Dr. N.G.P. ARTS AND SCIENCE COLLEGE

(An Autonomous Institution, Affiliated to Bharathiar University, Coimbatore)
Approved by Government of Tamil Nadu and Accredited by NAAC with 'A++' Grade (3rd Cycle-3.64 CGPA)
Dr. N.G.P. - Kalapatti Road, Coimbatore-641048, Tamil Nadu, India
Web: www.drngpasc.ac.in |Email: info@drngpasc.ac.in | Phone: +91-422-2369100

Regulations 2023-24 for Post Graduate Programme

(Outcome Based Education model with Choice Based Credit System)

M.Sc. Biotechnology Degree

(For the students admitted during the academic year 2023-24 and onwards)

Programme: Biotechnology

Eligibility:

A candidate who has passed in Higher Secondary Examination with any Academic Stream or Vocational Stream as one of the subjects under Higher Secondary Board of Examination and as per the norms set by the Government of Tamil Nadu or an Examination accepted as equivalent thereto by the Academic Council, subject to such conditions as may be prescribed thereto are permitted to appear and qualify for the **M.Sc. Biotechnology Examination** of this College after a programme of study of three academic years.

Programme Educational Objectives:

The Curriculum is designed to attain the following learning goals which students shall accomplish by the time of their graduation:

1. This programme will enable students to acquire knowledge on the fundamentals of Biochemistry, Cell biology, Microbiology and Molecular biology. It helps them to understand emerging and advanced concept in modern biology and guide them to take up their carrier in this field.

2. This programme will facilitate the students to acquire knowledge in fields such as Genetic Engineering, Protein Engineering and Molecular Therapeutics.

3. The programme will aid the students to learn the recent developments in the field of Genomics, Proteomics, Stem cell biology and Tissue Engineering approach.

PROGRAMME OUTCOMES:

On the successful completion of the program, the following are the expected outcomes.

PO Number	PO Statement
PO1	Impart quality biotechnology education to students and to develop young minds as outstanding scholars/teachers/entrepreneurs and responsible citizens.
PO2	Apply their understanding of the commercialization processes to biotechnology products or services in future.
PO3	Graduates of the course will have strong background in the interface of biotechnology and be able to use the tools in industry and/or institutes wherever necessary.
PO4	Ability to design and carry out experiments (safely) and to interpret experimental data and apply the scientific method by developing valid hypotheses, designing experiments, gathering relevant data using current technology, and interpreting quantitative and qualitative data.
PO5	Develop an awareness of ethical issues in biochemical research and careers options along with understanding of the area of biotechnology chosen.

TOTAL CREDIT DISTRIBUTION

Courses	Credits	Total Marks		Credits	Cumulative Total credits
Core Theory	4	13 X 100 =	1300	52	78
Core Theory	3	1 X 100 =	100	03	
Core Lab	3	3 X 100 =	300	09	
Core Lab	2	3 x100 =	300	06	
Project and Viva Voce	8	1 X 200=	200	08	
Elective	3	4X 100 =	400	12	12
Internship	2	1X100	100	02	2
		Total	**2700**	**92**	**92**

CURRICULUM

M.Sc. BIOTECHNOLOGY

Course Code	Course Category	Course Name	L	T	P	Exam (h)	Max Marks			Credits
							CIA	ESE	Total	
First Semester										
233BT2A1CA	Core - I	Molecular Biology & Genetics	4	-	-	3	25	75	100	4
233BT2A1CB	Core - II	Biochemistry	4	-	-	3	25	75	100	4
233BT2A1CC	Core - III	Microbiology	4	-	-	3	25	75	100	4
233BT2A1CD	Core - IV	Biodiversity & Bioprospecting	4	-	-	3	25	75	100	4
233BT2A1CP	Core Practical - I	Molecular Biology, Genetics and Biochemistry	-	-	5	6	40	60	100	2
233BT2A1CQ	Core Practical - II	Microbiology and Biodiversity & Bioprospecting	-	-	5	6	40	60	100	2
233BT2A1DA	DSE - I	Applied Biotechnology	3	1	-	3	25	75	100	3
233MB2A1DA		Microbial Technology								
233BC2A1DA		Cancer Biology, Diagnosis and Therapy								
Total			**19**	**1**	**10**	-	-	-	**700**	**23**

BoS Chairman/HoD
Department of Biotechnology
Dr. N. G. P. Arts and Science College
Coimbatore – 641 048

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AC-15th 14/07/2023
GB-20th 05/08/2023

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Course Code	Course Category	Course Name	L	T	P	Exam (h)	Max Marks			Credits
							CIA	ESE	Total	
Second Semester										
233BT2A2CA	Core - V	Immunotechnology	4	-	-	3	25	75	100	4
233BT2A2CB	Core - VI	Genetic Engineering	4	-	-	3	25	75	100	4
233BT2A2CC	Core - VII	Environmental Biotechnology	4	-	-	3	25	75	100	4
233BT2A2CD	Core - VIII	Bioprocess Technology	4	-	-	3	25	75	100	4
233BT2A2CP	Core Practical – III	Immunotechnology and Bioprocess Technology	-	-	4	6	40	60	100	2
233BT2A2CQ	Core Practical – IV	Genetic Engineering and Environmental Biotechnology	-	-	6	6	40	60	100	3
233BT2A2DA	DSE - II	Forensic Biotechnology	3	1		3	25	75	100	3
233MB2A2DA		Bionanotechnology								
233BC2A2DA		Biochemistry of Toxicology								
Total			**19**	**1**	**10**	**-**	**-**	**-**	**700**	**24**

17/10/23

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17/10/23	13/12/23	05/01/24

Academic Council
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Course Code	Course Category	Course Name	L	T	P	Exam (h)	Max Marks			Credits
							CIA	ESE	Total	
Third Semester										
233BT2A3CA	Core - IX	Research Methodology & IPR	4	-	-	3	25	75	100	4
233BT2A3CB	Core - X	Genomics and Proteomics	4	-	-	3	25	75	100	4
233BT2A3CC	Core -XI	Marine Biotechnology	4	-	-	3	25	75	100	3
233BT2A3CD	Core - XII	Plant Biotechnology	4	-	-	3	25	75	100	4
233BT2A3CE	Core - XIII	Animal Biotechnology	4	-	-	3	25	75	100	4
233BT2A3CP	Core Practical - V	Plant, Animal, Marine Biotechnology, Genomics & Proteomics	-	-	6	6	40	60	100	3
233BT2A3DA	DSE - III	Molecular Therapeutics	3	1	-	3	25	75	100	3
233MB2A3DA		Medical Laboratory Techniques								
233BC2A3DA		Free Radicals and Antioxidant System								
233BT2A3CT	Internship		-	-	-	3	40	60	100	2
Total			23	1	6	-	-	-	800	27

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Course Code	Course Category	Course Name	L	T	P	Exam (h)	Max Marks			Credits
							CIA	ESE	Total	
Fourth Semester										
233BT2A4CA	Core - XIV	Pharmaceutical Biotechnology	4	-	-	3	25	75	100	4
233BT2A4CP	Core Practical - VI	Pharmaceutical Biotechnology	-	-	6	6	40	60	100	3
233BT2A4CV	Core - XV	Project and Viva Voce	-	-	16	-	80	120	200	8
233BT2A4DA	DSE - IV	Stem Cell Technology	3	1	-	3	25	75	100	3
233MB2A4DA		Molecular Diagnostics and Bioinformatics								
233BC2A4DA		Neurobiology								
Total			**7**	**1**	**22**				**500**	**18**
Grand Total									**2700**	**92**

8.11.24
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AC - 18th 26/11/24
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DISCIPLINE SPECIFIC ELECTIVE

Students shall select the desired course of their choice in the listed elective course during Semesters I - IV

Semester I (Elective I) List of Elective Courses

S. No.	Course Code	Name of the Course
1.	233BT2A1DA	Applied Biotechnology
2.	233MB2A1DA	Microbial Technology
3.	233BC2A1DA	Cancer Biology, Diagnosis and Therapy

Semester II (Elective II)

