simplistic languages available.

UNIT I

PYTHON FUNDAMENTALS - Running programs, types and operations, Functions, modules, classes, Exceptions,

UNIT II

OBJECT ORIENTED PROGRAMMING, MODULES- Object Oriented Programming, Threads, process, synchronization, databases and persistence, NumPy, SciPy, image manipulation, Akando and Dancer modules.

UNIT III

BIOLOGICAL SEQUENCE ANALYSIS- Biopython: Parsing DNA data files, Sequence Alignment, Dynamic programming, Hidden Markov Model, Genetic algorithms, Multiple Sequence Alignment, gapped alignment.

UNIT IV

ADVANCED ANALYSIS TECHNIQUES - Trees, text mining, clustering, Self Organizing Map, Principal Component Analysis, Fourier transforms, Numerical Sequence Alignment.

UNIT V

EXPRESSION ANALYSIS - Gene expression array analysis, Spot finding and Measurement, Spreadsheet Arrays and Data Displays, Applications with Expression Arrays.

REFERENCES

- 1. Jason Kinser, "Python for Bioinformatics", Jones & Bartlett Publishers, 2008.
- 2. Mark Lutz, "Learning Python", 3rd edition, O'Reilly, 2007.
- 3. Alex Martelli, David Ascher, "Python cookbook", O'Reilly, 2002.
- 4. http://www.biopython.org

PAPER 10: STRUCTURAL BIOINFORMATICS

4 CREDITS

Objectives:

• This course talks about databases used in bioinformatics.

Outcomes:

- This includes NDB, MMDB, PROSEARCH, and Molecular mechanics.
- The outcome of the course is to train the students in the use of databases for structure determination for diagnostic therapeutic application.

Unit I:

Structural biology and structural databases. Nucleic acid structures, RNA folding, RNA loops, conformational study. various ribose ring conformations, ribose-ring puckering. protein-protein interactions, protein ligand interactions. DNA-binding proteins, RNA-binding proteins. Ramachandran plot, 3-dimensional structures of membrane proteins, importance of 310 helix and loops, biophysical aspects of proteins and nucleic acids. Strutural databases:- Protein Data bank (PDB), Nucleic Acid Data Bank (NDB), Molecular modeling Data Bank (MMDB). Secondary structure, three-dimensional structure prediction, protein folding and functional sites, protein folding classes.

Unit II:

Protein structure prediction, Protein Structure Prediction:- Homology modeling, prediction of protein structure from sequences, functional sites. Protein folding problem, protein folding classes, protein identification and characterization:- AA-CompIdent, TagIdent, PepIdent and MultiIdent, PROSEARCH, PepSea, PepMAP-PER, FindPept, Predicting transmembrane helices, Primary structure analysis and prediction, Secondary structure analysis and prediction, motifs, profiles, patterns and fingerprints search. Methods of sequence based protein prediction.

Unit III:

Molecular Modeling and Molecular Mechanics, Molecular modeling:-Introduction, force field, quantum chemistry, Schrödinger equation, potential energy functions. Energy minimization, local and global minima, saddle point, grid search. Various approximations; LCAO, HF, semi-empirical calculations; single point calculations, full-geometry optimization methods, ZDO, MNDO, CNDO, NDDO, AM1, PM3, RM1. Conformational search, Z-matrix, docking, molecular modeling packages.

Unit IV:

Molecular mechanics, Definition, balls and springs, force fields, bond-stretching, bond-bending, dihedral motions, out of plane angle potential, non-bonded interaction, coulomb interactions, conformational search, united atoms and cut-offs. Derivative methods:- First-order methods; Steepest descent, conjugate gradient, Second order methods; Newton-Raphson method.

Unit V:

Molecular dynamics:-Introduction, Newton's equation of motion, equilibrium point, radial distribution function, pair correlation functions, MD methodology, periodic box, algorithm for time dependence; leapfrog algorithm, Verlet algorithm, Boltz-man velocity, time steps, duration of the MD run. Starting structure, analysis of MD job, uses in drug designing, ligand protein interactions.

Reference:

- 1. Bourne Philip E., Weissig Helge. Structural Bioinformatics (Methods of BiochemicalAnalysis, V. 44), 2003. Publisher: Wiley-Liss. ISBN: 0471202002.
- 2. Höltje Hans-Dieter, Sippl Wolfgang, Rognan Didier, Folkers Gerd. Molecular Modeling: Basic Principles and Applications. Publisher: New York, Wiley-VCH. 2003. ISBN: 3527305890.
- 3. Leach, Andrew. Molecular Modelling: Principles and Applications. Publisher: PrenticeHall. 2001. ISBN: 0582239338.

PAPER 11: CADD (DRUG DESIGNING) 4 CREDITS

Objectives:

• This interdisciplinary course introduces the students with molecular dynamics, simulation, and modeling for drug discovery.

Outcomes:

• The outcome of the course is to train the students in use of computer aided technology to fasten the drug discovery through simulation and modeling.

Unit I:

Concepts in Molecular Modeling: Introduction; Coordinate System; potential energy surfaces molecular graphics; Molecular Mechanics: Features of molecular mechanics, force fields; Bond structure and bending angles – electrostatic, van der Waals and nonbonded interactions, hydrogen bonding in molecular mechanics; Derivatives of molecular mechanics energy function; Calculating thermodynamic properties using force field; Transferability of force field parameters, treatment of delocaliised pi system; Force field for metals and inorganic systems – Application of energy minimization.

Unit II:

Molecular Dynamics Simulation Methods: Molecular Dynamics using simple models; Molecular Dynamics with continuous potentials and at constant temperature and pressure; Timedependent properties; Solvent effects in Molecular Dynamics; Conformational changes from Molecular Dynamics simulation.

Unit III:

Drug Designing Related Applications: Drug discovery process, Role of Bioinformatics in drug design, Target identification and validation, lead optimization and validation, Structure-based drug design and ligand based drug design, Modeling of target-small molecule interactions, Finding new drug targets to treat diseases, Molecular Simulations.

Unit IV:

Molecular Modeling in Drug Discovery: Pharmacophore identification, Deriving 3D pharmacophore, Molecular Docking, methods to identify lead compounds, de novo ligand ,design, Applications of 3D Database Searching and Molecular docking.

Unit V:

Structure Activity Relationship: QSARs and QSPRs, QSAR Methodology, Various Descriptors used in QSARs: Electronic; Topology; Quantum Chemical based Descriptors. Use of Genetic Algorithms, Analysis in the QSAR equations. Drug designing softwares: Free and commercial Tools available for various stages in drug discovery and refinement processes.

References:

- 1. Andrew R. Leach (2001) "Molecular Modeling Principles and Applications"; Second Edition, Prentice Hall, USA
- 2. Gasteiger Johann (2003) Chemoinformatics: A Textbook, Wiley, John & Son, ISBN13: 9783527306817
- 3. Schaum's Outline of Computer Graphics by Zhigang Xiang and Roy A. Plastock Second Edition, Mc Graw Hill, USA
- 4. Fenniri, H. (2000) "Combinatorial Chemistry A practical approach", Oxford University Press, UK.
- 5. Lednicer, D. (1998) "Strategies for Organic Drug Discovery Synthesis and Design"; Wiley International Publishers.

PAPER 12: IMMUNOINFORMATICS 4 CREDITS

Objectives:

 To integrate a simulation tool for immune system dynamics that is both patient and pathogen specific

 To provide molecular information and bioinformatics prediction methods to create a detailed computational model of the innate and adaptive immune response

Outcome:

 This course will enable the students to understand the immune system, its components and their functions to study informatics-based approaches for prediction of allergen epitopes, design of vaccines and immuno-diagnostic tools.

Unit I:

Introduction: overview of the immune system-Lymphatic system, Lymphoid organs, Cells of the immune system and their functions-Immune system. Innate and Acquired immunity: Cells and processes of Innate immunity—Cells and organs of the Acquired immunity- Anatomical and Physiological barriers; Innate immune response and their recognition structures; Immunogens and Antigens: Requirements for immunogenicity; major classes of antigens; antigen recognition by B and T lymphocytes.

Unit II:

Structures and Functions of T-Cells and B-Cells, T- and B- Cell generation and differentiation: BCR--Antibody diversity: Genetic basis—T- dependent activation of B cells-B-lymphocyte signal transduction. Cytokines.

Unit III:

ANTIBODY STRUCTURE AND FUNCTIONS, Monoclonal antibodies, Antigen- antibody interaction: antibody affinity and activity- Isolation of lymphoid cells from blood and lymphoid organs--precipitation reaction, agglutination reaction -Radioimmunoassay, ELISA, Western Blot, Immunoprecipitation, Immunofluoresence, flow cytometry

Unit IV:

Definition of Immunoinformatics – overview of the Immune system- Bioinformatics strategies for better understanding of immune function - structural features of MHC peptides-MHC peptide interaction parameters: a) interface area between peptide and

MHC, b) intermolecular hydrogen bonds, Immunological databases – IMGT – IMGT-GENE-DB – IMGT-HLA IMGT/LIGM-DB - HaptenDB – EPITOME – dbMHC – JenPep **Unit V:**

Experimental and theoretical description of peptide-MHC binding, selection of epitopes using bioinformatics, prediction of proteasome processing, and TAP binding, Predictions of Class I and Class II MHC Epitopes, IEDB analysis Resourse, CTLPred, Population Coverage analysis, Epitope conservancy analysis.

Introduction to vaccines, Different generations of Vaccines, Concepts of reverse vaccinology, case study of Reverse Vaccinology with Meningococcus B, Comparision of Traditional Vaccinology and Reverse Vaccinology, Tools & servers for computational Vaccine design-from Genome to Vaccine.

Reference:

- 1. Flower Darren R. Bioinformatics for Vaccinology Publisher: UK, John Wiley & Sons Inc. 2008. ISBN: 9780470027110.
- 2. Flower Darren R. Immunoinformatics: Predicting Immunogenicity In Silico Publisher: New Jersey, Humana Press. 2007. ISBN: 9781603271189.
- Kindt, Thomas J.,Osborne Barbara A.Goldsby Richard A. Kuby Immunology 6 th Edition. Publisher:New York, W. H. Freeman. 2007. ISBN: 9780716785903.
- 4. Lund Ole , Nielsen Morten , Lundegaard Claus, Kesmir Can, Brunak SÃ, ren. Immunological Bioinformatics. Publishesr: London, MIT PRess 2005 ISBN: 0262122804.
- 5. Foundation Novartis.Immunoinformatics: Bioinformatic Strategies for Better Understanding of Immune Function. Publisher: Chichester,John Wiley & Sons Inc. 2003. ISBN: 0470853565.
- 6. Roitt Ivan, Delves Peter. Roitt's Essential Immunology 10th Edition.Publisher: Canada,Blackwell. 2001, ISBN: 0632059028.
- 7. Ellis Ronald W. Vaccines: New Approaches to Immunological Problems. Publisher: Stoneham, Butterworth-Heinemann 1992. ISBN: 0750692650.

ELECTIVE 3: BIOINFORMATICS TOOLS ON MATLAB 4 CREDITS

Objectives:

• The computer based course introduces the students to the use of MatLab as a tool for bioinformatics.

Outcome:

• Outcome of the course is to provide knowledge to student through additional toolbox of bioinformatics in MatLab for image processing, simulation, pharmacokinetics, and biological data analysis.

Unit I:

Introduction To Matlab, Matlab key features, basic functionalities-tool box , data types, variables, operators, vectors, matrix operations, trigonometric functions, 2D,3D- graphics , Limits. Control structures, function handling, class file handling, mat file creation, symbolic mathematics. Numerical Methods- solving linear equations, solving differential equations-ODE suite, integration, interpolation, regression. Statistical analysis- probability, hypothesis testing, ANOVA and cluster analysis.

Unit II:

Bioinformatics Tool Box, Sequence Analysis, NGS, Graph Theory, Gene Ontology, Importing Data and Deploying.

Unit III:

Biological Data Analysis, Microarray Data Analysis, Mass Spectrometry Data Analysis, statistical classification of biological data

Unit IV:

Image Processing, Key Features, Importing and Exporting Images, image file formats and format conversion, Pre- and Post-Processing Images, Spatial Transformations and Image Registration. Microarray image analysis.

Unit V:

Systems Biology, Basics of enzyme kinetics, Kinetic Laws.Modeling Biological System, Simulation, sensitivity analysis, parameter estimation using simbiology.Pharmacokinetic modeling- simulation, population study.Model of the Yeast Heterotrimeric G Protein Cycle and glycolysis.

Reference:

- 1. Alterovitz G., M. F. Ramoni, "Systems Bioinformatics: An Engineering Case-Based Approach", Artech House, 2007.
- 2. Michael R. King, Nipa A. Mody, "Numerical and Statistical Methods for Bioengineering: Applications in MATLAB", Cambridge University Press, 2011.
- 3. Gibas C., Per Jambeck, "Developing bioinformatics computer skills", O'Reilly Media, Inc., 2001.
- 4. Semmlow, "Biosignal and Biomedical Image Processing", Marcel Dekker, Inc., 2004.
- 5. Hoppensteadt, Peskin, "Modeling and Simulation in Medicine and Life Sciences", Springer, 2010.

Practical III

1. Assigning protein function using protein networks

- 2. Cytoscape, GeneMania
- 3. Kyoto Encyclopedia of Genes and Genomes (KEGG), NetPath, Wetslim.
- 4. Genome Browse- NCBI, ENSEMBLE, UCSC Genome Browser, Integrative Genome Viewer.
- 5. Y2H (yeast two-hybrid)
- 6. Map viewer- Search or Browse the Genome, BLAST, Clone Finder, Use of Genome Resources.
- 7. Sequence to determine genetic cause of the disease, NGS- BOWTIE, TO-PHAT, VARSCAN, TOPHAT FUSION.

SEMESTER IV

Summer project work – 2 Credits Thesis and viva-voce examination – 12 Credits

Master of Science in Microbiology

Microbiology is one of the fascinating and dynamic science. It is constantly being evolved and more information is being added in continuation with the existing literature including all the microbiological techniques being rapidly modified and refined. Microbiologists and other scientists employ the scientific method to understand natural phenomena. It provides a blend of traditional and contemporary knowledge of microbiological science to meet the pedagogical needs of all students pursuing masters in Microbiology. The Master degree course covers the studies of microorganisms, their effect on human, environment, society etc., the applied aspects and branches of microbiology. The course is career oriented and precisely towards entrepreneurship after successful completion of the course.

Core objectives

- To provide basic insight on the diversity which intersects with many other disciplines of Life Sciences.
- To facilitate basic research approach in Microbiology that leads to the better understanding of molecular techniques that are used to study and comprehend complex forms from microbes to humans including diagnostic areas like Biotechnology, Synthetic biology, production of therapeutic proteins etc.,
- To enable the stakeholders to explore the intricacies of life forms, cellular, molecular and at Nano level.
- To accelerate the creative power and capability in Microbiology that promotes to apply the advanced principles for managing the accurate diagnostic study
- To promote the stakeholders to design their careers in various branches of Microbiology viz., Food, Diary, Agricultural, Industrial, Environmental sectors in academia, research and development, corporate including entrepreneur set-ups.

Outcomes

- With the course structure and type of experience and skills the students will benefit profoundly in gaining exposure to the latest trends and concepts that equip them with facility of building successful career
- Microbiologists work for a wide range of employers, including hospitals, universities, industries including pharmaceuticals, agrochemicals, food and drinks, consumer goods and water supply, corporate fields, Agri-Chemical Companies, Environmental Consultancy, etc.,
- Competent with the knowledge obtained with critical and updated version in different fields of microbiology enables to find impetus avenues in different branches of science.
- When the discipline of Microbiology is strong and intellectually vibrant, there exists better avenues in different fields as research officer, food and hygiene quality controller, medical coding trainers, etc.,

M.Sc. Microbiology Course Suitability

- Research and development in the field of Life Sciences
- To design the career towards academics
- The course is suitable to establish the career in Pharmaceutical Industries,

Food Processing, Biotechnologyand Bioremediation fields.

• Corporate Companies with Life Science literacy

How is M.Sc. Microbiology Course Beneficial?