List of Elective Courses

S. No.	Course Code	Name of the Course
1.	233BT2A2DA	Forensic Biotechnology
2.	233MB2A2DA	Bionanotechnology
3.	233BC2A2DA	Biochemistry of Toxicology

Semester III (Elective III) List of Elective Courses

S. No.	Course Code	Name of the Course
1.	233BT2A3DA	Molecular Therapeutics
2.	233MB2A3DA	Medical Laboratory Techniques
3.	233BC2A3DA	Free Radicals and Antioxidant System

Semester IV (Elective IV)

List of Elective Courses

S. No.	Course Code	Name of the Course
1.	233BT2A4DA	Stem Cell Technology
2.	233MB2A4DA	Molecular Diagnostics & Bioinformatics
3.	233BC2A4DA	Neurobiology

EXTRA CREDIT COURSES

The following are the courses offered under self study to earn extra credits:

S. No.	Course Code	Course Title
1.	233BT2ASSA	Food Biotechnology
2.	233BT2ASSB	Developmental Biology

CERTIFICATE COURSES

S. No.	Course Code	Course Name
1	233BT5A1CA	Plant Tissue Culture
2	233BT5A2CA	Molecular Diagnosis

PG REGULATION (R5)

(2023-24 and onwards)

(OUTCOME BASED EDUCATION WITH CBCS)

Effective from the academic year 2023-24 and applicable to the students admitted to the Degree of Master of Arts/Commerce/Management/Science.

1.NOMENCLATURE

1.1 Faculty: Refers to a group of programmes concerned with a major division of knowledge. Eg. Faculty of Computer Science consists of Programmes like Computer Science, Information Technology, Computer Technology, Computer Applications, Cognitive Systems, Artificial Intelligence and Machine Learning and Cyber Security and Data Analytics etc.

1.2 Programme: Refers to the Master of Arts/Management/Commerce/Science Stream that a student has chosen for study.

1.3 Batch: Refers to the starting and completion year of a programme of study. Eg. Batch of 2023–2025 refers to students belonging to a 2-year Degree programme admitted in 2023 and completing in 2025.

1.4 Course: Refers to component of a programme. A course may be designed to involve lectures / tutorials / laboratory work / seminar / project work/ practical training / report writing / Viva voce, etc or a combination of these, to effectively meet the teaching and learning needs and the credits may be assigned suitably.

a) Core Courses A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.

b) Extra Departmental Course (EDC): A course chosen generally from a related discipline/subject, with an intention to seek exposure in the discipline relating to the core domain of the student.

c) Discipline Specific Elective Course (DSE): Elective courses are offered under main discipline/ subject of study.

d)Internship/Industrial Training (IT)

Students must undertake industrial / institutional training for a minimum of 15 days during the II semester summer vacation. The students will submit the report for evaluation during III semester.

e) Project Work: It is considered as a special course involving application of knowledge in problem solving/analyzing/exploring a real-life situation. The Project work will be given in lieu of a Core paper.

f) Extra credits Extra credits will be awarded to a student for achievements in co-curricular activities carried out outside the regular class hours. The guidelines for the award of extra credits are given in section two, these credits are not mandatory for completing the programme.

g) Advanced Learner Course (ALC): ALC is doing work of a higher standard than usual for students at that stage in their education. Research work / internships carried out in University/ Research Institutions/ Industries of repute in India or abroad for a period of 15 to 30 days.

2. STRUCTURE OF PROGRAMME

- Core Course
- Extra Departmental Course (EDC)
- Discipline Specific Elective (DSE)
- Industrial Training (IT)
- Project

3. DURATION OF THE PROGRAMME

M.Sc. /M.Com. / M.A. Programme must be completed within 2 Years (4 semesters) and maximum of 4 Years (8 semesters) from the date of acceptance to the programme. If not, the candidate must enroll in the course determined to be an equivalent by BoS in the most recent curriculum recommended for the Programme.

4. REQUIREMENTS FOR COMPLETION OF A SEMESTER

Every student shall ordinarily be allowed to keep terms for the given semester in a program of his/ her enrolment, only if he/ she fulfills at least seventy five percent (75%) of the attendance taken as an average of the total number of lectures, practicals, tutorials, etc. wherein short and/or long excursions/field visits/study tours organised by the college and supervised by the faculty as envisaged in the syllabus shall be credited to his attendance. Every student shall have a minimum of 75% as an overall attendance.

5. EXAMINATIONS

The end semester examinations shall normally be conducted after completing 90 working days for each semester. The maximum marks for each theory and practical course as follows,

Mark distribution for Theory Courses

Continuous Internal Assessment (CIA) : 40 Marks

End Semester Exams (ESE) : 60 Marks

Total : 100 Marks

i) Distribution of Internal Marks

S.No.	Particulars	Distribution of Marks
1	CIA I (2.5 Units) (On completion of 45th working day)	5
2	Model (All 5 Units) (On completion of 85th working day)	5
3	Attendance	05
4	Library Usage	05
5	Skill Enhancement *	05
	Total	**25**

Breakup for Attendance Marks:

S.No	Attendance Range	Marks Awarded
1	95% and Above	5
2	90% - 94%	4
3	85% - 89%	3
4	80% - 84%	2
5	75% - 79%	1

Note:
Special Cases such as NCC, NSS, Sports, Advanced Learner Course, Summer Fellowship and Medical Conditions etc. the attendance exemption may be given by principal and Mark may be awarded.

Break up for Library Marks:

S.No	Attendance Range	Marks Awarded
1	10h and above	5
2	9h– less than 10h	4
3	8h – less than 9h	3
4	7h - less than 8h	2
5	6h – less than 7h	1

Note:
In exception, the utilization of e-resources of library will be considered.

***Components for "Skill Enhancement" may include the following:**

Class Participation, Case Studies Presentation/Term paper, Field Study, Field Survey, Group Discussion, Term Paper, Presentation of Papers in Conferences, Industry Visit, Book Review, Journal Review, e-content Creation, Model Preparation, Seminar and Assignment.

Components for Skill Enhancement
Any one of the following should be selected by the course coordinator

S.No.	Skill Enhancement	Description
1	Class Participation	• Engagement in class • Listening Skills • Behaviour
2	Case Study Presentation/ Term Paper	• Identification of the problem • Case Analysis • Effective Solution using creativity/imagination
3	Field Study	• Selection of Topic • Demonstration of Topic • Analysis & Conclusion
4	Field Survey	• Chosen Problem • Design and quality of survey • Analysis of survey

5	Group Discussion	• Communication skills • Subject knowledge • Attitude and way of presentation • Confidence • Listening Skill
6	Presentation of Papers in Conferences	• Sponsored • International/National • Presentation • Report Submission
7	Industry Visit	• Chosen Domain • Quality of the work • Analysis of the Report • Presentation
8	Book Review	• Content • Interpretation and Inferences of the text • Supporting Details • Presentation
9	Journal Review	• Analytical Thinking • Interpretation and Inferences • Exploring the perception if chosen genre • Presentation
10	e-content Creation	• Logo/ Tagline • Purpose • Content (Writing, designing and posting in Social Media) • Presentation
11	Model Preparation	• Theme/ Topic • Depth of background Knowledge • Creativity • Presentation
12	Seminar	• Knowledge and Content • Organization • Understanding • Presentation
13	Assignment	• Content and Style • Spelling and Grammar • References

ii) Distribution of External Marks

Total	**:**	**75**
Written Exam	**:**	**75**

Marks Distribution for Practical course

Total	**:**	**100**
Internal	**:**	**40**
External	**:**	**60**

i) **Distribution of Internals Marks**

S. No.	Particulars	Distribution of Marks
1	Experiments/Exercises	15
2	Test 1	10
3	Test 2	10
4	Observation Notebook	05
	Total	**40**

ii) **Distribution of Externals Marks**

S.No.	Particulars	External Marks
1	Practical	40
2	Record	10
3	Viva- voce	10
	Total	**60**

Practical examination shall be evaluated jointly by Internal and External Examiners.

A) Mark Distribution for Project

Total	**:**	**200**
Internal	**:**	**80**
External	**:**	**120**

i) Distribution of Internal Marks

S.No.	Particulars	Internal Marks
1	Review I	30
2	Review II	40
3	Attendance	10
	Total	**80**

ii) Distribution of External Marks

S.No	Particulars	External Marks
1	Project Work & Presentation	100
2	Viva –voce	20
	Total	**120**

Evaluation of Project Work shall be done jointly by Internal and External Examiners.

6 . Credit Transfer

a. Upon successful completion of 1 NPTEL Course (4 Credit Course) recommended by the department, during Semester I to II, a student shall be eligible to get exemption of one **4 credit course** during the 3rd semester. The proposed NPTEL course should cover content/syllabus of exempted core paper in 3rd semester.

S. No.	Course Code	Course Name	Proposed NPTEL Course	Credit
1			Option – 1 Paper title	4
			Option – 2 Paper title	
			Option – 3 Paper title	

b. Upon successful completion of **2 NPTEL Courses** (2 Credit each) recommended by the department, during Semester I to II, a student shall be eligible to get exemption of **one 4 credit course** during the 3rd semester. Out of 2 NPTEL proposed courses, **at least 1 course** should cover content/syllabus of exempted core paper in 3rd semester.

Mandatory

The exempted core paper in the 3rd semester should be submitted by the students for approval before the end of 2nd semester

Credit transfer will be decided by equivalence committee

S. No.	Course Code	Course Name	Proposed NPTEL Course	Credit
1			Option – 1 Paper title	2
			Option – 2 Paper title	
			Option – 3 Paper title	
2			Option – 1 Paper title	2
			Option – 2 Paper title	
			Option – 3 Paper title	

NPTEL Courses to be carried out during semester I – II.

S. No.	Student Name	Class	Proposed NPTEL Course		Proposed Course for Exemption
			Course I	Option 1- Paper Title Option 2- Paper Title Option 3- Paper Title	Any one Core Paper in 3rd Semester
			Course II	Option 1- Paper Title Option 2- Paper Title Option 3- Paper Title	

Class Advisor **HoD** **Dean**

7. Internship/Industrial Training

Mark Distribution for Internship/ Industrial Training

Total	**:**	**100**
Internal	**:**	**40**
External	**:**	**60**

i) Distribution of Internal Marks

S.No.	Particulars	Internal Marks
1	Review I	15
2	Review II	20
3	Attendance	5
	Total	**40**

ii) Distribution of External Marks

S.No	Particulars	External Marks
1	Internship /Industrial training Presentation	40
2	Viva –voce	20
	Total	**60**

Internship/ Industrial training shall be evaluated jointly by Internal and External Examiners.

9. Extra Credits: 10

Earning extra credit is not essential for programme completion. Student is entitled to earn extra credit for achievement in Curricular/Co-Curricular/ Extracurricular activities carried out other than the regular class hours.

A student is permitted to earn a maximum of 10 extra Credits during the programme period. A maximum of 1 credit under each category is permissible.

Category	Credit
Self study Course	1
CA/ICSI/CMA (Foundations)	1
CA/ICSI/CMA (Inter)	1
Sports and Games	1
Publications / Conference Presentations (Oral/Poster)/Awards	1
Innovation / Incubation / Patent / Sponsored Projects / Consultancy	1
Representation in State / National level celebrations	1
Awards/Recognitions/Fellowships	1
Advanced Learner Course (ALC)*	2

Credit shall be awarded for achievements of the student during the period of study only.

GUIDELINES

Self study Course

A pass in the self study courses offered by the department.

The candidate should register the self study course offered by the department only in the III semester.

CA/ICSI/CMA(Foundations)

Qualifying foundation in CA/ICSI/CMA / etc.

CA/ICSI/CMA(Inter)

Qualifying Inter in CA/ICSI/CMA / etc.

Sports and Games

The Student can earn extra credit based on their Achievement in sports in University/ State / National/ International.

Publications / Conference Presentations (Oral/Poster)

Research Publications in Journals

Oral/Poster presentation in Conference

Innovation / Incubation / Patent / Sponsored Projects / Consultancy

Development of model/ Products /Prototype /Process/App/Registration of Patents/ Copyrights/Trademarks/Sponsored Projects /Consultancy

Representation in State/ National level celebrations

State / National level celebrations such as Independence day, Republic day Parade, National Integration camp etc.

Awards/Recognitions/Fellowships

Regional/ State / National level awards/ Recognitions/Fellowships

***Advanced Learner Course (ALC):**

ALC is doing work of a higher standard than usual for students at that stage in their education.

Research work/internships carried out in University/ Research Institutions/ Industries of repute in India or abroad for a period of 15 to 30 days will be considered as Advanced Learners Course.

QUESTION PAPER PATTERN

CIA Test I : [1½ Hours-2.5 Units] - 25 Marks

SECTION	MARKS	DESCRIPTION	TOTAL	Remarks
Section – A	8 x 0.5= 04 Marks	MCQ	25 Marks	Marks secured will be converted To 5 mark
Section - B	3 x 2 = 06 Marks	Answer ALL Questions Either or Type ALL Questions Carry Equal Marks		
Section - C	3 x 05 = 15 Marks			

CIA Test II/ Model [3 Hours-5 Units] - 75 Marks

SECTION	MARKS	DESCRIPTION	TOTAL	Remarks
Section – A	10 x 1 = 10 Marks	MCQ	75 Marks	Marks secured will be converted To 5 mark
Section - B	5 x 3 = 15 Marks	Answer ALL Questions (Either or Type Questions) Each Questions Carry Equal Marks		
Section - C	5 x 8 = 40 Marks			
Section - D	1 x 10 = 10 Marks	Compulsory Question		

End Semester Examination [3 Hours-5 Units] - 75 Marks

SECTION	MARKS	DESCRIPTION	TOTAL
Section – A	10 x 1 = 10 Marks	MCQ	75 Marks
Section - B	5 x 3 = 15 Marks	Answer ALL Questions (Either or Type Questions) Each Questions Carry Equal Marks	
Section - C	5 x 8 = 40 Marks		
Section - D	1 x 10 = 10 Marks	Compulsory Question	

Course Code	Course Name	Category	L	T	P	Credit
233BT2A1CA	MOLECULAR BIOLOGY & GENETICS	CORE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The replication and repair mechanism in prokaryotic and eukaryotic cells
- The Transcription, translation and protein targeting mechanisms
- The concept of human genetics, disorders and inheritance pattern

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Appraise the mode of DNA replication and repair mechanisms	K3
CO2	Formulate transcriptional events and its role in gene regulation	K3
CO3	Infer translational events and its role in gene expression & protein targeting	K4
CO4	Integrate the human genetics and various genetic disorders	K5
CO5	Generalize the inheritance pattern and population genetics	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓				✓
CO2	✓	✓	✓		✓
CO3	✓		✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

✓	Skill Development		Entrepreneurial Development
✓	Employability		Innovations
	Intellectual Property Rights		Gender Sensitization
	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

233BT2A1CA	MOLECULAR BIOLOGY & GENETICS	SEMESTER I

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I Replication and Recombination 10 h

Introduction to Replication & Experimental proof for Semiconservative method. Enzymes & accessory proteins involved in DNA replication. DNA Replication and Regulation mechanism in prokaryotic & Eukaryotic. Other Replication models – Theta and Rolling circle model. DNA Repair mechanism - Nucleotide excision, Base excision, Mismatch repair, Double-Strand Breakage Repair, Photo-reactivation, SOS and recombination repair. Recombination: Homologous and site-specific recombination.

Unit II Transcription and Posttranscriptional Mechanisms 10 h

Importance of DNA binding Proteins, RNA polymerase. Mechanism of Transcription in prokaryotes & Eukaryotes. Transcriptional regulatory elements and mechanisms of transcription regulation. Transcriptional and post-transcriptional gene silencing. mRNA Stability and Localization. RNA processing - r-RNA & t- RNA processing, mRNA 5′ capping, 3′-end processing and polyadenylation, RNA splicing, RNA Editing, Nuclear export of mRNA and mRNA based therapeutics.