- The roles of microorganisms in the life of human and theenvironment are better understood. This favors in focusing towards the area interested to design the career.
- The course gives good base to pursue M.Phil. and Ph.D. degree
- Placement opportunities in hospitals, clinical laboratories, brewing industries, Diary industry, fulfilling different roles depending on their interests and qualifications.
- Microbiology and immunology provide major inputs to physiology and infections associated with the disease hence several organizations involved in microbiological research offer opportunities for microbiologists.
- To handle industrial production organisms or cultures on various aspects including preservation and maintenance and carryout various microbiological operations involved in bacterial and fungal fermentations from Labscale to Pilot-Scale to industrial – scale.

M.Sc. Microbiology Employment areas

- Research and development firms
- Educational Institutions
- Food and Beverage Companies
- Food Standard Agencies
- Waste Management Companies
- Pharmaceutical Companies
- Agri-Chemical Companies
- Environmental Consultants
- Water Companies

M.Sc. Microbiology Job Types

- Research Officer
- Microbiologist
- Food & Hygiene Quality Controller
- Associate Consultant Health Care
- Quality Systems Coordinator
- Professor & Associate Professor
- Trainer Scientific Officer
- Project Assistant and Field Assistant
- Medical Coding Trainer
- Chief Hygienist
- Microbiology Lab Technician
- Executive/Sr. Executive

M.Sc. Microbiology Eligibility

 Any undergraduate Science Degree recognized by UGC with Biology as one of the subjects

Advance Courses in M.Sc. Microbiology

- M. Phil (Microbiology)
- Ph. D (Microbiology)

Course Curriculum

Paper code	Semester I	Credits	Duration teaching hours/ week	Exam duration	
Paper 1	Virology& Parasitology	4	4	3	
Paper 2	Bacteriology	4	4	3	
Paper 3	Мусоlоду	4	4	3	
Paper 4	Phycology	4	4	3	
Practical I	Virology, Parasitology & Bacteriology	3	2	4	
Practical II	Mycology & Phycology	3	2		
Elective 1	Statistical Methods for Biology	4	4	3	
	Total	26			
	Semester II				
Paper 5	Microbial Enzymology	4	4	3	
Paper 6	Microbial Physiology, Ge- netics and Genomics	4	4	3	
Paper 7	Food and Dairy Microbiol- ogy	4	4	3	
Paper 8	Soil, Agriculture and Envi- ronmental Microbiology	4	4	3	
Elective 2a	Bioinformatics or				
Elective 2b	Biofertilizer and Bioma- nure Technology or	4	4	3	
Elective 2c	Microbial Nanotechnology				
Practical III	Microbial Physiology, Ge- netics, Genomics & Enzy- mology	3	2	4	
Practical IV	Food, Dairy, Soil, Agricul- ture and Environmental Microbiology	3	2		
	Summer Project (for two months)	2			
	Total	26 +2= 28			

Course Curriculum

Paper code	Semester III	Credits	Duration teaching hours/ week	Exam duration
Paper 9	Medical Microbiology and Im- munology	4	4	3
Paper 10	Molecular Biology and Ge- netic Engineering	4	4	3
Paper 11	Industrial Microbiology and Fermentation Technology	4	4	3
Paper 12	Microbial Bioremediation and Technology	4	4	3
Elective 3a	Disease Diagnostic Technol- ogy or	4	4	3
Elective 3b	Industrial training and Entre- preneurship or			
Elective 3c	Intellectual Property Rights, Biosafety and Bioethics			
Practical V	Medical Microbiology, Im- munology, Molecular Biology and Genetic Engineering	3	2	4
Practical VI	Industrial Microbiology, Fermentation Technology, Microbial Bioremediation and Technology	3	2	
	Total	26		
	Semester IV			
	Dissertation and viva voce examination	12 (Disser- tation: 4; Presen- tation: 4; VivaV- oce: 4 credits)	4	3
	Total Credits	92		

FIRST SEMESTER

PAPER 1– Virology& Parasitology 4 Credits

Objectives:

- Students will be able to evaluate modern virology including areas of virus biology, pathogenesis and disease control
- Introduce students with advanced concepts of parasitology and expose them to host-parasite relationship
- Give students a broad perception of epidemiology of virus and parasitic diseases

Outcome:

- At the successful completion of the course will give a solid understanding of basic concepts in the field of virology and enable them to apply these concepts to problems in the field of virology
- Upon completion of the course student will be able to understand and explain the concept of parasitism and will be able to apply the same in various human and veterinary parasite control and treatment.

Unit I: History and Brief Account: Brief outline on discovery of Viruses, nomenclature and classification of Viruses; Distinctive properties of Viruses; Morphology & ultra-structure. General methods of diagnosis and serology, viriods, prions, satellite RNAs and virusoids. Newly emerging viral diseases.

UNIT II: Classification and Nomenclature: Animal and Human Viruses, Epidemiology, life cycle, pathogenicity, diagnosis, prevention and treatment of DNA Viruses- Pox viruses, Herpes viruses, Adeno viruses, Hepatitis viruses ; RNA Viruses- Picorna, Orthomyxo, Paramyxo, Toga and other arthropod borne viruses, Rhabdo, Rota, HIV- oncogenic viruses. Viral Vaccines and Antiviral agents.

UNIT III:Types of Viruses: Bacteriophage, Bacteriophage typing, application in bacterial genetics. Plant viruses: TMV- general characters,morphology,replication,RNA as its initiators of infection. Cauliflower mosaic virus; Transmission of plant viruses; common viral diseases of crop plants- paddy, cotton, tomato, and sugarcane. Viruses of cyanobacteria, algae, fungi and insects.

Unit IV: Introduction and Classification of Parasites - Laboratory techniques in parasitology - Examination of faeces - Direct and concentration methods - Intestinal amoebae - Entamoeba histolytica, E. coli. Free living amoebae - Naegleriafowleri, Acanthamoeba spp. Intestinal and genital flagellates - Giardia, Trichomonas. Blood and tissue flagellates - Leishmaniadonovani, Trypanosome cruzi and T. bruceicomples. Haemosporina - Malarial parasites. Coccidian - Toxoplasma, Cryptosporium.

Unit V: Infection of Helminthes - Taeniasolium, T. Saginata, Echinococcusgranulosus, Fasciola hepatica, Paragonimuswestermani and Schistosomes, Ascarislumbricoids, Ancylostomaduodenale, Trichuris, Enterobius and Wuchereriabancrofti. Blood smear examination - cultivation of protozoan parasites, serology and PCR techniques.

Reference Books:

- 1. Topley and Wilson (1995) Principles of Bacteriology, Virology and Immunity. 9th Edn. Vol I, Edward Arnold, London
- 2. Chakraborty, P., 2003. A Text Book of Microbiology. 2nd edition, Published by New Central Agency (P) Ltd., Kolkatta.
- 3. Subhash Chandra Parija, 2004. Text book of Medical Parasitology Protozoology and Helminthology. 2nd edition, published by All India Publishers and Distributors, Medical book publisher, New Delhi.
- 4. Chatterjee, 1986. Medical Parasitology. Tata McGraw Hill, New Delhi.
- 5. Karyakarte, R.P. and Damle, A.S., 2005. Medical Parasitology. Revised edition. Published by Books and Allied (P) Ltd., Kolkatta.
- 6. JeyaramPaniker, 2004. Text book of Medical Parasitology. 5th edition, JAY-PEE brothers, Medical Publishers (P) Ltd, New Delhi.
- 7. Ichpujani, R.L. and Rajesh Bhatia, 2003. Medical Parasitology. 3rd edition, JAYPEE brothers, Medical publishers (P) Ltd, New Delhi.
- 8. 8. Nigel J. Dimmock, Andrew J. Easton and Keith N. Leppard , 2016, Introduction to Modern Virology 7Edition, John Wiley & Sons Inc
- 9. 9. Paul Schmid-Hempel, 2011. Evolutionary Parasitology : The Integrated Study of Infections, Immunology, Ecology, and Genetics, 1st edition, Oxford University Press, ISBN10 019922949X, ISBN13 9780199229499
- 10.10. Bruce Hofkin and Eric S. Loker, Parasitology : A Conceptual Approach, 1st edition , Taylor & Francis Inc, ISBN10: 0815344732, ISBN13: 9780815344735
- 11.11. Sarah Jane Pitt , By (author) Alan Gunn, 2012, Parasitology an Integrated Approach, 1st edition, John Wiley and Sons Ltd, ISBN10 0470684232, ISBN13 9780470684238
- 12.12. Larry S. Roberts , Steve Nadler and John Janovy, 2012. Foundations of Parasitology, 9th edition, McGraw-Hill Education Europe, ISBN10 0073524190, ISBN13 9780073524191
- 13.13. Marilyn J. Roossinck , Foreword by Carl Zimmer, 2016, Virus : An Illustrated Guide to 101 Incredible Microbes, 1st Edition ,Princeton University Press
- 14.14. Douglas D. Richman, Richard Whitley and Frederick Hayden , 2017. Clinical Virology, 4th New edition, American Society for Microbiology ISBN10:1555819427 ISBN13:9781555819422

PAPER 2 - Bacteriology 4 Credits

Objectives:

- To introduce students to bacterial structure, growth and nutrition
- To introduce students to Koch postulates and its application in determining the pathogenicity of an oraganism
- Outcomes:
- Students will be able to understand the sources and differentiate between pathogenic and non pathogenic bacteria
- Students will be able to inculcate the pureculture techniques in isolation and identification of pathogenic and non pathogenic bacteria.

UNIT I: History & Scope: Spontaneous generation conflict, Antony van LeeuwenhoekLouis Pasteur, Robert Koch, Paul Ehrlich, Alexander Fleming. Important events in development ofbacteriology, Scope and relevance of bacteriology. Structure: An overview of bacterial size, shape anarrangement, Structure, chemical
composition of cell wall of archaebacteria, gram-negative bacteria, gram-positive bacteria and acid fast bacteria- wall deficient organisms including L-form structure, composition and function of cell membrane, capsule, flagella, pili, Inclusion bodies, ribosomes, mesosomes, reserve food materials, magnetosomes and phycobilisomes, bacterial nucleic acids and genome organization.

UNIT II: Bacterial Taxonomy: Major groups of Bacteria: Classification based on Bergey's manual (Determinative & Systematic). **Archaebacteria**: general characteristics and classification; extremophiles, halophiles, thermophiles and barophiles; type studies- adaptation, role of archaebacteria in the evolution of microbial world. **Actinomycetes**-general characteristics and classification, diversity and distribution, economic importance.

Cyanobacteria- general characteristics and classification, ultra structure, reproduction and economic importance. **Bioluminescent bacteria**; characteristics and examples, mechanism of bioluminescence applications.

UNIT III: Bacterial Growth & Cultivation: Fission, budding, binary cell division, septum formation, planes of cell division, control of cell division: conjugation, transformation, transduction and Bacterial motility and Endospore: spore forming bacteria-formation, properties and germination of endospores, induction of endospore formation. Diversity of bacteria: metabolic diversities-phototrophy, lithotrophy, organotrophy- molecular mechanisms, adaptations and type studies. Aerobic, anaerobic, batch and continuous cultivation. Nutritional requirements: Micro and macro nutrients, Chemical elements as nutrients.

UNIT IV: Medical Bacteriology: Morphology, classification, cultural characteristics, Pathogenicity, pathology, Laboratory diagnosis and prevention – Control and treatment of diseases caused by the following organisms: Staphylococci, Streptococci, Pneumococci, Neisseriae (Gonococci & Meningococci), Corynebacterium, Mycobacterium, Clostridium and Bacillus. Studies on Salmonella, Shigella, Vibrios, Brucella, Gram negative anaerobes Spirochetes, Rickettsiae, Chlamydiae, Mycoplasmas and Ureoplasmas. Zoonotic diseases and their control – Hospital acquired infections – Hospital Infection control committee – functions – Hospital waste disposal – Ethical committee – functions.

Unit V: Economic Importance of Bacteria: A brief account of economic importance of bacteria inAgriculture, industry- brewing, medicine-Vaccines, hormones and environment- bioleaching, bioremediation.

- 1. Sherwood, and Woolverton Willey (2007), Prescott, Harley, and Klein's Microbiology (7th International Edition), McGraw-Hill
- 2. Mara, Duncan, and Nigel J. Horan, (2003). Handbook of water and wastewater Microbiology, Academic Press.
- 3. Michael T. Madigan, David P. Clark, David Stahl, John M. Martinko, 2012, Brock Biology of Microorganisms 13th Edition.
- 4. Jacquelyn G. Black (2012) Microbiology: Principles and Explorations ,8th edition, Wiley
- 5. Michael J. Leboffe, Burton E. Pierce , David Ferguson (2012) Microbiology Laboratory Theory& Application, Brief, 2nd Edition, Morton Publishing Company
- 6. Jeffrey C. Pommerville (2010) Alcamo's Fundamentals of Microbiology, 9th

Revised edition, Jones and Bartlett Publishers, Inc

- 7. Jeffrey C. Pommerville (2010) Alcamo's Laboratory Fundamentals of Microbiology, Jones And Bartlett Publishers, Inc
- 8. Alfred Brown (2011) Benson's Microbiological Applications Short Version (Brown, Microbioligical Applications), 12th edition, McGraw-Hill Science/ Engineering/Math
- 9. Jerome J. Perry , James Staley , Stephen Lory (2002), Microbial Life, Sinauer Associates.
- 10. Richard Tanner Hewlett, 2011, Bacteriology, ,1st edition, Nabu Press, ISBN10: 1248153510, ISBN13: 9781248153512
- 11.Frederick Carl Zapffe, 2016. Bacteriology, 1st edition, Palala Press, ISB-N10:135879412X, ISBN13:9781358794124
- 12.Arthur Isaac Kendall, 2018. Bacteriology : General, Pathological and Intestinal (Classic Reprint), 1st edition, Forgotten Books, ISBN10: 0265396344,ISBN13: 9780265396346

PAPER 3- Mycology 4 Credits

Objectives:

- To introduce the students to the concept of mycology which includes classification, structure, life cycle, genetic, growth and nutrition
- To provide students with opportunities to develop advanced methods in mycological studies
- To know the economic importance of fungi

Outcome:

- It enables students to understand the role of fungi in alleviating the challenges of the current development goals
- The study will be able to explain the significance of fungi in industries, diseases, human health and welfare

UNIT I: Historical Introduction to Mycology: Structure and cell differentiation. Lichens – ascolichens, basidiolichens, deuterolichens. Fungi as insect symbiont. Morphology, Taxonomy, Classification of fungi.

UNIT II: Salient Features Major Groups: Chytridiomycota, Zygomycota, Basidiomycota, Ascomycota, Deuteromycota, Oomycota, Hypochytriomycota, Labyrinthulomycota, Plasmodiophoromycota and Myxomycota. Symbiotic fungi- Lichens.

UNIT III: Clinical Dermatophytes:Dermatophytes and agents of superficial mycoses. Yeasts of medical importance. Dimorphic fungi causing systematic mycoses. Dimatiaceous fungi, opportunistic hyaline hyphomycetes, agents of zygomycosis. Fungi causing Eumycoticmycetoma.

UNIT IV: Diagnostic Dermatophytes:Detection and recovery of fungi from clinical specimens. Newer methods in diagnostic mycology. Immunity to fungal infections. Mycotoxins. Antifungal agents - testing methods and quality control.

UNIT V: Economic Importance of Fungi: Fungi as biocontrol agent, Economic importance of Fungi in Agriculture, Industry and medicine. Fungi as SCP, Fungi as parasites of human and plants. Role of fungi in bio deterioration of wood and paper. Mycorrhiza – ectomycorrhiza, endomycorrhiza, vesicular arbuscular mycorrhiza. Fungi as insect symbiont.