Unit III Translation and Post Translational Modifications 10 h

Overview of Genetic code, codon, anticodon and wobble hypothesis. The translation machinery, role of tRNA & ribosome. Mechanism of translation in Prokaryotes & Eukaryotes. Post translational modifications of proteins-Phosphorylation, Deformylation, Glycosylation, Acetylation, Amidation, Lipid attachment, S - Nitrosylation and Disulfide bond formation. Translation Regulation-Translational inhibitors, Control of gene expression at translational level. Protein targeting- Synthesis of Secretory and membrane proteins, import into nucleus, mitochondria and chloroplast.

Unit IV Mendelism and Non Mendelism 09 h

Overview on mendelian and non-mendelian inheritance. Human Genetics - Introduction to Human Genetics. Chromosomal changes resulting in abnormal phenotype: Numerical (Aneuploidy) changes resulting in genetic syndromes eg: Turner, Down & Klinefelter Syndromes. Structural changes resulting in genetic diseases: eg: Cri-du-chat syndrome. Genetic Diseases and Inheritance Pattern:

Autosomal inheritance – Dominant (Eg: Adult polycystic kidney, Achondroplasia); Autosomal inheritance – Recessive (Eg: Albinism, Sickle Cell Anemia, Phenyl Ketonuria); X-linked: Recessive (Eg: Duchenne muscular dystrophy – DMD); X-linked: Dominant (eg. Xg blood group); Y-linked inheritance (Holandric – eg. Testes determining factor); Mitochondria disorders like LHON, DAD, MERRF and MELAS. Cancer genetics.

Unit V Analysis of inheritance pattern 09 h

Pedigree analysis; Diagnosis of disease: Molecular cytogenetics, DNA markers - VNTR, STR, microsatellite, SNP and their detection techniques - RFLP genotyping, RAPD, AFLP. Prevention of disease: Prenatal diagnosis; Genetic counseling. Population genetics: Organization and measure of genetic variation: Random mating population, Hardy-Weinberg principle. Sources responsible for changes in gene frequencies: Mutation, selection, migration and isolation; random genetic drift; insights into human migration, natural selection and evolution.

Text Books

1. Harvey Lodish, Arnold Berk, Chris A Kaiser, Monty Krieger, Anthony Bretscher, 2021, "Molecular Cell Biology", 9th edition, W H Freeman & Co. USA
2. Thomas D Pollard, William C Earnshaw, Jennifer Lippincott-Schwartz, Graham T Johnson, 2017, "Cell biology", 3rd edition, Elsevier, Inc., USA.

References

1. George M Malacinski, 2015, "Freifelders Essentials Of Molecular Biology", 4th edition, Jones & Bartlett Publisher. USA
2. Jocelyn E Krebs, Elliott S Goldstein, Stephen T Kilpatrick, 2017, "Lewin's GENE XII", 12th edition, Jones and Bartlett Publishers. USA
3. David L Nelson and Michael Cox, 2021, "Lehninger Principles of Biochemistry", 8th edition, W.H. Freeman & Co Ltd., USA
4. Nancy Craig, Rachel Green, Carol Greider, Gisela Storz and Cynthia Wolberger, 2021, "Molecular Biology: Principles of Genome Function", 3rd edition, OUP Oxford. UK

Course Code	Course Name	Category	L	T	P	Credit
233BT2A1CB	BIOCHEMISTRY	CORE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The Structure of Biomolecules
- The function and biosynthesis of the biomolecules
- The metabolism and their regulatory pathways.

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Experiment the physical properties, Classification, metabolism and disorders of carbohydrates	K4
CO2	Interpret the concepts of structure andfunction, metabolism and disorders of lipid and fatty acid	K4
CO3	Summarize the biosynthesis of amino acids and disorders related to amino acids	K4
CO4	Integrate the mechanism, kinetics and inhibition of enzymes and coenzymes	K5
CO5	Appraise the regulatory mechanism of different metabolic activities and their disorders of nucleic acid	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓		✓		✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

✓	Skill Development		Entrepreneurial Development
✓	Employability		Innovations
	Intellectual Property Rights		Gender Sensitization
	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

233BT2A1CB	BIOCHEMISTRY	SEMESTER I

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I Carbohydrates 10 h

Classification and reactions: occurrence, properties and biological reactions. Structural features of carbohydrates and Conjugated carbohydrates (Glycoproteins and Glycolipids), Glycolysis and TCA cycle; Glycogen breakdown and synthesis; Gluconeogenesis; interconversion of hexoses and pentoses. Carbohydrate metabolic disorders. Glycogen storage diseases. Lectins – characteristics and functions in biological systeM.

Unit II Lipids 10 h

Classification, Structure, functions and reactions of Lipids, Biosynthesis of fatty acids, Triglycerides, phospholipids and Sterols, Catabolism of Fatty acids - Oxidation(α, β and ω), Catabolism of triglycerides and phospholipids, Essential fattyacids and their physiological functions. Disorders associated with lipid metabolism and its therapeutic intervention - ketone bodies and ketosis; fatty liver, atherosclerosis.

Unit III Amino Acids and Proteins 8 h

Classification and Biosynthesis. Peptides, Classification of Protein, Primary structure of proteins, structural comparison at secondary and tertiary levels (Ramachandran Plot), quaternary and domain structure and architecture.Motifs, functional relationship between domains and function of protein. Regulation of Protein metabolism. Protein metabolism in prolonged fasting. Disease related to protein folding – Alzheimer's and mad cow disease

Unit IV Enzymes and coenzymes 10 h

IUBMB classification of enzymes, active site, Lock and key Model and induced fit hypothesis. Factors affecting enzyme activity, Mechanism of enzyme catalysis: Lysozyme, Enzyme kinetics- Michaelis – Menten (MM) equations, Transformations of MM equation and their significance, Enzyme inhibition: Reversible – Competitive, Noncompetitive, Uncompetitive, Irreversible inhibition, Kinetics of Enzyme inhibition. Isoenzymes, allosteric enzymes, ribozymes, abzymes and artificial enzymes. Diseases Caused By Deficiency Of Digestive Enzymes-Obesity, Galactosemia, Maple Syrup Urine Disease.

Unit V Nucleic Acids 10 h

Nucleic acids: Structural characteristics of A, B and Z-DNA. 3D structure of t-RNA, ribozymes and riboswitches. Biosynthesis of Nucleotides –De nova and Salvage pathway, Regulations of Purines and Pyrimidine, Metabolism of Purine and Pyrimidine. Disorders of nucleic acids metabolism- Gout, Lesch-Nyhan syndrome, oroticaciduria, and xanthinuria.

Text Books

1 Lehninger AL and Cox M M, 2013, "Principles of Biochemistry", 6th edition, W. H. Freeman and Company, New York

2 Rodwell VW, Bender DA, Botham KM, Kennelly PJ, and Weil PA, 2018, "Harper's Illustrated Biochemistry", 31st edition, McGraw Hill publications, New Delhi.

References

1 Berg JM, Stryer L et al., 2015, "Biochemistry", 8th edition, Palgrave Macmillan Publications, India

2 Ramadevi K, 2016, "Ambika Shanmgam's Fundamentals of Biochemistry for Medical Students". 8th edition, Wolters Kluwer (India) Pvt, Ltd., New Delhi.

3 Voet D and Voet J G, 2011, "Biochemistry". 4th edition. John Wiley and Sons Inc. USA

4 Fromm HJ and Hargrovem , 2012, "Essentials of Biochemistry", Springer publisher

Course Code	Course Name	Category	L	T	P	Credit
233BT2A1CC	MICROBIOLOGY	CORE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The microbial diversity and the molecular identification techniques
- The role of Microbes in Food and Agriculture
- The interaction of microbes with host and the control measures

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Interpret the Microbial classification and their preservation	K4
CO2	Infer the techniques used in Microbial identification	K4
CO3	Relate the role of microbes in agricultural field	K5
CO4	Analyze the causes for various infections	K5
CO5	Find the solutions to control the spread of infections	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	✓
CO4	✓	✓		✓	✓
CO5	✓	✓	✓	✓	✓

✓	Skill Development		Entrepreneurial Development
✓	Employability		Innovations
	Intellectual Property Rights		Gender Sensitization
	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

233BT2A1CC	MICROBIOLOGY	SEMESTER I

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I Microbial Diversity 08 h

Concepts of species and hierarchical taxa – Bacterial nomenclature– Bergey's system of Classification, Classification of Fungi and Viruses, Polyphasic taxonomy, Preservation and maintenance of microbes, Microbial Culture Collection centers – India and International organizations, Modern methods to study microbial diversity: NGS.

Unit II Microbial Identification Techniques 10 h

Microbial Identification through physiological and biochemical methods (BIOLOG, Vitex). Techniques used in diversity analysis – Fatty Acid Methyl Ester (FAME), 16S rRNA & 18s rRNA gene sequencing. Mol % G+C analysis, DNA-DNA hybridization, Molecular methods to study complex microbial communities: DGGE, SSCP, T-RFLP and FISH.

Unit III Food and Agricultural Microbiology 10 h

Spoilage of food – Principles and types; Food preservation: physical and chemical- Food sanitation – Food poisoning – Food borne pathogens – Quality control and Food laws. Role of microorganisms in soil fertility – Role of nif gene in Biological nitrogen fixation, Plant microbe interaction: Biopesticides (B. thuringiensis and NPV) - Biofertilizers - PGPR –mycorrhiza

Unit IV Microbial Interactions and Infection 10 h

Bacterial Diseases: Host-parasite relationship, epidemiology, pathogenesis, prevention and treatment – Mycobacterium, Salmonella and Yersinia. Viral Diseases: Epidemiology, pathogenesis, prevention and Treatment - H1N1, HIV, SARS-COV-2. Fungal Diseases: Infections caused by yeast: Candida. Filamentous Fungi: Aspergillus sp. Protozoan Diseases: Malaria, Leishmaniasis.

Unit V Control of micro-organisms 10 h

Concept of sterilization and disinfection. Physical and chemical methods of microbial control. Chemotherapeutics, susceptibility test (broth procedures and diffusion methods), mode of action of antibiotics, narrow and broad spectrum (Penicillin, ampicillin, sulfonamide, vancomycin, tetracycline, chloramphenicol),

antifungals(clotrimazole, fluconazole), antiretroviral (tenofovir, AZT).

Text Books

1. Pelczar MJ Jr., Chan ECS and Kreig NR., 1993, "Microbiology", 5th edition, Tata McGraw Hill, New Delhi.
2. Vijaya Ramesh, K, 2020, "Food Microbiology"1st edition, MJP Publishers, Chennai.

References

1. Joanne Willey, Kathleen Sandman, Dorothy Wood, 2020, "Prescott's Microbiology", 11th edition, McGraw Hill Education, New York.
2. David H. Persing, Fred C. Tenover, James Versalovic, Yi-Wei Tang, Elizabeth R. Unger, David A. Relman, Thomas J. White, 2004, "Molecular Microbiology- Diagnostic Principles and Practice, 1st edition, ASM Press, Washington, DC
3. William C. Frazier, Dennis C. Westhoff, 2021, "Food Microbiology", 1st edition, McGraw Hill Education, India.
4. David Greenwood, Richard C.B. Slack, John F. Peutherer, 2002, "Medical Microbiology – A Guide to Microbial Interactions: Pathogenesis, Immunity, Laboratory Diagnosis and Control", 16th edition, Churchill Livingstone, Edinburgh.

Course Code	Course Name	Category	L	T	P	Credit
233BT2A1CD	BIODIVERSITY & BIOPROSPECTING	CORE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The importance of biodiversity and various methods of conservation
- The Bioprospecting potentials of available natural resources
- The regulations related with biodiversity and bioprospecting

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Articulate the types of biodiversity, the threats to the biodiversity and Biodiversity hotspots	K2
CO2	Illustrate the discovery of medicinal compounds from natural products and their significance	K2
CO3	Infer the sustainable utilization of microbial resources and benefit sharing	K3
CO4	Report the screening and purification process of various bioactive substances	K4
CO5	Formulate regulations and laws for biodiversity	K3

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2		✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓		
CO5	✓	✓	✓		✓

✓	Skill Development		Entrepreneurial Development
✓	Employability		Innovations
✓	Intellectual Property Rights		Gender Sensitization
✓	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

233BT2A1CD	BIODIVERSITY & BIOPROSPECTING	SEMESTER I

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I Biodiversity- Overview and Acts 10 h

Biodiversity- Facts about global & Indian biodiversity- Hot spots of Indian Biodiversity- Types of Biodiversity- Measures of Biodiversity (alpha, beta & gamma)-Threats to Biodiversity, Endemic, threatened, Red List of IUCN- National biodiversity strategy and action plan (Initiatives to conservation (international & national)- Organization involved in Biodiversity conservation and research (NBA,BSI, and ZSI)- The biological diversity act 2002.

Unit II Natural products from plants 10 h

Drugs derived from plants, Antitumor agent - Etoposide, Colchicine, Taxol, Vinblastine, Vincristine. Cardiotonic – Convallatoxin, Acetyldigoxin, Adoniside. Antiinflammatory – Aescin, Bromelain. Choleretic – Curcumin. Laxatives, Antimalarial Quinine- Cinchona. Morphine-Opium plant- analgesic. Volatile, pigments and terpenes, Phenols, flavonoids.

Unit III Bioprospecting of Microbial Products 10 h

Screening for bioactivity, antimicrobials, pharmacologically active agents of microbial origin, bioprospecting for industrial enzymes, plant growth promoting agents, antifoulants and anti-biofilm agents from microbes. Bioprospecting of marine organisms. Bio piracy issues.

Unit IV Techniques used in bioprospecting 10 h

Drug discovery and product development: Discovery from traditional medicine. Modern tools in drug discovery. Role of chromatography in drug analysis including HPLC, GC and LC and GC Mass spectrometry, FTIR, -NMR their principles and merits. Product development procedures and policies.

Unit V Bioprospecting Regulations 08 h

Regulations on bio-prospecting, access and benefit-sharing (National Environmental Management: Biodiversity act, 2004)- Rules and regulations in patenting and Intellectual Property Rights of Bio-Prospecting products in India.

Text Books

1 Russell Paterson, Nelson Lima, 2004, "Bioprospecting: Success, Potential and Constraints", 1st edition, Springer Publications

2 Upadhyay, 2021, "Bioprospecting of Plant Biodiversity for Industrial Molecules", 1st edition, Wiley, USA.

References

1 Jeffries MJ, 2006, "Biodiversity and Conservation", 2nd edition, Routledge, USA

2 Vanesha S, 2010, "Marine Bioprospecting and Natural Product Research", 1st edition, LAP Lambert Academic Publishing, Germany

3 Dubey KN and Yadav GP, 2011, "Biodiversity - Threats to Conservation", 1st edition, Axis Publication, India.

4 Krishanmurthy KV, 2018, "An Advanced Textbook on Biodiversity", 1st edition, Oxford and IBH Publishing Co Pvt Ltd., India

233BT2A1CP	CORE PRACTICAL - I : MOLECULAR BIOLOGY, GENETICS AND BIOCHEMISTRY	SEMESTER I

Total Credits: 2
Total Instructions Hours: 60 h

S.No	Contents
1	Isolation of genomic DNA from human blood sample
2	Bacterial conjugation
3	Bacterial Transformation
4	Molecular analysis using RAPD
5	RFLP analysis
6	Estimation of total Protein and albumin from serum
7	Estimation of glucose from serum
8	Estimation of Vitamin C from Citrus fruit
9	Estimation of total amino acids from serum
10	Estimation of DNA & RNA
11	Determination of blood cholesterol
12	Separation of amino acids from serum Paper Chromatography

References

1 Sambrook, J. and Green, M.R., 2012, "Molecular Cloning: A Laboratory Manual", 4th Edition, Cold Spring Harbor, USA

2 Mertens, T.R., and Hammersmith, R.L., 1997, "Genetics Laboratory Investigations", 11th edition, Benjamin Cummings, USA

3 Sadasivam, S. and Manickam, A, 1996, "Biochemical Methods", 4th edition, New Age International, India

4 Varghese, N., 2014, "Microbiology Laboratory Manual", 1st edition, Aromatic and Medicinal Plant Research Station, India