Reference Books:

- 1. 1. Alexopoulas C J and Mims C W, 1979 Introductory Mycology 3rd edn, Wiley Eastern., New Delhi.
- 2. Deacon, J W, 1997- Modern Mycology 3rd Edition, Blackwell Science publishers, London.
- 3. Mehrotra, RS & Aneja, K R, 1998. An Introduction to Mycology. New Age International Pvt. Ltd. New Delhi.
- 4. Odum, E.P. 1971. Fundamentals of Ecology; Third Edition. Toppan Co. Ltd. Tokyo, Japan.
- 5. Mercedes S. Foster& Gerald F. Bills (2011) Biodiversity of Fungi: Inventory and Monitoring Methods. Academic Press
- 6. Michael John Carlile, Sarah C. Watkinson, G. W. Gooday (2007) The fungi. Academic Press. London, U. K
- 7. Kevin Kavanagh (2011) Fungi: Biology and Applications. John Wiley & Sons, Sussex, U.K.
- 8. David Moore, Geoffrey D. Robson, Anthony P. J. Trinci (2011) 21st Century Guidebook to Fungi. Cambridge University Press.
- G. C. Ainsworth, 2009. Introduction to the History of Mycology, 1st edition, CAMBRIDGE UNIVERSITY PRESS, ISBN10: 0521112958, ISBN13: 9780521112956
- 10.Brian Sutton, 2013, A Century of Mycology, 1st edition, CAMBRIDGE UNI-VERSITY PRESS, ISBN10:0521570565, ISBN13: 9780521570565
- 11.Jens Petersen, 2013. The Kingdom of Fungi, 1st edition, Princeton University Press, ISBN10: 0691157545, ISBN13: 9780691157542
- 12.Steven L. Stephenson, 2010, The Kingdom Fungi : An Introduction to Mushrooms, Molds, and Lichens, 1st edition, Timber Press, ISBN10: 0881928917, ISBN13: 9780881928914
- 13. Jeff Lowenfels, 2017. Teaming with Fungi,1st edition,Timber Press,ISBN10: 1604697296 ISBN13: 9781604697292

PAPER 4 - Phycology 4 Credits

Objectives:

- To introduce students about the structure, special characteristic features, multiplication, association of algae and its environment which include the biotic and abiotic factors, economic importance etc.,
- To make the students aware of commercial production of some forms which is of great importance in agricultural sector and also as single cell protein

Outcome:

- Upon successful completion of this course, the student will be able to know the importance of algae and commercial cultivation.
- Student entails knowledge on entrepreneurship with the advanced skills of cultivation

Unit I: History and Classification of Algae: Definition, General characteristics, phases of development of phycology, scope of modern phycology, Classification of algae: Types of classification, Fritsch's classification (in detail).

Unit II: Ecology of Algae: Habitats, communities, succession, primary production, phytoplankton, marine epilithic, freshwater and soil algae. Algal ecology at extreme temperatures, ecology of algae in symbiotic associations.

Unit III:Type Study: Thallus, structural organization, morphology, reproduction, life cycle and economic importance of Chlorophyceae(Chlamydomonas), Xanthophyceae (Vaucheria), Bacillariophyceae (Diatoms), Pheophyceae (Sargassum), Rhodophyceae(Gracilaria), Myxophyceae (Anabaena).

Unit IV: Culture and Commercial Cultivation of Algae: Introduction phycology. Laboratory culturing of algae. Importance of laboratory culture, isolation of algal cultures. Different kinds of algal cultures. Culture media for algae. Commercial cultivation of algae.

Unit V: Economic Importance of Algae:Beneficial and detrimental aspects of algae. Algae as primary source of food and energy, single cell protein. Applications in the field of agriculture, bioremediation, pharmaceutics, cosmetics, sewage and research.

- 1. Kumar, H.D., 1990. Introductory Phycology. Affiliated East-West Press Ltd., Madras.
- 2. O.P Sharma 1986. Text Book of Algae. Tata Mc Graw-Hill Education (007451928X, 9780074519288)
- 3. AVSS Sambamurthy. A Text Book of Algae. I. K. International Pvt Ltd
- 4. OP Sharma. Algae. 2017. McGraw Hill Education (0070681945, 978-0070681941)
- 5. B R Vashishta, AK Sinha, VP Singh Botany for Degree Students Algae. S Chand & Company, 2 edition (8121935210, 978-8121935210)
- 6. S. N. Pandey, P. S. Trivedi 1995 Text Book of Algae Vikas Publishing House (0706994884, 9780706994889)
- Christiaan Hoek, Hoeck Van den Hoeck, David Mann, H. M. Jahns, 1995. An Introduction to Phycology ,Cambridge University Press (0521316871, 9780521316873)
- 8. G. R. South, A. Whittick, 2009, An Introduction to Phycology, Wiley publications (1444314203, 9781444314205)
- 9. Robert Edward Lee, 1999. Phycology. Cambridge University Press (0521638836, 9780521638838)
- 10.Philip Sze A Biology of the Algae. 1998. WCB/McGraw-Hill, The University of California, (0697219100, 9780697219107)
- 11. Robert Edward Lee, 2018. Phycology, 5th Revised edition, CAMBRIDGE UNIVERSITY PRESS, ISBN10: 1107555655, ISBN13: 9781107555655
- 12.Kara Rogers, Fungi, Algae, and Protists, 1st edition,Rosen Education Service, ISBN10: 1615303103, ISBN13: 9781615303106
- 13.Laura Barsanti and Paolo Gualtieri, 2014. Algae : Anatomy, Biochemistry, and Biotechnology, Second Edition, 2nd New edition, Taylor & Francis Inc,ISBN10: 1439867321,ISBN13: 9781439867327
- 14.Helga Meyer and Dagmar Krueger, 2012. Algae : Ecology, Economic Uses & Environmental Impact, 1st edition, Nova Science Publishers Inc, ISBN10: 1620812800, ISBN13: 9781620812808
- 15.Yusuf Chisti and FaizalBux, 2016. Algae Biotechnology : Products and Processes, 1st edition, Springer International Publishing AG, ISBN10: 3319123335, ISBN13: 9783319123332

Elective 1: Statistical Methods for Biology (common paper) 4 Credits

(Biochemistry/ Molecular Biology/ Nanoscience & Technology/ Nutrition& Dietetics/ Geo- informatics/ Environmental Sciences/ Cognitive Neurosciences/Cosmetic Science)

Course Objectives: To train the students intensively in both theoretical and practical aspects of statistics, to bring them in contact with basic concepts and methods and to create a problem-solving attitude with the aid of statistical methodology.

Course Outcomes: It provides an introduction to selected important topics in Biostatistical concepts and reasoning. This course represents an introduction to the field of data and data types. The students learn specific topics including tools for describing central tendency and variability in data; methods for performing inference on population means and proportions via sample data; statistical hypothesis testing and its application to group comparisons; issues of power and sample size in study designs; random sample and other study types.

Unit I. Numerical Methods to Represent Variation:

Importance and Scope of Statistics, Data Types, Frequency Distribution, Graphical Representation Methods (Histogram, Bar Charts, Pie Charts), Measures of Center Tendency (Mean, Median, Mode,) and Dispersion (Standard Deviation, Variance) Advantages and Disadvantages, Co-Efficient of Variance.

Unit II. Probability:

Basic Terminology, Definition of Probability, Basic Laws of Probability, Types of Probability,

Additional Rule of Probability and Multiplication Rule of Probability, Probability Distribution-Bernoulli Distribution, Binomial Distribution, Poisson distribution and Normal Distribution-Simple Problems.

Unit III. Sampling Methods:

Collection of Data, Census Method, Concept of Population, Sample, Sampling, Sample Size, Sampling Error, Advantages and Disadvantages of Sampling Method, Necessity of Sampling, Types of Sampling Methods, Types of Random Sampling Methods – SRS, Stratified Random Sampling, Systematic Random Sampling and Cluster Sampling.

Unit IV. Testing of Hypotheses:

Statistical Hypotheses-Null and Alternative, Level of Significance, Type I and Type II Error, Critical Region, Power of the Test, P Value, Degrees of Freedom, Chi-Square Test for Independence of Attributes and Goodness of Fit, Student's t Test: One Sample t Test and Paired t Test, F Test.

Unit V. Regression and Analysis Of Variance:

Simple Linear Regression, Multiple Linear Regression (Definition, Assumptions, Applications, and Examples), Analysis of Variance –Introduction, Definition of ANOVA, Assumption, Test of ANOVA, Types of ANOVA, Construction of One Way Analysis of Variance.

- 1. Fundamentals of Biostatistics. Veer Bala Rastogi. Publisher: ANE Books. 2nd Edition, 2009.
- 2. Fundamentals of Mathematical Statistics, S.C. Gupta and V. K. Kapoor, Publisher: Sultan Chand & Sons (2014).
- 3. Fundamentals of Statistics. S.C.Gupta. Publisher: Himalaya Publishing House Pvt. Ltd.Edition.7th Edition, 2012
- 4. Introductory Statistics for Biology. R. E. Parker. Publisher: Cambridge University Press 2nd Edition, 1991.
- 5. Statistics for behavioral science. Chintamani Kar. Publisher: Dominant Publishers & Distributors (P) Ltd. (2015).

Virology, Parasitology & Bacteriology PRACTICAL 1

- 1. Isolation of coliphages from sewage and testing for plaque formation by infecting susceptible bacterial culture.
- 2. Extraction and artificial inoculation of TMV to healthy tobacco plant and study of viral symptoms.
- 3. Isolation of protozoa from sewage.
- 4. Study of the following genera of protozoa: Entamoeba histolytica, Naegleriafowleri, Acanthamoeba Giardia, Trichomonas, Leishmaniadonovani, Trypanosome cruzi and T. bruceicomples. Haemosporina - Malarial parasites. Coccidian - Toxoplasma, Cryptosporium.
- 5. Isolation of bacteria from water.
- 6. Study of bacterial growth curve with determination of growth rate of E.coli culture
- 7. Endospore formation and staining in Bacillus subtilis.
- 8. Ames test.

Mycology and Phycology PRACTICAL 11

- 1. Isolation of aquatic fungi.
- 2. Enumeration of fungal spores/ cells by Haemocytometer
- 3. Study of the following representative genera: Aspergillus, Penicillium, Fusarium, Neurospora, Saccharomyces, Erysiphae, Polyporus, Agaricus, Puccinia, Ustilago, Alternaria, Drechslera, Saprolegnia, Rhizopus, Trichoderma and symbiotic fungi- Lichens.
- 4. Isolation of algae from fresh water.
- 5. Isolation cultivation and identification of algae
- 6. Study of the following representative genera: Chalmydomonas, Vaucheria, Sargassum, Diatoms, Gracilaria, Anabaena.

SEMESTER II

PAPER 5: Microbial Enzymology 4 Credits

Objectives:

- Students will be made aware of concepts and applications of microbial enzymes and kinetics in different fields of industries, biotransformers, biocatalists, biosensors etc.,
- To provide students with current trends in use of enzyme in various microbiological, biotechnological and biochemical processes

Outcome:

- Students will be able to apply the concepts and principles of microbial enzymology in various industrial processes.
- Students will be able to understand the various applications of enzymes in a varied industrial processes, appreciate the suitability of enzyme as a sustainable alternative to the chemical industry including justifying the critical conditions involved in the selection of a typical enzymes in industrial processes

Unit I: Introduction to Enzymes: Microbial enzymes: Structure and Classification, Mechanism of Enzyme actions: Lock and Key model, induced fit Theory, Factors affecting rates of enzyme mediated reactions (pH, temperature and substrate and enzyme concentration), Enzyme Inhibition and Enzyme regulation. Classification of enzymes. Mechanisms of enzyme action; concept of active site and energetics of enzyme substrate complex formation; specificity of enzyme action; principles of catalysis – collision theory, transition state theory; role of entropy in catalysis.

Unit II: Kinetics of Enzyme Action: Kinetics of single substrate reactions; estimation of Michelis – Menten parameters, multisubstrate reactions- mechanisms and kinetics; turnover number; types of inhibition & models –substrate, product. Allosteric regulation of enzymes, Monod Changeux Wyman model, pH and temperature effect on enzymes & deactivation kinetics.

Unit III: Enzyme Immobilization and Biosensors: Physical and chemical techniques for enzyme immobilization – adsorption, matrix entrapment, encapsulation, cross-linking, covalent binding etc., - examples, advantages and disadvantages, design of enzyme electrodes and their application as biosensors in industry, healthcare and environment.

Unit IV: Purification And Characterization Of Enzymes From Natural Sources: Production and purification of crude enzyme extracts from plant, animal and microbial sources; methods of characterization of enzymes; development of enzymatic assays .

Unit V: Biotransformation Applications Of Enzymes: Hydrolytic- Ester bond, Amide, Epoxides, Nitriles, Reduction reactions – aldehydes, Ketones, C=C, Oxidation reactions – Alkanes, Aromatic, Baeyer-Villiger, Enzymes in organic synthesis – esters, amide, peptide, Modified and Artificial Enzymes, Catalytic antibodies

- 1. Harvey W. Blanch, Douglas S. Clark, Biochemical Engineering, Marcel Dekker, Inc.
- 2. James M. Lee, Biochemical Engineering, PHI, USA.
- 3. James. E. Bailey & David F. Ollis, Biochemical Engineering Fundamentals, McGraw Hill.
- 4. Wiseman, Enzyme Biotechnology, Ellis Horwood Pub.
- 5. Trevor Palmer , Enzymes II edHorwood Publishing Ltd
- 6. Faber K ,Biotransformations in Organic Chemistry, IV edition , Springer
- Jan Zelinka, Jozef Balan, 2011. Metabolism and Enzymology of Nucleic Acids: Including Gene Manipulations, Springer, ISBN-10: 146128063X, ISBN-13: 978-1461280637
- Kurt Faber, 2011. Bio-transformations in Organic Chemistry, 6th Edition, Springer-Verlag Berlin Heidelberg, ISBN-10: 3642173926, ISBN-13: 978-3642173929
- Trevor Palmer & Philip Bonner, 2014. ENZYMES: Biochemistry, Biotechnology, Clinical Chemistry, 2nd Edition, AbeBooks Seller, ISBN 10: 1904275273 ISBN 13: 9781904275275
- Hsiu-Chiung Yang, Wu-Kuang Yeh , J. R. McCarthy, 2015. Enzyme Technologies: Pluri potent Players in Discovering Therapeutic Agent, Wiley-Blackwell, ISBN-10: 0470286261, ISBN-13: 978-0470286265
- 11.S. G. Borkar, 2015. Microbes as Bio-fertilizers and their Production Technology, 1st Edition, WPI , Publishing, ISBN-10: 9380308574, ISBN-13: 978-9380308579
- 12.R. A Crowther, 2016, Methods in Enzymology, 1st Edition, Academic Press Publisher, ISBN-13: 978-0128053829, ISBN-10: 0128053828

PAPER 6: Microbial Physiology, Genetics & Genomics 4 Credits

Objectives:

- Students are made familiar with the importance of metabolism and physiology in microbial growth
- To enable students to understand the involvement of microbes in photosynthesis and respiration
- Provide students with advanced knowledge on microbial genetics and mutations

Outcomes:

- Upon successful completion of the course students will be able to know the nutrition and culturing of microbes
- Students will understand the concepts of genetics and mutation and apply the same for the utility of microbes in industrial sector

Unit I:

a) Microbial Physiology: Microbial Energetics, Basic aspects of bioenergitics, entropy, enthalpy, electron carriers, artificial electron donors, inhibitors, uncouplers, energy bond, phosphorylation.

b) Microbial Photosynthesis: Photosynthetic Pigments and apparatus in bacteria. Oxygenic and AnoxygenicPhotosynthesis. Autotropic CO2 fixation and mechanism of Photosythesis. Utilization oflight energy by Halobacteria.

c) Autotrophic Mechanisms in bacteria: Hydrogen bacteria, Nitrifying bacteria, Purple sulfur

bacteria, Non-sulfur bacteria, Green sulfur bacteria, Iron bacteria, Methylotrophs.

d) Microbial Stress Responses: Oxidative stress, Thermal stress, Starvation stress, Aerobic to anaerobic transitions. Biofilm and quorum sensing.

Unit II: Microbial Metabolism:

a)Nucleic acid metabolism: Biosynthesis and degradation of purines and pyrimidines.

b) Carbohydrate metabolism Glycolysis, Citric acid Cycle and different types of Phosphorylation, Fates of pyruvate, Fermentation. Utilization of sugars other than glucose: Lactose, Galactose, Maltose, Mannitol. Degradation of cellulose, Starch and Glycogen.

Unit III: Fundamentals of Microbial Genetics:

a) Concepts in Microbial Genetics: History and developments of Microbial genetics. Essentials ofmicrobial genetics: Microbes as Genetic Tools for Basic and Applied Genetic studies. Advantages and disadvantages of Microbes, Generalized reproductive cycles of microbes- Neurospora, Saccharomyces, Chlamydomonas and Acetabularia.

b) Mutation and Mutagenesis: Nature, type and effects of mutations. Mutagenesis –physical and chemical mutagens, base and nucleoside analog, alkylating agents, interrelatingagents, ionizing radiation. Induction and detection of mutation in microorganisms. Sitedirected mutagenesis and its applications.