233BT2A1CQ	CORE PRACTICAL - II: MICROBIOLOGY AND BIODIVERSITY & BIOPROSPECTING	SEMESTER I

Total Credits: 2
Total Instructions Hours: 48 h

S.No	Contents
1	Isolation of enzyme producing Bacteria from soil
2	Isolation of Antibiotic producing microorganisms against pathogen
3	Isolation of Fungi from spoiled food
4	Sampling and analysis of microbial load on food contact surfaces.
5	Morphological Analysis of Microbes using stereomicroscope
6	Observation of fungal morphology using Phase contrast microscopy
7	Methylene blue reductase test for milk.
8	To identify and classify 5 different types of pollen and note the observation under stereomicroscope
9	Observation of bacterial growth curve
10	Phytochemical Analysis of same plant species grown in different geographic locations
11	TLC analysis of the secondary metabolites of same plant species grown in different geographic locations
12	To run column chromatography of a single phytochemical (alkaloid, flavonoid, tannin) obtained from different sources (fruits, vegetables,leaves etc)

References

1 Demain AL and Davies JE, 1999, " Manual of Industrial Microbiology and Biotechnology", ASM Press, Washington, D.C., USA.

2 Doyle MP, Beuchat LR and Montville TJ, 1997, "Food Microbiology: Fundamentals and Frontiers", ASM Press, Washington D.C., USA.

3 Paterson Russell and Lima Nelson, 2017, "Bioprospecting: Success, Potential and Constraints", Springer Publications.

4 Judith A Scheppler, Patricia E Cassin and Rosa M Gambier, 2014, "Biotechnology explorations: Applying the fundamentals", ASM Press

Course Code	Course Name	Category	L	T	P	Credit
233BT2A1DA	APPLIED BIOTECHNOLOGY	DSE	3	1	-	3

PREAMBLE

This course has been designed for students to learn and understand

- The applications of biotechnology in plant , animal and Environmental field
- The applications of biotechnology in health care sector
- The products obtained from fermentation and its applications.

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Understand the fundamental applications of Biotechnology	K1
CO2	Know the basics and fundamentals of biotechnology applications in environment.	K2
CO3	Discuss about the disease and disease prevention.	K3
CO4	Discuss the applications of Enzymes in various fields.	K4
CO5	Discuss the production and application of products obtained from fermentation technology.	K1

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓		✓	
CO2	✓		✓	✓	✓
CO3			✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

	Skill Development	✓	Entrepreneurial Development
✓	Employability		Innovations
	Intellectual Property Rights		Gender Sensitization
	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

233BT2A1DA	APPLIED BIOTECHNOLOGY	SEMESTER I

Total Credits: 3

Total Instruction Hours: 48 h

Syllabus

Unit I Agricultural, Plant Biotechnology and Animal Biotechnology 10 h

Applications of transgenic crop technology: Herbicide resistance (Glyposate Resistance plants), Pest resistance (Bt Cotton) and Virus Resistance. Enhancement of micro-nutrients (Vitamin A & Vitamin E). Delayed Fruit Ripening. Molecular pharming in plants. Transgenic animals (Transgenic mice and Transgenic cattle). Production and recovery of products from animal tissue cultures (Blood clotting factors, Growth hormones, insulin)

Unit II Environmental Biotechnology 08 h

Bioremediation- (Bioaugmentation and Biostimulation). Biodegradation of Xenobiotic componds. Bioleaching. Microbially Enhanced Oil Recovery. Biotechnological methods for hazardous waste management. Bioindicators – Biomarkers –Biosensors –Management for effluent toxicity, heavy metal pollution, thermal and radioactive pollution

Unit III Health Care Biotechnology 10 h

Disease prevention – vaccines: conventional vaccines, purified antigen vaccines, recombinant vaccines, DNA vaccines, synthetic vaccines. Disease Diagnosis – Probes, monoclonal antibodies and detection of genetic diseases. Disease treatment – interferons, monoclonal antibodies. Gene therapy, enzyme therapy and replacement. Forensic medicine.

Unit IV Enzyme Biotechnology 10 h

Enzyme used for diagnostics purpose- (acid phosphatase, alanine aminotransferase and alkaline phosphatase). Cardiac Biomarkers. Enzymes used for screening liver and kidney diseases. Enzymes used in food industry, leather industry, wool industry, dairy industry and textile industry.

Unit V Fermentation Biotechnology 10 h

Production, harvest, recovery and uses – enzymes, antibiotics (Tetracycline), vitamins (B2), aminoacids (glutamic acid), organic solvents (ethanol); organic acids (lactic acid). Single cell protein (algae), beverages (Wine). Formulation of Biofertilizer (Rhizobium), Biopesticides.

Text Books

1. Bernard R Glick and Jack J Pasternak, 2010, "Molecular Biotechnology: Principles and Applications of recombinant DNA", 4th edition, ASM Press
2. Slater, Scott and Fowler, 2008, "Plant Biotechnology: The genetic manipulation of plants", 2nd edition, Oxford University Press, UK

References

1. Marwaha SS & Arora K, 2000, "Food processing: Biotechnological application", Asiatech Publishers INC, New Delhi
2. Palmer T, Bonner PLR, 2014, "Enzymes: Biochemistry, Biotechnology and Clinical Chemistry", 2nd edition, Woodhead Publishing Limited, Oxford.
3. Stanbury PF and Whitaker A, 2005, "Principles of Fermentation technology", 2nd edition. Pergamon press.
4. Stanbury PF and Whitaker A, 2007, "Fermentation microbiology and Biotechnology", 2nd edition, Taylor and Francis

Course Code	Course Name	Category	L	T	P	Credit
233MB2A1DA	MICROBIAL TECHNOLOGY	DSE	3	1	-	3

PREAMBLE

This course has been designed for students to learn and understand

- The production of Sustainable products using Microorganisms.
- The importance of Microorganisms in Pharmaceutical sector.
- How to explore the ideas in commercial level

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Inculcate about microbial products and its scale up production through establishing a small scale industry	K2
CO2	Exemplify the ideas about the production and uses of Biofuel and Biofertilizer.	K3
CO3	Demonstrate the commercial production of Biopolymers using Microorganisms.	K4
CO4	Understand the way of cells and enzymes were immobilized for industrial uses.	K3
CO5	Explore the pharmaceutical products and possibilities of converting it to a commercial product.	K4

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓		✓	✓	✓
CO2	✓	✓		✓	✓
CO3	✓		✓	✓	✓
CO4	✓		✓		✓
CO5	✓	✓		✓	✓

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability	✓	Innovations
✓	Intellectual Property Rights		Gender Sensitization
	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

233MB2A1DA	MICROBIAL TECHNOLOGY	SEMESTER I

Total Credits: 3

Total Instruction Hours: 48 h

Syllabus

Unit I Microbial products 10 h

Single Cell Protein and its Economic Aspects: Bacterial, Yeast, Fungal and Algal Proteins – Brewer's and Baker's yeast – Food and Fodder yeast – Mushroom (Agaricus, Oyster) and Products from Higher fungi (Ganoderma lucidum).

Unit II Production of Biofuel & Biofertilizer 10 h

Production, Methods and Uses of Bioethanol (S cerevisiae) – Biodiesel (Chlorella) – Biohydrogen (Chlamydomonas) – Biogas (Methanobacteria). Biofertilizer - N2 fixing, Phosphate Solubilizing, Phosphate Mobilizing, Plant Growth Promoting Rhizobacteria -Mass production and Applications.

Unit III Biopolymer production 8 h

Production and Uses of Polyhydroxybutyrate (PHB) – Xanthan – Alginate – Cellulose – Cyanophycin – Levan - Melanin - Welan - Succinoglucan- Curdlan- Chitosan - Polyhydroxyalkanoates - Hyaluronic acid.

Unit IV Immobilization of Cells & Enzymes 10 h

Cells – Surface attachment of cells – Entrapment - Hydrogel method, Preformed support materials – Containment behind a barrier: Microencapsulation, Immobilization using membranes – Self aggregation of cells –Methods for Enzyme immobilization – Carrier binding method, Intermolecular cross linking – Applications of Immobilized cells and Enzymes

Unit V Microbial products with pharmaceutical importance 10 h

Vaccines – Steps of Manufacturing – Growing the microbes and separation – Preparation of Live and killed vaccine – Preparation of Toxoid and uses – BCG Vaccine – Cholera vaccine – Rabies vaccine – Diptheria toxoid. Pharmaceutical industry - certification & accreditation required. Bioentreprenurship opportunities and Funding sources - Government funds, Venture capital, NGOs, Crowd funding and Incubation centers. Antimicrobial compounds from soil microbes - Case study

Text Books

1. Patel A H, 2012, "Industrial Microbiology", 2nd Edition, Trinity Press, New Delhi
2. El-Mansi E M T, Bryce C F A, Dahhou B, Sanchez S, Demain A L and Allman A R, 2012, "Fermentation Microbiology and Biotechnology", 3rd Edition, CRC Press, USA

References

1. Bernard R Glick, Jack J Pasternek and Cheryl L Patten, 2010, "Molecular Biotechnology - Principles and Applications of Recombianant DNA", 4th Edition, ASM Publishers, USA.
2. Nidhi Goel, 2013, "Pharmaceutical Microbiology", 1st Edition, Narosa Publishing House, New Delhi.
3. Puvanakrishnan R, Sivasubramanian S and Hemalatha T, 2012, "Microbial Technology - Concepts and Applications", 1st Edition, MJP Publishers, New Delhi.
4. https://agritech.tnau.ac.in/org_farm/orgfarm_biofertilizertechnology.html

Course Code	Course Name	Category	L	T	P	Credit
233BC2A1DA	CANCER BIOLOGY, DIAGNOSIS AND THERAPY	DSE	3	1	-	3

PREAMBLE

This course has been designed for students to learn and understand

- Molecular basis of cancer, mutations causing cancer, and repair mechanisms.
- The basic principles of cancer development and available therapeutic options
- The different diagnostic and treatment methods for cancer.

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Compare and contrast benign and malignant tumors and the morphological characteristics of cancer cells.	K4
CO2	Justify the molecular basis of cancer. Distinguish interdisciplinary areas in cancer biology.	K5
CO3	Evaluate the molecular mechanism of oncogenesis, tumor biology and the role of cell cycle in cancer.	K5
CO4	Validate the role of tumor suppressor genes and apoptosis. Explain about epigenetics.	K5
CO5	Summarize on the choice of diagnosis and therapy available for cancer patients.	K6

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

✓	Skill Development		Entrepreneurial Development
✓	Employability		Innovations
	Intellectual Property Rights		Gender Sensitization
	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

233BC2A1DA	CANCER BIOLOGY, DIAGNOSIS AND THERAPY	SEMESTER I

Total Credits: 3

Total Instruction Hours: 48 h

Syllabus

Unit I Introduction 9 h

Introduction: Cancer cell-morphology and growth characteristics. Metastasis and cytoskeleton. Types of growth- hyperplasia, dysplasia, anaplasia and neoplasia. Types and prevalence of cancer. Nomenclature of neoplasms, classification based on origin/organ. Differences between benign and malignant tumors.

Unit II Carcinogenesis 9 h

Cancer epidemiology and endocrinology. Cancer causing agents-radiation, viruses, chemicals. Multistep carcinogenesis: Initiation, Promotion, Progression. Para-neoplastic syndromes. Mutation-definition, significance, rates and frequency. Mutagenic agents. Molecular basis of mutagenesis: induced and spontaneous mutations, crossing over and segregation. Mutation Types-addition, deletion, inversion, reciprocal, translocation, insertional translocation and frame-shift mutations. Chemical carcinogenesis- genetic and epigenetic carcinogens, pro- carcinogens and co-carcinogens, promoters and initiators, testing for carcinogenecity, Ames test. Aberrant metabolism during cancer development.

Unit III Tumor Markers and Signal Transduction 10 h

Oncogenes - RNA and DNA tumor viruses, retroviruses and viral oncogenes and abrupt activation. Src and Ras gene, mechanism and characteristic of cell transformation. Molecular mechanism of oncogenesis- protooncogenesis, oncoproteins, tumor suppressor genes involved in cancer. Radiation- effect of ionizing radiations on DNA, chromosomal aberrations. Cancer Markers: Genetic basis of cancer, use of tumor markers in detection and monitoring of cancer. Signal transduction in cancer: cell-cell interactions, cell adhesion, invasion and metastasis, VEGF signaling and angiogenesis; role of transcription factors. Growth factors-EGF, TNF-α and TGF-β and growth factor receptors. Free radicals and antioxidants in cancer. Diet and cancer.

Unit IV Cell Cycle, Cell Death and Cancer 10 h

Cell Cycle Regulation cancer: control of the cell cycle - cyclins and CDKs, and tumor suppressor genes p53, p21Rb, BRAC1 and BRAC2. Telomeres, and Immortality; Epigenetics- role of DNA methylation in gene silencing- epigenetic silencing of tumor - suppressor genes. Death - signaling pathways - mitochondrial and death receptor pathways, (Intrinsic- extrinsic pathways). Mechanism and Impact of apoptosis.

Unit V Cancer Diagnosis and Cancer Therapy, Stem Cells and Cancer 10 h

Principles and methods of cancer diagnosis - biochemical, genetic, cytotoxic, cell growth and viability tests. Diagnosis of cancer by histopathology, MRI scans, PET scan, cytogenetics test, kariotype, FISH. Strategies of anticancer drug therapy–chemotherapy, gene therapy, immuno therapy, radiotherapy and surgical therapy. Principles of cancer biomarkers and their applications.

Text Books

1 Mc Kinnell R.G et al, 2012, "The Biological Basis of Cancer", 2nd edition, Cambridge University Press, London.

2 Weinberg R.A, 2014, "The Biology of Cancer", 2nd edition, Garland Science, New York & London.

References

1 Vincent T. De Vita M. D et al, 2020, "Principles and Practice of Oncology: Primer of Molecular Biology in Cancer", 3rd edition, Lippincott Williams and Wilkins, Philadelphia.

2 Pelengaris S and Khan M, 2010, "The Molecular Biology of Cancer - A bridge from bench to bed side", 2nd edition; Wiley Black well, London.

3 Hesketh R, 2013, "Introduction to Cancer Biology", 1st edition, Cambridge University Press, London.

4 Pezzella F et al, 2019, "Oxford textbook of Cancer Biology", 1st edition, Oxford University Press, London

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APPROVED

BoS- 15th	AC - 15th	GB - 20th
10/06/2023	14/07/2023	05/08/2023

Academic Council
Dr.N.G.P. Arts and Science College

Course Code	Course Name	Category	L	T	P	Credit
233BT2A2CA	IMMUNOTECHNOLOGY	CORE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- Mechanism of immune system
- Various detection methods of antigen-antibody interaction
- Importance in vaccine development

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Understand about basis of immune response	K3
CO2	Know the antigen-antibody related tests	K3
CO3	Learn about new generation of antibody production techniques	K5
CO4	Aware on vaccine immunological types and its role in immune system	K5
CO5	Know about allergic reaction, tumour immunology and its effect on immune system	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2		✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓		
CO5	✓	✓	✓		✓

COURSE FOCUSES ON

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability	✓	Innovations
✓	Intellectual Property Rights		Gender Sensitization
✓	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

233BT2A2CA	IMMUNOTECHNOLOGY	SEMESTER II

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I Cells and Organs of Immune system 08 h

History and scope of immunology. Types of Immunity: Passive, Active and Acquired immunity. MHC and its types. Humoral, Cell Mediated immunity. Cells and organs of immune systems - Bone marrow, Spleen, Lymph nodes and their immune response and their functions. Antigens-Types, haptens, epitopes and Factors influencing antigenicity. Antibody-Structure, types, properties and functions. Immunoglobin gene rearrangements

Unit II Antigen Antibody Reactions 10 h

Antigen–Antibody interaction, affinity, avidity, cross reactivity, specificity, epitope mapping; Agglutination reactions and Precipitation reactions. Immunoassays–Immuno Diffusion and Immunoelectrophoresis, RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence - FISH and GISH, Surface Plasmon resonance, Biosensor assays for assessing ligand–receptor interaction. CMI techniques - lympho proliferation assay, mixed lymphocyte reaction.