Unit IV: Microbial Genetics:

a) Viral Genetics: Lytic and Lysogenic cycles, Phage Phenotypes, Phenotypic Mixing, Recombination in viruses: Mutations, Recombination and Mapping.

b) Bacterial Genetics: Bacterial Transformation: Types of transformation mechanisms found in

prokaryotes, Bacterial Conjugation: properties of the F plasmid, F + x F - mating, F' x F- conjugation, Hfr conjugation. Transduction: Generalized and specialized transduction, Transposable elements.

c) Fungal Genetics: Neurospora- Tetrad analysis and linkage detection - 2 point and 3 point crosses, chromatid and chiasma interference, Mitotic recombination in Neurosporaand Aspergillus.

d) Algal Genetics: Chlamydomonas- unordered tetrad analysis - Recombination and Mapping,

Nucleocytoplasmic interactions and gene expression in Acetabularia. Extra nuclear (cytoplasmic) inheritance.

Unit V: Genomics:

a) Whole genome analysis: Preparation of ordered cosmid libraries, bacterial artificial chromosome libraries, shotgun libraries and sequencing, conventional sequencing (Sanger, Maxam and Gilbert method), Automated sequencing.

b) Sequence Analysis: Computationl methods, homology algorithms (BLAST) for proteins and nucleic acids, open reading frams, annotations of genes, conserved protein motifs related stryucture / function (PROSITE, PFAM, Profile Scan). DNA analysis for repeats (direct and inverted) palindromes, folding programmes,

c) DNA Microarray: printing or oligonucleotides and PCR Products on glass slides, nitrocellulose paper. Whole genome analysis for global patterns of gene expression using fluorescent labeled cDNA or end labeled RNA probes. Analysis of single nucleotide polymorphisms using DNA chips.

Reference Books:

1. Albert G. Moat, Michael P. Spector John W. Foster (2009) Microbial Physiol-

ogy. BWSTM

- 2. Daniel R.Caldwell (1999) Microbial Physiology and metabolism, Star Pub Co
- 3. Albert G. Moat, Michael P. Spector John W. Foster (2009) Microbial Physiology.
- 4. Daniel R.Caldwell (1999) Microbial Physiology and metabolism; Star Pub Co
- 5. Robert K. Poole (2014) Advances in Microbial Systems Biology, Volume 64 (Advances in Microbial Physiology); Academic Press
- 6. Rose, Anthony H. (2010) Chemical Microbiology. An Introduction to Microbial Physiology; Basic Books
- 7. Larry Snyder, Joseph E. Peters, Tina M. Henkin, Wendy Champness (2013) Molecular Genetics of Bacteria, 4th Edition; ASM Press
- 8. D. Peter Snustad, Michael J. Simmons (2011) Principles of Genetics, 6th Edition; Wiley
- Stanley R.Maloy, Jhon E. Cronan, Jr. David Freifelder (1994) Microbial Genetics (Jones and Bartlett Series in Biology), 2nd edition; Jones and Bartlett Publishers
- 10.Uldis N. Streips, Ronald E. Yasbin (2002) Modern Microbial Genetics, 2nd edition; Wiley-Liss
- 11.Nancy Jo Trun, J. E. Trempy (2003) Fundamental Bacterial Genetics; Wiley- Blackwell
- 12. Vikas Chaudhary, 2008. Microbial Physiology and Metabolism,-Navyug Publishers & Distributors, ISBN-10: 8190694014, ISBN-13: 978-8190694018
- 13.David Freifelder, John Cronan, Stanly R. Maloy 2009, Microbial Genetics,2nd Edition, Narosa publisher, ISBN-10: 8173196974, ISBN-13: 978-8173196973
- 14.Michael P. Sector, Albert G. Moat, John W. Foster, Michael P. Spector, 2009. Microbial Physiology, 4th Edition, Wiley India Publisher, ISBN 10: 8126521066 ISBN 13:9788126521067
- 15.Robert K. Poole, 2015. Advances in Microbial Physiology, 1st Edition, Academic Press, ISBN-13: 978-0128032985, ISBN-10: 0128032987

Paper 7: Food and Dairy Microbiology 4 Credits

Objectives:

- To introduce students about occurrence and interactions of microorganisms with foods.
- provide information on different techniques of detecting the presence of microbes in foods and explain the different effects of microbial growth on fermentation, spoilage and food-borne diseases.
- Introduce the students to food sanitation and microbiological food quality control and biological hazards in food in food other than food poisoning bacteria.
- To make the students aware of food-borne viruses; Mycotoxins; food poisoning and etc.,
- To describe about the milk, milk products and beverages, types of fermentation adopted

Outcome:

• Upon successful completion of the course the student will be able to explain the occurrence and interactions of microorganisms with food, under-

stand sanitation and microbiological quality control of foods•

- Student will be capable to explain the different techniques of detecting the presence of microbes in foods and understand the different microorganisms that can cause spoilage of foods and be able to detect them (Skills) to develop skills useful to detect the microorganisms in foods
- The student will be capable in designing efficient methods of quality and microbiological control of foods
- Student will be equipped with advanced skills on productivity of dairy products and beverages

Unit I: Food as Substrate to Microbes: Microorganisms important in food microbiology- Molds, yeasts and bacteria, general characteristics, classification and importance. Sources of contamination of food. Factors influencing microbial growth in food- Extrinsic and Intrinsic factors.

Unit II: Food Preservation Methods: Radiations – UV, Gamma and microwave. Temperature-High and Low temperatures, Canning. Chemical and naturally occurring antimicrobials, Genetically modified foods. Biosensors in food, Applications of microbial enzymes in dairy industry (Protease, Lipases)

Unit III: Quality Assurances in Foods: Foodborne infections and intoxications; bacterial with examples of infective and toxic types –, Clostridium, Salmonella, Shigella, Staphylococcus, Campylobacter, Listeria. Mycotoxins in food with reference to Aspergillus species. Quality assurance: Microbiological quality standards of food. Government regulatory practices and policies. FDA, EPA, HACCP, ISI.

Unit IV: Microbiology of Cheese and Beverage Fermentation: Microbiology of milk and fermented milk products (cheese, ice cream, whole and skimmed milk powder, acidophilus milk, yoghurt). Role of microorganisms in beverages – tea and coffee fermentations. Vinegar Fermentation. Utilization and disposal of dairy by-product – whey.

Unit V: Detection of Food-borne Microorganisms: Culture, Microscopic and Sampling methods. Chemical: Thermostable nuclease *Limulus* Lysate for Endotoxins, Nucleic Acid (DNA) probes, DNA Amplification (PCR), Adenosine- Triphosphate Measurement, Radiometry, Fluoro-and Chromogenic substrates. Immunologic Methods: Fluorescent Antibody, Enrichment Serology, Salmonella 1-2. Test, Radioimmunoassay, ELISA.

- 1. Food Microbiology. 2nd Edition By Adams
- 2. Basic Food Microbiology by Banwart George J.
- 3. Food Microbiology: Fundamentals and Frontiers by Dolle
- 4. Biotechnology: Food Fermentation Microbiology, Biochemistry and Technology. Volume 2 by Joshi.
- 5. Fundamentals of Dairy Microbiology by Prajapati.
- 6. Essentials of Food Microbiology. Edited by John Garbult. Arnold International Students Edition.
- 7. Microbiology of Fermented Foods. Volume II and I. By Brian J. Wood.Elsiever Applied Science Publication.
- 8. Microbiology of Foods by John C. Ayres. J. OrwinMundt. William E. Sandinee. W. H. Freeman and Co.
- 9. Dairy Microbiology by Robinson. Volume II and I.

- 10.Thomas J. Montville, Karl R. Matthews, 2012. Food Microbiology: An Introduction, 3rd Edition, ASM Press, SBN-13: 978-1555816360, ISBN-10: 1555816363
- 11.M.R. Adams and M.O. Moss, RSC,2016. Food Microbiology, 2nd Edition, Royal Society of Chemistry, ISBN-10: 1849739609, ISBN-13: 978-1849739603
- 12.Richard K. Robinson, 2017. Dairy Microbiology Handbook: The Microbiology of Milk and Milk Products, 1st Edition, John Wiley & Sons Publisher, Print ISBN:9780471385967 |Online ISBN:9780471723950
- 13.Pratyoosh Shukla 2017. Recent advances in Applied Microbiology, 1st Edition, Springer Publisher, ISBN-13: 978-9811052743, ISBN-10: 9811052743
- 14.William C Frazler, 2017. Food Microbiology, 5th Edition, Mc Graw Hill Publisher,ISBN-10: 1259062511, ISBN-13: 978-1259062513

Paper 8: Soil, Agriculture and Environmental Microbiology 4 Credits

Objectives:

- To introduce students to the characteristics of soil environment and factors affecting presence and activities of microorganisms in the soil provide information on ecological relationship among soil microorganisms, biogeochemical cycle, effect of pesticides on soil microorganisms
- To introduce students about different aspects of agricultural microbiology, fertilizers, diseases of economically important plants and crop, and management .
- To make the students aware of factors and adaptive mechanisms that affect the presence of microorganisms in fresh and marine water environment, skills in treatment of surface and contaminated waste water sewage for both household industrial uses and municipal supply.
- To introduce to different microorganisms of importance in sewage systems; provide information on ecology of fresh water and polluted water; explain the different water purifications and microbiological examinations of water; introduce students to various diseases that can be transmitted through water; provide information on the importance of BOD and COD in sewage treatment; and microbiology of sewage disposal.

Outcome:

- Upon successful completion of this course, the student will be able to understand the factors influencing presence of and activities of microorganisms in different soils, explain influence of pesticides on soil microorganisms, explain biodegradation and biofuel generation, develop skills in using techniques for isolation, characterization and identification of soil microorganisms Identify pesticide degrading microorganisms by using microbiological techniques.
- The student will be aware of entrepreneurship opportunities in agricultural sector, maintaining fertility of soil, to study the causal agent and management of plant diseases
- The student will understand the microbiology of water supply and use of wastewater for fish culture and agricultural purpose (e.g. irrigation). Ex-

plain sewage (or waste water) treatment under primary, secondary and tertiary treatments.

- Student will be able to identify microorganisms that are associated with natural waters such as ponds, springs (cold and warm), rivers and sea, acquire practical knowledge on kinds of treatments suitable for waste waters or sewage in our environment, determine the kinds of antibiotics that can be used to cure water borne infection or diseases
- The student will be skillful and aware of the need for proper sewage disposal in the environment and roles of microorganisms in the disposal of sewage, treat both drinking and polluted waters, characterize diseases transmitted by polluted waters, carry out various tests on drinking water using microbiological techniques.

Unit I: Soil Microbiology: Characteristics and classification of soil. Interactions between microorganisms: Mutualism, commensalism, ammensalism synergism, parasitism, predation, competition. Interaction of microbes with plants and animals: Rhizosphere, phyllosphere, mycorrhizae. Biogeochemical cycles: Carbon, Nitrogen, Phosphorus and Sulfur.

Unit II: Symbiotic and Asymbiotic Nitrogen Fixation – mechanism and genetics of Nitrogen Fixation. Biogeochemical cycles - carbon, nitrogen, phosphorus, sulfur. Biofertilizers - Rhizobium, Azotobacter, Azospirillum, VAM, Phosphobacteria, Azolla Cyanobacteria. Biopesticides. Interrelationships between microorganisms, plants and soil - Enzymes of microbial origin and their role in release of available plant nutrients.

Unit III: Plant Pathology: Plant pathogens and classification of plant diseases. Host-pathogen recognition and specificity. Principles of plant infection and defense mechanisms - entry of pathogen in to host, colonization of host; role of enzymes, toxins and growth regulatory substances. Defense mechanisms in plants - Structural and biochemical - Molecular aspects of host defense reactions - Lipoxygenase and other enzymes in the expression of disease resistance.

a) Isolation of plant pathogens - Study of the following diseases: Tobacco mosaic, Bacterial blight of paddy, Red root of sugarcane, Citrus cancer, Leaf spot of mulberry, Sandal Spike, Root knot of mulberry, Tikka disease.

Unit IV: Microbiology of Air and Water: Composition of air, Number and types of organisms in air, Distribution and sources of air borne organisms, Droplet and droplet nuclei, Assessment of air quality, Airborne diseases, Air sanitation, Microbes and climatic change, Microbial carbon sequestration. Microbiology of water: Aquatic habitats - their microflora and fauna - lake, ponds, river, estuary and sea. Biology and ecology of reservoirs and influence of environmental factors on the aquatic biota. Microbial assessment of water.

Unit V: Waste Water Microbiology: Types of wastes. Characterization of solid and liquid wastes. Treatment of solid wastes - composting, vermiform composting, silage, pyrolysis and saccharifications. Treatment of liquid wastes - Primary, secondary (anaerobic and aerobic) - trickling, activated sludge, oxidation pond, and oxidation ditch-tertiary - disinfection. Degradation of Xenobiotic compounds: Simple aromatics, chlorinated polyaromatic petroleum products, pesticides and surfactants. Biodeterioration of materials - paper, leather, wood, textiles and paint. Metal corrosion - Bioaccumulation of heavy metals. Biofouling and Bioleaching.

Reference Books:

- 1. Alexander M 1971. Microbial Ecology. John Wiley and Sons Inc., New York.
- 2. Alexander M. 1977. Introduction to Soil Microbiology. John Wiley and Sons New York.
- 3. Ecology and Biotreatment by EcEldowney, S. Hardman D.J. and Waite S. 1993. Longman Scientific Technical.
- 4. Bioremediation by Baker K.H. and Herson. D. S, 1994, Mc Graw Hill Inc.,
- 5. Baker KH and Herson DS 1994. Bioremediation. New York.
- 6. Brock TD and Madigan, 1999. Biology of Microorganisms. Prentice Hall Int. Inc. Michel R.(ed). Introduction to Environmental Microbiology.
- 7. Environmental Microbiology edited by Ralph Mitchell. A John Wiley and Sons. Inc.
- G. Rangaswami, D J Bagyaraj, Seiman A. Waksman, 2009, Agricultural Microbiology, 2nd Edition, Prentice-Hall of India Pvt.Ltd, ISBN-10: 8120306686, ISBN-13: 978-8120306684
- 9. Ghulam Hassan Dar, 2010, Soil Microbiology and Biochemistry, New India Publishing, ISBN-10: 9380235135, ISBN-13: 978-9380235134
- 10.Ian Pepper Charles Gerba Terry Gentry, 2014, Environmental Microbiology, 3rd Edition, Academic Press, eBook ISBN: 9780123948175, Hardcover ISBN: 9780123946263
- 11.Eldor A. Paul, 2014. Soil Microbiology, Ecology and Biochemistry, 4th Edition, Academic Press Hardcover ISBN: 9780124159556, eBook ISBN: 9780123914118
- Marylynn V. Yates, Cindy H. Nakatsu, Robert V. Miller, Suresh D. Pillai, 2016, Manual of Environmental Microbiology, 4th Edition, ASM Press, ISBN-10: 1555816029, ISBN-13: 978-1555816025
- 13.Dr. Singh T, Dr. Purohit SS, Dr. Parihar P,2018.Soil Microbiology, 1st Edition, Agrobios, ISBN 10: 8177543903 ISBN 13: 978-8177543902

Elective 2a: Bioinformatics 4 Credits

Objectives:

 To introduce students to the use of information networks and bioinformatics tools on the internet; give students hands-on training on data mining, pairwise and multiple sequence, alignment using packages such as BLAST, ClustalW; and enable students to be able to carry out phylogenetic analysis and predict nucleic acid and protein structures

Outcome:

• Upon successful completion of the course, the students should be able to explain the basics of bioinformatics and computational biology and also be able to use bioinformatics search tools on the internet for mining data, pairwise and multiple sequence alignments and predict protein structures

Unit I: Introductory Bioinformatics and overview of biological research with bioinformatics. Molecular evolution and phylogeny, Publicly available Biological databases (NCBI, EBI and UniProt, HPRD *etc.*,)

Unit II: Biological databases, Plants database, Fly database, Genomics (TCGA, PSRA), Proteomics, Human Proteomic Atlas and Metabolomics (HMDB), Pathway database (KEGG, Netpath), dbSNP.

Unit III: Pairwise and multiple sequence analysis (BLAST, Fasta, BLAT and Clustal). Motif and domain assignments.

Unit IV Integrating multi-omics datasets and understanding biological systems – Genomics, proteomics, transcriptomics, metabolomics and phenomics. Understanding genomics and proteomics into biology *in-silico*. Omics analysis tools.

Unit V: General introduction to Gene expression in prokaryotes and eukaryotes, transcription factors binding sites. SNP, EST, STS. Protein structure prediction- Homology modeling, prediction of protein structure from sequences.

References

- 1. Principles of Gene Manipulation and Genomics(link is external) 7th Edition – Sandy B. Primrose, Richard Twyman – Blackwell Publishing
- 2. Gene Cloning and DNA Analysis: An Introduction(link is external) 6th Edition T. A. Brown John Wiley & Sons
- 3. An Introduction to Genetic Engineering(link is external) 3rd Edition -Desmond S. T. Nicholl - Cambridge University Press
- Molecular Biotechnology: Principles and Applications of Recombinant DNA (link is external)- 4th Edition - Bernard R. Glick, Jack J. Pasternak, Cheryl L. Patten - ASM Press.
- 5. Hiroaki Kitano (editor). Foundations of Systems Biology. MIT Press: 2001. ISBN 0-262-11266-3.
- 6. CP Fall, E Marland, J Wagner and JJ Tyson (Editors). "Computational Cell Biology." Springer Verlag: 2002 ISBN 0-387-95369-8.
- 7. G Bock and JA Goode (eds).In Silico" Simulation of Biological Processes, Novartis Foundation Symposium 247. John Wiley & Sons: 2002. ISBN 0-47084480-9.
- 8. E Klipp, R Herwig, AKowald, C Wierling, and H Lehrach. Systems Biology in Practice. Wiley-VCH: 2005. ISBN 3-527-31078-9.
- L. Alberghina and H. Westerhoff (Editors) Systems Biology: Definitions and Perspectives, Topics in Current Genetics 13, Springer Verlag (2005), ISBN 9783540229681.
- 10. Z. Szallasi, J. Stelling, and V.Periwal (eds.) System Modeling in Cellular Biology: From Concepts to Nuts and Bolts (Hardcover), MIT Press: 2006, ISBN 0-262-19548-8.
- 11.Arthur Lesk, 2013. Introduction to Bioinformatics, 4th Edition, OUP Oxford Publisher, ISBN-10: 0199651566, ISBN-13: 978-0199651566

Elective 2b: Biofertilizer and Biomanure Technology 4 Credits

Objectives:

- To teach students the importance of biofertilizer and biomanure in the field of crop cultivation
- To arouse students interest in the application of modern equipments and understanding of biofertilizers as sustainable means of improving soil health and increasing crop yields
- To make an impact on students with the knowledge of tissue culture and micro propagation as techniques in crop/pest management
- To create students interest in the application of modern equipments and understanding of microbes and their association with fertility and humus formation

Outcomes:

- Upon successful completion of this course, the student will be able to relate increased crop yield to the application of advanced technology in agriculture
- Student will be able to explain the difference between tissue culture and micro propagation; understand usefulness of pest resistant varieties for pest management and biofertilizers and biomanure for soil health and develop skills in handling the modern equipments used for biofertilizer and biomanure production

Unit I: Introduction - History, importance and present status of different types of biofertilizers and their application to crop plants (symbiotic, non-symbiotic, phosphate solubilisers, silicate-zinc solubilisers, Plant Growth Promoting Rhizobacteria (PGPR). Biological fixation of nitrogen; Natural cycles associated with microorganisms - carbon, nitrogen, phosphorous and sulphur.

Unit II:

a) Cyanobacterial Biofertilizers - Nostoc, Anabaena, Gloeocaps and Scytonema as biofertilizers; Symbiotic association with Azolla; Multiplication of blue green algae and its effect on agricultural (rice) yields.

b) Bacterial Biofertilizers - Free living forms :Azatobacter, Azospirillum; Symbiotic forms : Rhizobium - Legume Association; Psuedomanas, Nonlegume association.

c) Fungal Biofertilizers - Ectomycorrhizal association with pines; Vescicular arbuscular mycorrizal association (VAM) - Glomus sp; Actimomycetes as Biofertilizers - Actinomycetes associations - Frankia sp

Unit III: Mass cultivation: Production and application of Rhizobium, Azospirillum, Azotobacter, phospho bacteria and Cyanobacteria. PGPR's plant growth promoting Rhizobacteria and their uses. Composts, Vermi Compost; Microbial compost - pure culture techniques, consortium - types of compost pits. Biodegradation of organic components

Unit IV: Biomanures - A general account of manures – Agro-industrial wastes - Poultry manure and saw-dust; Farm Yard Manure - Oil seed cakes - Castor and neem; Green leaf manures - Gyricidia, Sesbania and Crotalaria.

Unit V: Applications of Biofertilizers and Manures - A combination of biofertilizer and manure applications with reference to soil, seed and leaf sprays. Laboratory and field application; Cost analysis of biofertilizer and biomanure production.

- 1. Burns, R.C. and Hardy, R.W.F., 1975. "Nitrogen fixation in bacteria and higher plants. Springer Verlag, Bertin.
- 2. Gallen and Chaplin, 1987. Introduction to N2 fixation. Elswer Publications.
- 3. Harley, J.L. and Smith, S.E. 1983. Mycorrhizal Symbiosis. Academic Press, London.
- 4. Kumar, H.D., 1990. Introductory Phycology. Affiliated East-West Press Ltd., Madras.
- 5. Marks, G.C. and Koslowski, TT. (Eds.) 1973. Ectomycorrhizae, Academic Press, London.
- 6. Rao, N.S., Venkataraman, G.S. and Kanyan, 1983. Biological N2 fixation, ICAR Publications, New Delhi.

- 7. Sandera, F.E., Mosse. B. and Tinke, P.B., 1975. Endomycorrhizae Academic Press, London. 8. Rao, N.S., 1980. Biofertilizers in Agriculture. Oxford & IBH Publishing Co., Pvt., Ltd., Bombay.
- 8. Thompson, Louis, M. and Fredrick, T., 1979. Soils and Soil Fertility. Tata Mc Graw-Hill Publishing Co., New Delhi.
- 9. Tilak, K.V.B.R., 1990. Bacterial Biofertilizers. IARI Publications, New Delhi.
- 10.Tirdale, Nelson, S.L., Werver, L. and Becton, J.D., 1985. Soil fertility and fertilizers. Macmillan Publishing Co., New York.
- 11. Venkataraman, G.S., 1972. Algal Biofertilizers and Rice Cultivation. Today and Tomorrow's Printers and Publishers, New Delhi.
- 12. Totawat, K.L., Somani, L.L., Sharma, R.A. and Maloo, S.R., 2004. Biofertilizer Technology. Agrotech Publishing Academy. Udaipur, Rajasthan.
- 13.Kannaiyan, S., Kumar, K. and Govindarajan, K., Biofertilizer Technology.
- 14.Subba Rao, N.S., 1995. Soil Microorganisms and plant growth. Oxford and IBH, New york. 16. Subba Rao, N.S., 1995. Biofertilizer in agriculture and forestry. Oxford and IBH, New york.
- 15.http://agritech.tnau.ac.in/ta/org_farm/orgfarm_biofertilizertechnology. html

Elective 2c: Microbial Nanotechnology 4 Credits

Objectives:

- To provide the students with knowledge and the basic understanding of nanotechnology in the field of Microbiology
- To make the students aware of Nano medicines in the field og diagnostics, and health care products

Outcome:

- Upon successful completion of this course, the student will be able to know what it takes to have a career in nanotechnology, understand the need to increase Nanotechnology awareness.
- Student will know the processing of Nanoprticles and Nanomaterials and know the application of Nanotechnology and nanomaterials using microorganisms

Unit I. Introduction to Nanotechnology: Atomic structure, quantum phenomena, nanoparticles, nano-clusters, nanocomposite, nanotubes, nanowires and emergence of bionanotechnology. Characterization of nanoparticles – UV-Vis spectroscopy, Electron Microscopy – HRTEM, SEM, AFM. Scanning probe microscopy in biology and medicine.

Unit II. Biological Synthesis of Nanoparticles: Microbial synthesis of Nanoparticles. Synthesis of nanodrugs – metal nanoparticles, Nanoshells –dendrimers, Nanoparticle drug systems.

Unit III. Preparation of Nano-biomaterials: Polymeric scaffolds, Mucopolysaccharides, proteoglycans, cellulose and derivates; Dextrans; Alginates; Pectins; Chitin. Nanoparticles – types, functions – Silver, Gold and Titanium. Physical and chemical properties of nanoparticles.

Unit IV. Nanoscale applications in biology and medicine: Nanotechnologies for biology and medicine - Micro- and nano- fluidics. Self-assemblyof biological molecules. Drug delivery – protein mediated and nanoparticle mediated. Hybrid-conjugates of gold nanoparticles – DNA origami.Nanoparticles as carrier for genetic material and Nanosensors.

Unit V. Point of Care Diagnostics: Nanodiagnostic in infectious diseases. Nanotechnology to combat microbial resistance. Nanotechnology forPoint-of-Care diagnostics.

Reference Books:

- 1. Nanoscience :Nanobiotechnology and Nanobiology, P. Boisseau, P. Houdy and M. Lahmani, Springer, New York, 2010, ISSN: 978-3-540-88632-7.
- 2. Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology, Hari Singh Nalwa, American Scientific Publishers, USA, 2005, ISSN: 1588830349.
- 3. Nanobiotechnology, C.M.Niemeyer, C.A. Mirkin, Wiley VCH, 2004, ISSN: 3-527-30658-7.
- 4. Nanocomposite Science & Technology, Ajayan, Schadler& Braun, Wiley VCH, 2006, ISSN: 3527605177.
- 5. P. Boisseau, P. Houdy and M. Lahmani, 2010.Nanoscience: Nanobiotechnology and Nanobiology, Springer, New York, ISBN-13: 978-3540886327, ISBN-10: 354088632X
- 6. Jeremy Ramsden Jeremy Ramsden, 2011. Nanotechnology: An Introduction , 1st Edition, William Andrew, eBook ISBN: 9781437778373, Hardcover ISBN: 9780080964478

Practical III Microbial Enzymology, Physiology, Genetics & Genomics

- 1. Preparation of solutions, buffers, pH setting etc.
- 2. Enzyme activity assays: invertase, amylase, alkaline phosphatase
- 3. Glucose uptake by E. coli / Saccharomyces cerevisiae [Active and Passive diffusion]
- 4. Isolation of Photosynthetic bacteria
- 5. Methods for studying microbial respiration
- 6. Isolation of DNA.
 - Isolation of Genomic DNA from E. coli.
 - Determination of purity and concentration of isolated DNA using spectrophotometer
- 7. Isolation of plasmids from bacteria by agarose gel electrophoresis Amplification, purification and separation of PCR product.
- 8. Bioinformatics: FASTA/BLAST (gene /protein sequencing)

Practical IV

Food, Dairy, Soil, Agriculture & Environmental Microbiology

- 1. Microbiological examination of spoiled foods and fruits
- 2. Isolation of toxin producing organisms and estimation of their toxins in different foods
- 3. Microbiological examination of milk and milk products
- 4. Production of fermented milk by Lactobacillus acidophilus
- 5. Study of associated soil microbes with plants: Actinorhiza and Mycorrhiza
- 6. Degradation of cellulose by Chaetomium globosum
- 7. Testing of nodulaton and seed inoculation with Rhizobium

- 8. Mass multiplication techniques of Anabaena in Azolla
- 9. Determination of indices of pollution by measuring BOD/COD of different effluents
- 10.Physical analysis of sewage/industrial effluent by measuring total solids, total dissolved solids and total suspended solids.
- 11.Type study: TMV, Bacterial blight of paddy, Red rot of sugar cane; Leaf spot of mulberry, Root knot of mulberry, Sandal spike, Tikka disease

SEMESTER III

Paper 9: Medical Microbiology and Immunology 4 Credits

Objectives:

- To introduce student to the principles of infection and epidemiology of selected infections, know some viral, bacterial, protozoans and fungal diseases of man
- To give the students an insight to the basic concept of immunology, expose the students to the major determinants that confer immunity in a host to infections and acquire practical skills for immune-diagnosis of infectious diseases•

Outcomes:

- Upon successful completion of this course, the student will be able to understand the principles of infection, explain the epidemiology of some selected infections and their control/preventive measures, collect and analyse samples for laboratory diagnosis
- Upon successful completion of this course, the student will be able to discuss the basic principle underlining body response to foreign agents, purpose and function of antibodies and other molecules involved in resistance to infection, antigens and antibodies interact, mechanism of antibody formation and genetic basis of their synthesis, various diseases associated with immunodeficiency disorders and autoimmunity.
- Student will be able to understand the rejection phenomenon in transplantation immunology, use serological techniques in diagnosis of diseases and detection of contaminants in non clinical samples and acquire skill in immunoprophylaxis and serotherapeutic techniques in treating infections.

Unit I: History and development of Medical Microbiology: Introduction: Important developments in medical microbiology, Concept of epidemic, endemic and pandemic, acute, chronic, morbidity, mortality, prevalence, incidence, Normal microflora of human body and their advantage, Opportunistic infections, sources of infection for man, gnotobiotic study, vehicles or reservoirs of infection; exogenous infection i) patients, ii) carriers (healthy, convalescent, contact, paradoxical andchronic), iii) infected animals (zoonosis), iv) soil endogenous infection, v) water borne infections; Mode of spread of infection : i) respiratory, ii) skin, iii) wound & burn infection, vi) veneral infection, v) alimentary tract infection. Infections of nervous system, General concepts for clinical specimen collection and biosafety levels.

Unit II: Molecular Basis of Microbial Pathogenesis: **a)** Molecular Koch's postulates, Process of infection-Types, stages of infection, Establishment of pathogenic microorganisms: Entry, spread and tissue damage. Mechanism of bacterial adhesion, colonization and invasion of mucous membranes of respiratory, enteric and urogenital tracts. Biofilms and quorum sensing, modulation of apoptotic processes, aggressins and toxins.

b) Clinical Pathogens: Pathogen –morphology, cultural and biochemical charcteristics, classification, resistancepathogenesis, clinical symptoms, laboratory diagnosis, epidemiology, prophylaxis andtreatment of the following:

a) Bacterial diseases – Tuberculosis, Cholera, Typhoid, Syphilis.

b) Viral diseases - Hepatitis, Poliomyelitis, AIDS.

- c) Fungal diseases-Candidiasis, Dermatomycosis (Tinea ringworm infection).
- d) Protozoan diseases Malaria, Trichomoniasis.

c) Antibacterial agents: Mode of action of antibiotics and chemotherapeutic drugs. Antibiograms. Antibiotic sensitivity assays- disc method; replica plating technique; Ames test; Antibiotic resistance in bacteria-various factors that contribute to the development of resistance, MDR Biofilms.

d) Vaccinology: Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines. Antibody genes and antibody engineering-chimeric and hybrid monoclonal antibodies.

Unit III: Immune System: Overview of immune system; cells and organs of immune systems; innate and acquired immunity, Recognition of self and non-self, Humoral immunity-immunoglobulins, basic structure, classes and subclasses, structural and functional relationships, nature of antigen, antigen-antibody reaction, estimation of affinity constants. Molecular Mechanisms of Antibody Diversity and Cellular Immunity: Organization of genes coding for constant and variable regions of heavy chains and light chains, antibody diversity & class switching. Lymphocytes, cytokines, interferons, interleukins, antigen recognition-membrane receptors for antigens

Unit IV: Complement System and Major Histocompatibility System: Complement components, their structure and functions and mechanisms of complement activation by classical, alternative and lectin pathway. Structure and functions of Major Histocompatibility Complex (MHC) and Human Leukocyte Antigen (HLA) system, polymorphism, distribution variation and function. Association of MHC with disease and superantigen, recognition of antigens by T and B-cells, antigen processing, role of MHC molecules in antigen presentation and co-stimulatory signals, & tumor immunology.

Unit V:

a) Hypersensitivity: Types, features and mechanisms of immediate and delayed hypersensitivity reactions, immunity to microbes, immunity to tumors, AIDS and immune-deficiencies, hybridoma technology and vaccine, natural, synthetic and genetic, development of vaccine for diseases like AIDS, cancer and malaria.

b) Monoclonal Antibodies and Diagnostic Immunology: Production, characterization and applications in diagnosis, therapy and basic research, immunotoxins, concept of making immunotoxins. Methods for immunoglobulin determination-quantitative and qualitative antigen and antibody reactions, agglutination-precipitation, immunoflourescence and immunoblotting and assessment of human allergic diseases.

- 1. Roitt IM & Delves PJ (2001) Roitt's essential Immunology.Blackwell Science, Oxford. 10th edition
- 2. Kindt TJ, Goldsby RA, Osborne BA, &Kuby J (2006) KubyImmunology.W.H. Freeman, New York. 6th edition
- 3. Murphy K, Travers P, Walport M, &Janeway C (2008) Janeway'sImmunobiology. Garland Science, New York. 7th edition
- 4. Chapel H (2006) Essentials of clinical Immunology .Blackwell, Malden, Mass. ; Oxford. 5 th edition
- 5. Kimball JW (1986) Introduction to Immunology.Macmillan, London 2nd edition.
- 6. Paniker CKJ (2006) Ananthanarayan&Paniker's Textbook of microbiology. Orient Longaman 7th edition.
- 7. Greenwood, D., Slack, R.B. and Peutherer, J.F.(2002) Medical Microbiology, 16th Edn. Churchill Livingstone, London.
- 8. Finegold, S.M. (2000) Diagnostic Microbiology, 10th Edn. C.V. Mosby Company, St. Louis.
- 9. Ananthanarayanan, R. and JayaramPanicker C.K. (2004) Text book of Microbiology. Orient Longman, Hyderabad.
- 10.Gerhardt, P., Murray, R.G., Wood, W.A. and Kreig, N.R. (Eds) (1994) Methods for General and Molecular Bacteriology. ASM Press, Washington, DC.
- 11.Mackoe and Mc Catney, 1994, Medical Microbiology No I and II. Churchill Livingston, 14th edition.
- 12.Jenni Punt , Sharon Stranford, Patricia Jones, Judy Owen, 2018, Kuby Immunology, 8th Edition, WH Freeman, 978-1464189784
- 13.Andrew H. Lichtman, Abul K. Abbas, Shiv Pillai, 2015. Cellular and Molecular Immunology, 9th Edition, Elsevier 978-0323479783
- 14.Andrew H. Lichtman, Abul K. Abbas, Shiv Pillai,2015. Basic Immunology, 5th Edition, Elsevier, 9780323390828
- 15.Kenneth Murphy, Casey Weaver, 2016. Janeway's Immunobiology, 9th Edition, Norton, W. W. & Company, Inc, 9780815345053
- 16.Patrick R. Murray, 2017. Basic Medical Microbiology, 1st edition, Elsevier -Health Sciences Division, ISBN10: 0323476767, ISBN13: 9780323476768
- 17.Warren E. Levinson, 2016. Review of Medical Microbiology and Immunology, Fourteenth Edition, 14th edition, McGraw-Hill Education – Europe, ISBN10: 0071845747, ISBN13: 9780071845748
- 18.Patrick R. Murray, Ken S. Rosenthal and Michael A. Pfaller, 2015. Medical Microbiology 8th Revised edition, Elsevier - Health Sciences Division, ISBN10: 0323299563, ISBN13: 9780323299565
- 19.Michael Ford, 2014. Medical Microbiology, 2nd Revised edition, Oxford University Press ISBN10: 0199655138, ISBN13: 9780199655137

Paper 10: Molecular Biology and Genetic Engineering 4 Credits

Objectives:

- To enable the students understand the organization of DNA into genes give students deeper insight into the core aspects of the central dogma of molecular biology.
- To introduce students to the importance of elements of genetic engineering and biotechnology and provide students with the basic theoretical knowledge in the field of gene engineering.

Outcomes:

- Upon successful completion of this course, the student will be able to explain how DNA is organized into genes, understand the differences in how gene expression takes place in prokaryotes andeukaryotes; and appreciate how molecular genetic methodologies is impacting positively on medicine
- The student will be able to explain the structure and functions of nucleic acid and protein, understand biogenesis and biogenetics in cells, explain the importance of enzymes in metabolic processes, use of advanced techniques in molecular biology.
- The student will be capable to understand the molecular basis of mutation, exchange genetic information, learn genetic information rearrangement for form new associations, transfer of genetic information from one generation to another, molecular basis mutation, mechanisms of gene transfer in bacteria, the role of recombinant DNA and its application in biotechnology.

Unit I: Fundamentals of Molecular Biology:

a) Concepts in Molecular Biology: Microbes in molecular biology. Organization of Genomes: Prokaryotic genome- Genetic and Physical organization of bacterial genome, Eukaryotic genome, Genetic and Physical organization of nuclear genome.
b) DNA structure and Replication: DNA as Genetic material, Chemistry of DNA, Modes of DNAReplication, Enzymes of DNA replication, Molecular mechanism of DNA replication, Differences inprokaryotic and eukaryotic DNA replication.

c) DNA Damage and Recombination: Types of DNA damage - deamination, oxidative damage, alkylation and pyrimidine dimers; DNA repair – mismatch, short patch repair, nucleotide/base, excision repair, recombination repair and SOS repair. Molecular basis of mutation, Recombination; Site specific recombination, Homologous recombination, transposition

Unit II: Central Dogma of Protein Synthesis: Gene Expression: Structure of RNA- Classes of RNA, Chemistry of RNA. Transcription: Transcription in prokaryotes and eukaryotes, Eukaryotic transcription factors. RNA processing, Ribozymes, Antisense RNA, Inhibitors of transcription and their mechanism of action. Translation: Role of ribosome and different types on RNA in protein synthesis, basic feature of genetic code, mechanism of initiation, elongation and termination, Translational control and posttranslational events. **Regulation of Gene expres**sion: Regulation of gene expression in prokaryotes and Eukaryotes. Regulation of gene expression in bacteriophages, gene silencing – gene regulation after transcription.

Unit III: Fundamentals and Tools of Genetic Engineering: a) Introduction to Genetic Engineering: Definition, concepts and scope of genetic engineering.

Historical perspectives and milestones in Recombinant DNA Technology. Importance of gene cloning and future perspectives. **Tools in Genetic Engineering:** Enzymes in genetic engineering. Cloning vectors: Ti Plasmid,pBR322, pUC –series. Phage vectors-M13 phage vectors, Cosmids-Types, Phasmids or Phagemids, Shuttle vectors. YAC and BAC vectors, Adenoviruses, Retroviruses, Synthetic construction ofvectors, Ti cloning vector. **rDNA Technology:** The basic principles of gene cloning strategies: Preparation, Manipulation andInsertion of desired DNA into vector. Introduction of DNA into host cells – Transformation, Transduction, Transfection, Microinjection, Biolistics, Electroporation, Liposome fusion. Shot gun cloning. Genomic and c-DNA Libraries. Cloning and expression in bacteria, yeasts, Identification and Selection of recombinants.

Unit IV: Techniques in Genetic Engineering: a) Analysis of gene and gene products: Isolation and purification of nucleic acids, staining, Molecular markers in genome analysis: RFLP, RAPD, AFLP and ISSR analysis, DNA sequencing. Blotting techniques- Southern, Northern and Western blotting techniques. PCR – principles, types, and applications Synthetic Genes of microbes. **Microbial genome sequencing projects**: DOE microbial genome program, TIGR microbial database. Analysis of genome sequences, DNA chips: studying gene expression using DNA microarrays. Nest Generation sequence.

Unit V: Applications of Genetic Engineering: a) Applications of gene cloning and Ethics in Genetic Engineering: Applications of gene cloning in Biotechnology, Medicine, Agriculture, Forensic Science, Antisense technology. **Safety** of recombinant DNA technology: Restriction and regulation for the release of GMOs into Environment. Ethical, Legal, Social and Environmental Issues related to rDNA technology.

- 1. Benjamin, L. 1990. Gene 4th edn. Oxford Univ. Press, Oxford.
- 2. Brown, T. A. 1991. Essential Molecular Biology. A Practical Approach Vol-I & Vol.-II, Oxford Univ. Press. Oxford.
- 3. Flint, S.J., Enquist, L.W., Drug, R.M., Racaniello, V.R. and Skalka, A.M. 2000. Principles of Virology- Molecular Biology, Pathogenesis and Control. ASM Press, Washington, D.C.
- 4. Garrett and Grisham. 1999. Biochemistry. 2nd edn. Saunders college pub. USA.
- 5. Alexander N. Glazer, Hiroshi Nikaido(2007) Microbial BiotechnologyFundamentals of Applied Microbiology 2nd Ed. Cambridge University Press
- 6. H.-J. Rehm, G. Reed. (2008) Biotechnology: Genetic Fundamentals and Genetic Engineering, Volume 2, Second Edition. Wiley.
- 7. Desmond, S. T. and Nicholl. (2002) An Introduction to Genetic Engineering. Cambridge Univ. Press. Cambridge
- 8. Maheshwari, D.K., Dubey, R.C. and Kang, S.C.(2006) Biotechnological Applications of Microorganisms. I.K. International Publishing House. New Delhi.
- 9. Harvey Lodish, 2016, Molecular Biology, 8th Edition, W.H.Freeman, 1464183392
- 10. Gerald Karp, Janet Iwasa, Wallace Marshall, 2015. Cell and Molecular Biology: Concepts and Experiments, 8th Edition, Wiley, 978-1-118-88614-4
- 11.John Kammermeyer, Genetic Engineering Fundamentals: An Introduction to Principles and Applications, 1st Edition, CRC Press, Taylor & Francis

Group, 9780824780692

- Jeremy W.Dale, Malcolm Von Schantz, 2012. From Genes to Genomes: Concepts and Application of DNA Technology, 3rd Edition, Wiley-Blackwell, 978-0470683859
- 13. Jane K. Setlow, 2010. Genetic Engineering Principles and Methods, 1st Edition, Springer 978-1441941534
- 14. Sandy B.Primrose, Richard Twyman, 2016. Principles of Gene Manipulation and Genomics, 8th Edition, Wiley-Blackwell, 978-1-405-15666-0
- 15. David Calrk, Nanette Pazdernik, Michelle McGehee, 2018, Molecular Biology, 3rd Edition Elsevier, 9780128132883

Paper 11: Industrial Microbiology and Fermentation Technology 4 Credits

Objectives:

- To highlight the importance of microorganisms in the production of useful human products, To dispel the age long fear that microorganisms can only cause sicknesses and diseases
- To introduce the students to the various concepts of fermentation, role microorganism in fermentation process, skills to produce some foods and drinks resulting from either alcoholic or acidic fermentation processes

Outcome:

- Upon successful completion of this course, the student will be able to: know that microorganisms are important in the production of many useful products, source of microorganisms of industrial importance from the environment, physical and chemical conditions that are involved in the production of useful industrial products of microbial origin, cultural and genetic manipulation of these micro orgasms in order to produce more of these useful products
- The student will be able to understand the various concepts of fermentation, know the differences between aerobic and anaerobic fermentation and the classification of microorganisms based on their respiratory action, growth of microorganism and their role in producing foods and drinks, isolate and identify microorganisms from fermenting fruits, cereals and milk.

Unit I: Industrially Important Microorganisms - Isolation, preservation and improvement of strains - handling - development of inoculum for various fermentation processed upstream processing - media for industrial fermentation - formulation - sterilization.

Unit II: Fermentation Processes: An Introduction on fermentation process - The range of fermentation process, chronological development - component parts of fermentation process - fermentation economics.

Unit III: Types of Fermentation : Fermentation types - submerged and solid state fermentation - Down stream processing - Recovery of intracellular and extra cellular products - Biomass separation by centrifugation, filtration, flocculation and other recent developments, Cell disintegration - physical, chemical and enzymatic methods. Extraction - solvent, two phase, liquid extraction, whole broth, aqueous

multiphase extraction. Purification by different methods, Concentration by precipitation, ultra filtration, reverse osmosis. Drying and crystallization.

Unit IV: Design of Fermenter: Fermenter design - Body construction, individual parts, heat production - gas liquid exchange - mass transfer - heat transfer - oxygen transfer - stirring and mixing - Newtonian, non-Newtonian fluids - effect of viscosity - scale up - control of temperature, pH, form pressure - Sterilization of Bioreactors and nutrients, computer application and fermenter technology.

Unit V:Microbial Industrial Production: Microbial production of organic acids - Amino acids, antibiotics - enzymes - vitamins - alcoholic beverages - wine and beer. Fermented foods - bread, cheese, soy sauce. Microbial transformations - steroids and sterols, non steroid compounds - antibiotics and pesticides. Mushroom: Types, Cultivation and its nutritional value.

Reference Books:

- 1. Stanbury, P.F., Whittaker, A. and Hall, S.J., 1995. Principles of fermentation technology, 2nd edition, Pergamon press.
- 2. Crueger and Crueger, A., Biotechnology : A text book of Industrial Microbiology, 2nd edition, Sinavos association, InoSundeland.
- 3. Cassida, J.E., 1968. Industrial Microbiology, Willy Eastern.
- 4. Presscott and Dunn, S., Industrial Microbiology.
- 5. Peppler, H. J. and Pearlman, D. 1979. Microbial Technology, Vol 1 ans 2, Academic press.
- 6. Demain, A. L. and Soloman INA, 1986. Mammal of Industrial Microbiology and Biotechnology, American society for Microbiology, Washington DC.
- 7. Belter, P.A., Cussler, E.L. and Hu, W.S., Bioseparation: Down stream processing for Biotechnology, John Wiley and Sons, N.Y.
- 8. Chisti, Y., Fermentation, Biocatalysis and bioseparation, Encyclopedia of Bioprocess Technology, Vol. 5, John Wiley and Sons, N, Y.
- 9. Scragg, A. (1999) Environmental Biotechnology. Pearson Education Ltd., England.
- 10.Marshall, K.C. (1985) Advances in Microbial Ecology, Vol.8, Plenum Press, U.K.
- 11.Fletcher, M. and Gray, T.R.G. (1987). Ecology of Microbial communities. Cambridge University Press, Cambridge, UK.
- 12.Forster, C.F. (1985). Biotechnology and Wastewater Treatment. Cambridge University Press, Cambridge, UK.
- 13.Gray, N.F. (1989). Biology of Waste Water Treatment. Oxford University Press, Oxford, UK.
- 14. Peter Stanbury Allan Whitaker Stephen Hall, 2016. Principles of Fermentation Technology 3rd Edition, Butterworth-Heineman, 9780080999531
- 15.E.M.T.El-Mansi, C.F.A.Bryce, Arnold L.Demain, 2012. Fermentation Microbiology and Biotechnology, 3rd Edition, CRC Press Taylor & Francis Group, 9781439855799
- 16.Michael J. Waites, Neil L. Morgan, John S. Rockey, Gary Higton, 2010. Industrial Microbiology: An Introduction, 1st Edition, Blackwell Science, 0-632-05307-0
- 17.L E Casida, J R, 2016, Industrial Microbiology, 2nd Edition, John Wiley & Sons Inc. 978-0471140603,

Paper 12: Microbial Bioremediation and Technology 4 Credits

Objectives:

- To make students aware on the use and types of bioremediation, bioleaching and extraction of metals from ores using microbes.
- To expose students to the various groups of microbes and their exploitation in different fields of biodegradation of organic wastes, xenobiotic compounds, hazardous chemicals etc.,

Outcome:

- Upon successful completion of this course, the student will be able to identify the microorganisms useful in the field of bioremediation.
- Student will be skilled to understand and explain the principles of various techniques used in studying mechanism of microorganisms involved in degradation of environmental pollutants

Unit I: Bioremediation: definition, microbial approaches to bioremediation. Bioremediation of contaminated soils. Diversity and magnitude of soil contaminants. Bioremediation of contaminated aquifers. Oil spills degradation. Bioremediation of air pollutants. Bioleaching, biomagnifications, bioaccumulation of metallic and non metallic components.

Unit II: Microbes involved in biodegradation of organic wastes and xenobiotic compounds – heavy metals, pesticides, insecticides, Bioinsecticides – BT toxin. Microbial leaching: Extraction of metals from ores. Biofuels, Microbial hydrogen production, Biodegradation of oils and petroleum products

Unit III: Definition, concepts – history, biotechnological potentials of microalgae – food – feed – fuel and pharmaceutically valuable compounds. Cultivation methods of algae with reference to Dunaliella. Production of microbial biofertilizers – cyanobacteria, Rhizobium, Azotobacter, Azospirillum, Phosphobacteria and VAM **Unit IV:** Single cell protein – Chlorella, Spirullina, Yeasts, Mushrooms, SCP from wastes. Economic implications of SCP, microbial production of enzymes – cellulase, lipase, Taq polymerase and restriction endonuclease. Production of wine, vinegar and alcohol

Unit V:Immobilization of enzymes – Starch processing industry – proteases – therapeutic enzymes – Diagnostic enzymes - Enhancement of enzyme activity – uses of engineered protein – advantages of protein engineering

- 1. Bioremediation by Baker K.H. And Herson D.S. 1994..MacGraw Hill Inc. N.Y.
- 2. Biodegradation and Bioremediation, Academic Press, San Diego.
- 3. Genetics and Biotechnology of Industrial Microorgansims by C.I. Hershnergey, S.W. Queener and Q.Hegeman. Publisher. ASM. Ewesis ET. Al. 1998. Bioremediation Principles. Mac Graw Hill.
- 4. Balasubramaniam D, Bryce CFA, Dharmalingam K, Green J, Jayaraman K. (1996). Concepts in Biotechnology, University Press, India. Borowitzka MA,
- 5. Borowitzka LJ (1989) Microalgal technology, Cambridge University Press
- 6. Glick BR, Pastenak JJ (1998) Molecular Biotechnology Principles and applications of recombinant DNA, ASM press, Washington DC
- 7. Glick BR, Pastenak JJ (1994) Molecular Biotechnology, ASM press, Washington DC
- 8. Glazer AN., Nikaido H (1994) Microbial Biotechnology Fundamentals of Applied Microbiology, WH freeman and company, New York

- 9. Walsh G, Headon Dr. (1994) Protein Biotechnology, John Wiley and Sons, New York
- 10.Surajit Das, 2014. Microbial Biodegradation and Bioremediation, 1st edition, Elsevier Science Publishing Co Inc, ISBN10: 012800021X, ISBN13:9780128000212
- 11.Jesus Bernardino Velazquez-fernandez , Sae Muniz-hernandez, 2014. Bioremediation: Processes, Challenges & Future Prospects, 1st edition, Nova Science Publishers Inc, ISBN10: 1629485136, ISBN13: 9781629485133
- 12.Baskar Gurunathan Zainul Akmar Zakaria , DEEPAK PANT , Sunita J. Varjani and Edgard Gnansounou, Waste Bioremediation, 1st edition, Springer Verlag, Singapore, ISBN10: 9811074127, ISBN13: 9789811074127
- 13.Ashok K. Rathoure, Bioremediation: Current Research and Applications, 1st edition, K International Publishing House Pvt. Ltd, ISBN10: 9385909606, ISBN13: 9789385909603

Practical V

Medical Microbiology & Immunology and Molecular Biology & Genetic Engineering

- 1. Study of normal micro-biota of mouth; isolation, identification and preservation of microorganisms
- 2. Study of normal micro-biota of skin; isolation identification and preservation of Microorganisms
- Type Study:
 Viral: Influenza, Herpes, Ebola, HPV Bacterial: Whoopincaugh, Leprosy, Tetanus, Fungal: Tenia, Fungal Meningitis, Aspergillosis Protozoan: Leishmaniasis, Giardiasis, Trypanosomiasis
- 4. Isolation of mononuclear cells from peripheral blood and viability test by dye exclusion method
- 5. Double immunodiffusion test using specific antibody and antigen, Dot Immuno blot assay (DIBA), ELISA, VDRL.
- 6. Isolation of genomic DNA from bacteria/ fungi / plants.
- 7. Amplification of known DNA sequences by Polymerase Chain Reaction (PCR).
- 8. Digestion of DNA using restriction enzymes (RE) and agarose gel electrophoresis
- 9. cDNA synthesis and PCR analysis.

Practical VI

Industrial Microbiology & Fermentation Technology and Microbial Bioremediation & Technology

- 1. Isolation of industrially important microorganisms for microbial processes (citric / lactic/ alpha amylase) and improvement of strain for increase yield by mutation.
- 2. Biomass production (Baker's yeast and Spirulina).
- 3. Extraction of Citric acid/Lactic acid by salt precipitation.
- 4. Production of fermented milk by Lactobacillus acidophilus

- 5. Estimation of the fermentation products by titration Method
- 6. Biotransformation of toxic chromium (+ 6) into non-toxic (+ 3) by Pseudomonas species.
- 7. Tests for the microbial degradation products of aromatic hydrocarbons / aromatic compounds.
- 8. Reduction of distillery spent wash (or any other industrial effluent) BOD by bacterial cultures.
- 9. Microbial dye decolorization/adsorption

Elective 3a: Industrial training and Entrepreneurship 4 Credits

Objectives:

- The students are exposed to various definitions of Entrepreneur and Entrepreneurship also, distinguishes between entrepreneurship and entrepreneur.
- Introduce students to the principles and concepts of entrepreneurship; its historical development, and the importance of entrepreneurship in economic development and also master the need to effectively apply the theories and various approaches of entrepreneurship to create wealth

Outcomes:

- Upon successful completion of this course, the students will be able to master the relevance of Entrepreneurship and Entrepreneurs to the economic development of the nation especially regarding job creation and poverty alleviation in general.
- Students will be capable of identifying their community's personalities with entrepreneurial traits and the rewards which they enjoy including innvestment opportunities in their communities.

Unit I: Fundamentals of Entrepreneurship: Introduction, Concept of entrepreneurship, Historical background, need and scope of entrepreneurship in modern society, Entrepreneurial behavior, attributes and skills. Key elements of entrepreneur, Entrepreneurial process, Entrepreneurial culture, Environment of Entrepreneurship, Socio economic origins of Entrepreneurship, Barriers of Entrepreneurship and means to reduce those, types of Entrepreneurs, Characteristics of Entrepreneur.

Unit II: Business Organizations: Forms of business organizations such as sole proprietorship, partnership, Joint Stock Company, cooperative organization etc. Meaning and definition, Relative merits and demerits of each form, , Types of Small Scale Industry.

Unit III: Study of Organizations Promoting Entrepreneurship Sources of Information: Where to go for what? a) District Industry Centre (DIC) b) Maharashtra Industrial Development Corporation (MIDC) c) Maharashtra State Small Industries Development Corporation (MSSI DC) d) Small Industries Services Institute (SISI) e) National Institutes of Entrepreneurship and Small business Development (NIESBUD) f) National Entrepreneurship Development Board (NEDB) Entrepreneurship Development Institute of India h) Commercial and Co-operative Banks i) State Industrial Development Bank (SIDBI) j) Pollution Control Board Legal Aspects of Small Business: Elementary knowledge of Income Tax, Sales Tax, VAT, Service Tax, Patent Rules, Excise Rules, Factory Act and Payment of Wages Act, TDS act Procedures for registration of SSI, TDS no, PAN no.

Unit IV Entrepreneurship Development: Identification of opportunities for entrepreneurship, ideas to start new business, criteria for selection of new product or service, Market Survey as a tool, Technical and economic feasibility of a project, Role of consultancy organizations. 8 Lectures Project formulation and project report preparation (Use guidelines given in Schedule II)

Financial Aspects: Govt/Public sources of finance Sources of finance, Role of various funding agencies, government and commercial Role of various funding corporations and funding institutes such as chamber of commerce, MSFC, MCED, NSSIDC, Banks, special institutes such as IDBI,MIDC,SICOMetc, Working capital, cash flow, fund flow, study of basic financial statements, costing and pricing, breakeven point, SWOT analysis. Private Sources 1. Equity –Angel finance, Venture capital 2. Debt Finance – Loans from banks loan against co-lateral security, PMYR-Loans with subsidy from Central GOVT, State Govt , CGTSME(Central Grant For Small Medium Enterprise)

Unit V Marketing Aspects: Meaning, scope and importance, Marketing strategy, Market segmentation, marketing channels. Marketing mix and its effect. Digital marketing through Web browsing, Face book, Google search engines SMS campaigns, Mailers, Hand bills. Human Resource Aspects: (H.R Policies) Concept and scope in modern industry, Different modes of employment, Placement of proper person for a job, Interpersonal relations and communication skills, training of personnel, guidance for stress management, soft skills. Drafting -Appointment letter, termination tenure , experience certificates , exit policies Legal liabilities of employees, Group insurance for factory workers, understanding WAC (Workers Accident Compensation)

Reference Books:

- 1. Dynamics of Entrepreneurial Development and Management Shri. Vasant Desai.
- 2. Environment & Entrepreneur: Mr.B.C.Tondon
- 3. Business Environment: Dr.G.V.KayandePatil
- 4. Udyogvardhini -MCED
- 5. Basic Communication Skills: By P. KiranmaiDutt&GeethaRajeevan, 2000
- 6. Fundamentals of Office Management: By J.P. Mahajan , Office Management By S. P. Arrora.
- 7. A guide to small Scale Entrepreneurs, Director of Industries, Govt. of Tamil Nadu Chennai.
- 8. Entrepreneurship and small Business Management- Dr. C. B. Gupta & Dr. Khanna
- 9. 100 project Reports YashwantraoChavan Open Universiy (YCMOU) Edition
- 10. Entrepreneurship Ideas in Action Cynthia L. Greene (YCMOU) Edition
- 11. Project Management by K. Nagarajan.

Elective 3b: Disease Diagnostic Technology 4 Credits

Objectives:

- Student will be introduced with the importance od diseases and proper diagnosis of the diseases
- The student will be made aware on the serology and serological tests to diagnose the disease and the treatment measures
- Students will be taught with vaccine production, immunological techniques tools and techniques in disease diagnosis and antimicrobial chemotherapy

Outcomes:

- Student will be skilled with advanced tools and techniques in diagnosis od the disease
- Student will be capable of carrying the diagnostic tests specific to the disease and analyze the causative agent for the disease
- Student will be well- versed with serological tests, immunodiagnosis, vaccines and vaccine production

Unit I:

a) Introduction to clinical Microbiology: Role of Microbiologist in Diagnostic laboratory, General concepts for specimen collection, handling, transportation, processing, specimen workup, Laboratory safety and infection control.

b) **Scientific and Laboratory basis for Detection of infectious diseases:** RPR, WIDAL, VDRL, HBs-Ag, HIV, H1N1, SARS, Dengue, TB & Malaria.

Unit II: Bacterial Serology: Selection, collection and transport of specimens –Blood, Urine, Sputum, CSF, Pus & Faeces – transport media and storage. Microscopic examination of specimen for Bacterial pathogens – simple, differential staining and motility. Identification of organisms - Biochemical reaction – Sugar fermentation test - Susceptibility testing – MIC, E test - reporting of results & interpretation. Serology – Antigen - antibody reactions – Agglutinations (blood grouping, WIDAL) RPR and Hemaaglutination, Precipitation (VDRL), Immunodiffusion – mono and double immunodiffusion, Immunoelectorophoresis (rocket, counter current). ELISA, Radioimmune assay (RIA)

Unit III:

a) Immunotechniques and Immunodiagnosis: Antigens and Antibody reactions in vitro; Agglutination, complement fixation, ELISA, Western Blotting Immunodiffusion, Immunoelectrophoresis, Immunoflurescence, Immunoprecipitation, Radioimmunoassay and serotyping.

b) Vaccines and Vaccination: Vaccines – definition, types, Antigens used as Vaccines, effectiveness of vaccines, Vaccine safety, current vaccines, adjuvants, active immunization and passive immunization.

Unit IV: Recent Diagnostic tools and techniques: Principle, working and application of a) Autoanalyser b) Biosensor glucometer c) Diagnositic kits- ELISA, Western Blot d) Enzymes in Disease diagnosis and therapy: Lactate dehydrogenase, Aspartate aminotransferase, Alkaline phosphatase, Creatine kinase, Acid phosphotase, Cholinesterase.

Unit V: Antimicrobial Chemotherapy: Development of chemotherapy and chemoprophylaxis General characteristics of drugs and their testing; Mechanism of action. Antibacterial drugs; antifungal drugs, antiviral and antiprotozoan drugs; antibiotic sensitivity testing, MIC, Drug resistance; mechanism of drug resistance; multi drug resistance.

- 1. Brooks, G.F., Butel, J.S., and Ornston, L.N.1995. Jawetz, Melnick & Adelberg's Medical Microbiology, 20th ed, Stamford, Conn, Appleton & Lange.
- 2. Fernandes, P.B. 1996, Pharmaceutical perspective on the development of drugs to treat infectious diseases. ASM Press.
- 3. Gootz.T.D. 1990. Discovery and development of new antimicrobial agents, Clinical Microbiology.

- 4. Isenberg, H.D., editor, 1992, Clinical microbiology procedures handbook, Washington, D.C. American Society for Microbiology.
- 5. Miller, M.J. 1996. A Guide to specimen management in clinical microbiology, Washington, D.C. ASM press.
- 6. Murray, P.R., editor-in-chief, 1995, Manual of clinical microbiology, 6th ed. Washington, D.C., ASM Press.
- Rose, N.R., Macario, E., Fahey, J., Friedman, H., and Penn, G., edigtors. 1997, Manual of clinical laboratory immunology, 5th ed, Washington, D.C., American society for Microbiology. 8. Stites, D.P., Terr, A. I., and Parslow, T.G. 1994, Basic and clinical immunology, 8th ed, Norwalk, Conn, Appleton and Lange.
- 8. Turgeon, M.L., 1990. Immunology and serology in laboratory medicine, St.Louis, C.V. Mosby Co.

Elective 3c: Intellectual Property Rights, Biosafety and Bioethics 4 Credits

Objectives:

 The provide students with sound theoretical knowledge on intellectual property rights, biosafety and bioethics related to applications of Microbial biotechnology

Outcomes:

- Upon successful completion of this course, the student will be able to explain about patents, patent laws, agreements, concepts of patents and food laws
- Student will be aware of the genetically modified foods and the ethics with laws, rules and regulations of biosafety in the field of genetic engineering

Unit I: Introduction to Intellectual Property IPR: Definition - Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, IP as a factor in R&D; IPs of relevance to Microbiology / Biotechnology and few Case Studies WTO - Definition - Functions - Forms of IPR Protection.

Unit II: Agreements and Treaties: History of GATT & TRIPS Agreement; Madrid Agreement; Hague Agreement; WIPO Treaties; Budapest Treaty; PCT; Indian Patent Act 1970 & recent amendments.

Unit III: Basics of Patents and Concept of Prior Art: Introduction to Patents; Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent

of Addition; Specifications: Provisional and complete; Forms and fees Invention in context of "prior art"; Patent databases; Searching International Databases; Country-wise patent searches (USPTO, esp@cenet(EPO), PATENT Scope (WIPO), IPO, etc.). National & PCT filing procedure; Time frame and cost; Status of the patent applications filed; Precautions while patenting –disclosure/non-disclosure; Financial assistance for patenting -introduction to existing schemes Patent licensing and agreement Patent infringement- meaning, scope, litigation, case studies

Unit IV: Biosafety: Introduction; Historical Background; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; 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; Biosafety in relation to transgenic research and applications

Unit V: Bioethics: Definition - Animal ethics - Norms in India - Licensing of animal house - Ethical clearance norms for conducting studies on human subjects.

Reference Books:

- 1. BAREACT, Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., 2007
- 2. Kankanala C., Genetic Patent Law & Strategy, 1st Edition, Manupatra Information Solution Pvt. Ltd., 2007
- 3. Gurumani, N. Research Methodology, For Biological Sciences. MJP Publishers, Chennai 2006

SEMESTER IV

Project Work

Summer Internship – 2 Credits MSc dissertation – 12 Credits

PG Diploma Tissue Culture

Course Overview

The discipline "TISSUE CULTURE" a novel concept of culturing totipotent single cells and developing the plants that is challengeable to the environmental habitat including to the dominating pathogens that cause diseases. Gottlieb Haberlandt, the father of plant tissue culture, established this unique process that involves the cultivation of embryo and culturing of vegetative cells in vitro and acclimatizing in vivo. Tissue culture has at most priority in the fields of Plant Breeding, Plant Propagation and Plant Biotechnology. It has become one of the most reliable and dependent technology among the plant science study. Inclusive of Molecular Biology and Genetic Engineering this branch of science can revolutionize the existing system. This branch has been exploited and explored in different contexts viz., Industrial, Commercial production of saplings and Research and development etc.,

On the other hand, cell culture technique enables to understand the structure and functions of cells which is programmed by Genetic Engineering tools and techniques for the production of vaccines, interferon, clinical substances viz., growth hormones, monoclonal antibody production, stem cells etc.,

In the current scenario tissue cultured plantlets are on demand in the country. It is estimated that around 200 crores of turnover in the domestic market is proving its potency with 20% annual growth. There are more than 70 commercial tissue culture units established in the country. This field of science is also supported by Department of Biotechnology (DBT) in various research institutions and Universities for improving the protocols that can be extralopated to the different fields viz., State Agriculture Department, Agri ExportZones (AEZs), Spice Board, Sugar industry, Paper industry, Medicinal plant industry and StateForest Departments etc.,

Carrer oppurtunities:

- This field is another candidate in the pool of scientific horizon that creates ample avenues for undergraduate and postgraduate students in both the field of research and placements in research and developments and also in biotechnology based companies.
- The students will be technically and critically trained with good practical exposure to perform both the plant and animal culture, which is the at most required in this field of science, skilled candidates are absorbed in well established and commercial tissue culture units.
- This area can be taken up as micropropagation businesswith smaller investment by entrepreneurs.
- Many Central and State Government departments to name a few: TheDepartment of Agriculture and Cooperation, National Horticulture Board (NHB) underthe Ministry of Agriculture, Agricultural and Processed food products Export Development Authority (APEDA) under the Ministry of Commerce and Industry etc., are promoting by providing various schemes and subsidies along with incentives to strengthen this stupendous decipline.

ELIGIBILITY: This is an addon course. The students can enroll for this course along with their undergraduate or postgraduate course. This course can be also be taken by professionals from other specialized scientific areas of research.study.

Part	Study Compo- nents and Code	Paper	Hrs/ week	Deeme Exami				
				Dur. in Hours	CIA	The- ory/ prac- tical Exam	Max. Marks	Total Credit
SEMESTER I								

Course Curriculum

I	Paper I	Funda- mentals of Plant Tissue Culture	4	3	25	75	100	4
II	Paper II	Tech- niques in Plant Tissue Culture	4	3	25	75	100	4
	Practicals-I		6	3	50	150	200	6
400								14
	1		SEME	STER II			· · · · · ·	1
III	Paper III	Industri- al Appli- cation of Tissue Culture and Con- servation of Germ Plasm	4	3	25	75	100	4
IV	Paper IV	Applica- tions of Animal Cell Cul- ture	4	3	25	75	100	4
	Practicals - II		6	3	50	150	200	6
v	Project					150 + 50 (pre- sen- tation and viva)	200	(10+2)12
60						600	26	
ΤΟΤΑ	L (I & II SEM				MA :	TICCU		40
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Paper I						4	4	
Paper II 4						4		
Practicals-I (3+3)						6	6	
II SEMESTER								
Paper III						4	4	
Paper IV							4	

Practicals-II(3+3)	6		
Project	12(10+2)		
Total Credits	40		

I SEMESTER

PAPER 1: FUNDAMENTALS OF PLANT TISSUE CULTURE 4 CREDITS

Objectives:

- This course seeks to familiarize students to the basic principles of plant tissue culture and to expose them to its applications.
- To convey the concepts of plant tissue culture and transformation in lectures.

Outcome:

- Student will be able to initiate the tissue culture with acquired knowledge on sterilization and explants preparation
- Induce contamination free callus to generate disease free plants, being prime principle will be executed by the student

UNIT I: INTRODUCTION TO PLANT TISSUE CULTURE

Introduction of plant tissue culture: Origin, history, development, Scope and applications: Micropropagation, Crop improvement (Haploids and Protoplast culture), Disease free plants, production of transgenic plants (genetic variation), conservation of germ plasm, secondary metabolite production : Pharmaceutical and Food industries.

UNIT II: LABORATORY DESIGN AND STERILIZATION TECHNIQUES

Laboratory planning and design: Equipments /instruments, media / culture room, green houses, Sterile transfer room, water treatment and purification systems. Aseptic techniques: Physical methods ofsterilization (heating) chemical methods of sterilization (surfactants) surface sterilization of explants

UNIT III: TISSUE CULTURE MEDIA AND PREPARATION

Composition of media, growth regulators, role of organic supplements and undefined constituents in tissue culture, gelling agents (Tapioca), tissue culture media preparation.

UNIT IV: CONCEPTS OF TISSUE CULTURE

Plant cell culture: Cellular totipotency, polarity, differentiation and morphogenesis (in vitro), molecular basis of differentiation.

Unit V: INITIATION OF PLANT TISSUE CULTURE

Explants: Selection, preparation sterilization, inoculation, subculturing of explants: Callus and suspension cultures, Types of suspension cultures, secondary metabolite production and its applications.Batch cultures and bioreactors.

Reference Books:

1. Ammirato P.V., Embryogenesis. Handbook of plant cell culture. Event, D., sharp, W.R., ammirato, P.V. and Yamada, Y.(Eds.)Maccmillan, New york.1983Page.82-123.2)
- 2. Akio Fujiwara, ed. Plant Tissue Culture. Japan5th IAPTC Congress. 1982.
- 3. Barz W et al, Wagner F, "Plant Tissue Culture and its Bio -technological application", Springer-Verlag, Berlin Heidelberg, 1977, Page 250.18)
- 4. Bhojwani S. S. , razdan M.K., Plant Tissue Culture: Theory and Practice, Elsevier Science Pub, Amsterdam, 19834)
- 5. Dodds, JH and Roberts, LW. Experiments in Plant Tissue Culture . Cambridge University Press. 2nd edition, 1985.232pp.
- 6. Donnelly D.J., Vidaver W.E., Glossary of plant Tissue Culture, Timber Press, Porland 198812)
- 7. GuriA.Z., Patel K.N., Composition and method to prevent microbial contamination of plant tissue culture media,U.S.Patent No.5,750.420.8)
- 8. Jha, T. B and Ghosh, B. "Plant Tissue Culture Basic and Applied", Universities Press, 2005, 206 pp
- 9. Smith R.H., Plantt Tissue Culture-Techniques and Experiments, Academic Press, 1992.14)
- 10.Miller, LR and Murashige, T. In vitro. 12 1976.:797-813.
- 11.Carrel, Alexis and Montrose T. Burrows "Cultivation of Tissues in Vitro and its Technique"; Journal of Experimental Medicine 13 (1911: 387-96)

PAPER 2: TECHNIQUES IN PLANT TISSUE CULTURE 4 Credits

Objectives:

- To develop and standardize protocols for the in vitro propagation from ex vitro explants
- To optimize the culture conditions for rapid propagation to increase the biomass production
- Optimization of medium and culture conditions for the enhancement of active principle production by different approaches viz., Micropropagation, Somaclonal Variation, Somatic Hybridisation, Synthestic seeds etc.,
- To provide hands-on experience of the most common of these techniques in labs and demonstrations of more advanced techniques.

Outcome:

- Students will be acquiring high knowledge on micropropagation that can be used to produce disease-free plants.
- Student will be able to apply the skill of somaclonal variation in plant/crop improvement, synthetic eed technology, protoplast fusion, somatic hybridisation that leads to the creation of additional genetic variability. Characteristics for which somaclonal mutants can be enriched during in vitro culture includes resistance to disease pathotoxins, herbicides, high salt concentration, mineral toxicity and tolerance to environmental or chemical stress, as well as for increased production of secondary metabolites

UNIT I: MICROPROPAGATION

Definition, methods of micropropagation: Different pathways of Micropropagation. Shoot differentiation, Somatic embryogenesis, Callus organogenesis.

Stages of micropropagation: Stages, Commercial applications - Silviculture, forestry, horticulture, agriculture and crop improvement.

Merits and Demerits of micropropagation.

UNIT II: CULTURE OF REPRODUCTIVE STRUCTURES

Production of haploids: Anther and Microspores, Ovary and Ovule culture and ap-

plications. Applications of haploids in plant breeding (homozygous haploids).Embyo and Endosperm culture and their application.

Unit III: SYNTHETIC SEED TECHNOLOGY

History, production of synthetic seeds, types (Desiccated and hydrated synseeds), advantages and disadvantages of synthetic seeds and basic techniques:Synseed germination, advantages and disadvantages of artificial seeds and application.

Unit IV: SOMACLONAL VARIATION

Origin and cause of variation, molecular mechanismof somaclonal variation, kinds of variation, nature of variation, utility of somaclonal variation, Scope of somaclonal variation in interspecific crosses. Screening and selection of somaclones.Variability test in micropropagation (importance).Screening and variability of tissue culture regenerants, molecular screening.

Unit V: PROTOPLAST CULTURE AND SOMATIC HYBRIDIZATION

Isolation, purification and culture of plant protoplasts, protoplast fusion and somatic cell hybridization. Practical applications of protoplast technology

Reference Books:

- 1. Bajaj Y.P.S., Somatic Embryogenesis and Synthetic Seed, Biotechnology in Agriculture and Forestry, Springer-verleg, Berlin , Vol. 30, 1995.3)
- 2. Cutter E.G., Recent experiment studies of the shoot apex and shoot morphogenesis,Bot.REV. 31, page 7-113.6)
- Cyr D.R, Black M., Bewley J.D., Seed substitutes from the laboratory, Seed Technology and its Biological Basis.(Eds.).Sheffield Acad. Press, Sheffield.2000,page 326-372.5)
- 4. Debergh P.C., Zimmerman R.H., Micropropagation, Technology and Application \, Kluwer Academic Pubishers. 199111)
- 5. Dostoevsky F., Irodov I., "Essential of plant Biotechnology", San Puerto publication, 2 nd edition, page-1123-1131
- 6. Hanning G.E., Conger B.V., Factors influencing somatic embryogenesis from cultured leaf segment of Dactylisglomerata. J . plant Physiol, Vol123, 1986,Page 23-29.9)
- 7. Kyte L.J., Kleyn, Plants from Test Tubes: An Introduction to Micropropagation, 3 rd ed., Timber press, 1996.13)
- 8. Leifert C., Cassells A.C., Microbial hazards in plant tissue and cell cultures. In vitro cellular and development biology,Vol. 37,2001, page 133-138.10)
- 9. Merkle, SA. Morphogenetic Aspects of Somatic Embryogenesis. Kluwer Academic Publisher. 1995.

II SEMESTER

Paper 3: INDUSTRIAL APPLICATION OF TISSUE CULTURE AND CONSER-VATION OF GERM PLASM

4 CREDITS

Objectives:

- To make students aware of the importance of secondary metabolites, setting up fermentation units, cultivating the tissue culture plants, its competency in acclimatizing the external habitat, germ plasm conservation etc.,
- An examination of current genetic transformation practices in the industry; and their implications for farmers and consumers.

Outcome:

- Students will be skilled and with advanced kanowledge will be able to preserve the genetic diversity of a particular plant or genetic stock for its use at any time in future
- Its main objective is to provide necessary support for collection, conservationand utilization of plant genetic resources specially with endangered medicinal plants

UNIT I: SECONDARY METABOLITE PRODUCTION

Introduction, types of secondary metabolites, functions, plant secondary metabolite: culture initiation and maintenance, role of precursor and biotransformation, elicitation hairy root culture. Role of differentiation, immobilization and permeabilization.

UNIT II: BIOREACTORS/ FERMENTORS

History and Development: Basic configuration of a typical bioreactor, types and designs of bioreactors: commercial production of secondary metabolites using cell culture technology. Secondary plant metabolites production by tissue culture.

UNIT III: PLANT TISSUE CULTURE INDUSTRY

Global scenario, micropropagation technologies, plant tissue culture industry in India. current status, priority crops, organizations engaged in commercial micropropagation. Research and development activities in India. Problems associated with, micropropagation technology: cost considerations, protocol efficiency contamination, variability in cultures, microbial infection.

UNIT IV: GREENHOUSE HARDENING UNIT OPERATION AND MANAGEMENT

Green house construction, environmental control inside a green house: green house cooling and heating, pest and disease control in green house environment, root media, applications of green house in tissue culture industry.

UNIT V: GERMPLASM CONSERVATION

Collection and acquisition of germplasm, traditional methods of collection and propagation.*In vitro* plant collecting, Documentation and identity confirmation. Germplasm conservation, Storage-Slow (minimal) growth, cryopreservation, simple freezing method, encapsulation, reduced growth rate, pollen bank, applications, conservation centers in India and abroad.

Reference Books:

1. Martin S.M., Staba E.J., In "Plant Tissue Culture as a Source of Biochemi-

cals", CRCOress, Florida, USA, 1989, Page 151 -164.19)

- 2. Misawa M, Fiechter A, "Adv. In biochem. Eng. /Biotech.", Springer -Verlag,Berlin, Heidelberg,New York, Tokyo, Page 73,1985.16)
- 3. Tanaka H., BiotechnolBioeng, Florida, USA Vol. 24, 1983, Page 23-5920)
- 4. Trigiano R.N., Dennis J.G., Plant Tissue Culture Concepts and Laboratory Exercises, CRC Press, 1996.17)

PAPER 4: APPLICATIONS OF ANIMAL CELL CULTURE 4 CREDITS

Objectives:

- To develop understanding of industrial processes for production of antibiotics, enzymes
- To develop understanding of techniques for tissue culture, cell culture, organ transplantation, Vaccine production and etc.,
- To impart the knowledge on basic tissue culture techniques; chemically defined and serum free media; animal cell cultures, their maintenance and preservation; various types of cultures- suspension cultures, continuous flow cultures, immobilized cultures; somatic cell fusion; cell cultures as a source of valuable products; organ cultures

Outcomes:

- By studying this unit, students will learn to demonstrate foundational knowledge of Cell culture techniques and competence in laboratory techniques. Student can set up a tissue culture lab to carry out research
- The students are taught the indepth knowledge in artificial insemination and invitro fertilization methodology for better breeding of animal for quality products

UNIT I: INTRODUCTION TOANIMAL CELL CULTURE: PRINCIPLES and AP-PLICATIONS

Principles of animal cell culture, Types and methods of animal cell culture: Primary cells, cell lines (adherent and suspension culture) and organ culture, stem cells.

UNIT II: COMPOSITION OF ANIMAL CELL CULTURE MEDIA

Media composition and role of its components, Serum and its importance, role of growth factors and antibiotics in animal tissue culture.

UNIT III: CHARACTERIZATION OF CELLS IN CULTURE

Characterization of cell (shape, division, number and confluency, Methods of propagation)

UNIT IV: GENERATION AND MAINTENANCE OF ANIMAL CELLS IN CULTURE

Development of primary and transform cell lines, characterization and maintenance of cells lines, Genetic manipulation of cells and cryopreservation.

UNITV: APPLICATIONS OF ANIMAL CULTURE AND IMMORTAL CELLS

Screening and development of drugs for treating human diseases, testing drug toxicity, production of recombinant proteins and antibiotics, production of vaccines and other biologics.

Reference Books:

1. Freshney R.I., Wiley L, Culture of Animal cells: A manual of basic tech-

niques, 1987.15)

- 2. George E.F., Plant Propagation by Tissue Culture. Part 1, the Technology, Exegetics Ltd, Edington, 1993.7)
- 3. Purohit, SD. Introduction to Plant Cell, Tissue and Organ Culture.2013. 316pp.
- 4. Steinhardt, E; Israeli, C; and Lambert, R.A. (1913) "Studies on the cultivation of the virus of vaccinia" J. Inf Dis. 13, 294–300

PRACTICALS - I: I SEMESTER

6 Credits

- 1. Sterilization methods: physical and chemical
- 2. Preparation of various tissue culture media: MS and Rooting media
- 3. Explant preparation, inoculation and initiation of tissue culture
- 4. Callus formation, Multiplication and Organogenesis
- 5. Establishment of suspension cultures
- 6. Micropropagation Meristem and Nodal culture

PRACTICALS- II: SEMESTER (6 Credits) + Project (10+2=12 Credits)

- 1. Induction of somatic embryos: anther/ovary/ovule culture
- 2. Preparation of synthetic seeds
- 3. Protoplast isolation and Culture
- 4. Hardening and acclimatization in green house



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