Unit III New Generation Antibodies 10 h

Antibody engineering; Hybridoma and monoclonal antibody (MCAb) techniques, Production of murine hybridoma, Production of MCAbs in cultures and animal (Ascites), Purification of MCAbs. Characterization of MCAbs /and Labelling of antibodies. Phage display libraries; Antibodies as *in-vitro* and *in-vivo* probes. Applications of monoclonal antibodies in diagnostics and therapeutics.

Unit IV Vaccine Technology 10 h

Rationale vaccine design based on clinical requirements: Active immunization, live, killed, attenuated, Sub unit vaccines; Recombinant DNA and protein based vaccines, plant-based vaccines and reverse vaccinology; Peptide vaccines, conjugate vaccines; Passive Immunization; Antibody, Transfusion of immuno-competent cells, Cell based vaccines, edible vaccines, marker vaccines, viral like particles (VLPs), Dendritic cell based vaccines, Vaccine against cancer, T Cell based vaccines and Therapeutic vaccines.

Unit V Hypersensitivity and Transplantation 10 h

Hypersensitivity- Mechanism and Types. Auto immune disorders -Type I diabetes and Rheumatoid arthritis. Role and mechanism of CD4+ T cells, MHC and TCR in autoimmunity. Tumor immunology: tumor antigens, oncogenes, immune responses and tumor evasion of the immune system, detection of cancers and therapy-chemotherapy and radiation therapy. Transplantation Immunology - immunological basis of graft rejection, clinical transplantation and immunosuppressive therapy. Machine Learning in Cancer Diagnostics.

Text Books

1. Rao CV, 2006, "Immunology - A Text book", 2nd Edition, Narosa Publishing House Pvt. Ltd, New Delhi
2. Khan FH, 2009, "The Element of Immunology" , 1st Edition, Pearson Education, New Delhi

References

1. Kuby J,1997, "Immunology", 3rd Edition, W.H.Freeman and Company, New York
2. Peter J Delves, Seamus J Martin, Dennis R Buton and Ivan M Roitt, 2017, " Roitt's Essentials Immunology", 39th Edition, John Wiley & Sons, UK
3. Hay FC, 2002, "Practical immunology", 4th Edition, Blackwell Scientific Publications, London
4. Owen, Jenni Punt and Sharon A Stranford, 2013, "Kuby Immunology",7th Edition, W.H. Freeman and Company, New York.

Course Code	Course Name	Category	L	T	P	Credit
233BT2A2CB	GENETIC ENGINEERING	CORE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- Various types of vector host systems
- Steps in creating recombinant DNA molecule
- Various recombinant DNA techniques and their applications

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Conclude the steps in recombinant DNA preparation and labeling	K4
CO2	Explain the features of various types cloning vectors for bacteria, yeast, animals and plants	K4
CO3	Compare the methods of gene transfer and hybridization	K4
CO4	Analyze various molecular techniques and its applications	K4
CO5	Evaluate the different types of sequencing and gene therapy	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓		
CO5	✓	✓	✓		✓

COURSE FOCUSES ON

✓ Skill Development	Entrepreneurial Development
✓ Employability	Innovations
Intellectual Property Rights	Gender Sensitization
Social Awareness/ Environment	Constitutional Rights/ Human Values/ Ethics

233BT2A2CB	GENETIC ENGINEERING	SEMESTER II

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I Manipulation of DNA 7 h

Purification of DNA from living cells. DNA manipulative Enzymes – Nucleases, Ligases, Polymerases, DNA modifying Enzymes - Alkaline Phosphatase, Polynucleotide Kinase, Terminal deoxy nucleotidyl transferase. Enzymes for cutting DNA - Restriction Endonucleases. Ligation – Linkers, Adaptors, Homopolymer tailing.

Unit II Cloning Vectors 12 h

Vectors for Cloning – Plasmids - size, classification. Plasmids – pBR322 and pUC vectors, Bacteriophages – Infection cycle, Viruses as cloning vectors for other organisms. Bacteriophage vectors - M13 vectors, Lambda vectors (Insertion and Replacement vectors), Phagemids, Cosmids, Yeast vectors, Shuttle vectors, Animal Viral vectors - SV-40, Baculovirus Vector, retroviral vectors, Expression vectors – pMal, GST and pET-based vectors, Plant vectors -Ti and Ri Plasmids. Artificial chromosomes – BAC, HAC, YAC. Hosts for cloning.

Unit III Gene Cloning Methodologies 10 h

Direct and indirect methods of gene transfer, selectable markers and reporter genes. Construction of cDNA and genomic libraries. cDNA cloning – directional and non-directional method, Screening of genomic and cDNA libraries – colony and plaque hybridization, Blotting techniques – Northern, Southern and Immunological screening. Microarray - DNA and Protein (Protein chips). Site directed mutagenesis. Genome editing - CRISPR/Cas 9.

Unit IV PCR and Genetic markers 9 h

PCR & its types: Principle, steps and applications – Nested PCR, Multiplex PCR, Real Time qPCR, Reverse Transcriptase PCR, Colony PCR, Touchdown PCR and Hot Start PCR. Genetic markers: Types and Applications - RAPD, RFLP, SSLP, AFLP, SNPs, STR, STS, VNTRs and microsatellites.

Unit V Gene cloning Applications 10 h

Production of recombinant pharmaceuticals: insulin, factor VIII and Recombinant Vaccines. Identification of genes responsible for human diseases, Gene therapy for

inherited diseases, Gene therapy for cancer, Gene silencing - antisense and RNA interference, Gene knock out.

Text Books

1 Brown TA, 1998, "Introduction to Gene Cloning", 3rd Edition, Stanley Thornes Publishing Ltd, United Kingdom.

2 Primrose SB, 2003, "Principles of Gene Manipulation", 6th Edition, Blackwell Science Ltd, United States.

References

1 Bernard Glick R and Jack Pasternak J, 2010, "Molecular Biotechnology: Principles and Applications of Recombinant DNA" 4th Edition, ASM press, United States.

2 Singh BD, 2008, "Text book of Biotechnology", 4th Edition, Kalyani Publishers, New Delhi

3 Sambrook J and Russel DW, 2001, "Molecular Cloning: A Laboratory Manual", 3rd Edition, CSHL, United States.

4 James Watson D, 2001, "Recombinant DNA technology". 2nd Edition, WH Freeman and company, United Kingdom.

Course Code	Course Name	Category	L	T	P	Credit
233BT2A2CC	ENVIRONMENTAL BIOTECHNOLOGY	CORE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- Basic concepts of environmental biotechnology
- Biodegradation of industrial hazardous material
- Impact of pollution on ecosystem and environmental laws

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Illustrate the organization of ecosystem and its functions	K3
CO2	Appraise the global environment problems and the hazards of pollution	K4
CO3	Distinguish the various toxic chemicals of environment and their biodegradation	K4
CO4	Explain the xenobiotics and bioremediation methods	K4
CO5	Grade the awareness on environmental monitoring and environmental laws	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2		✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓		
CO5	✓	✓	✓		✓

COURSE FOCUSES ON

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability	✓	Innovations
✓	Intellectual Property Rights		Gender Sensitization
✓	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

233BT2A2CC	ENVIRONMENTAL BIOTECHNOLOGY	SEMESTER II

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I Ecosystem structure and functions 9 h

Abiotic and biotic components, energy flow, food chain, food web and tropic levels, ecological pyramids, N,P,C and S cycles in nature. Threats to environment - pollutions, waste materials and xenobiotics. Bioaccumulation and Biomagnification

Unit II Hazards of Pollution 10 h

Types of pollution - Water, Land, Air, Noise and Nuclear. Methods for the measurement of pollution, Global environmental problems: ozone depletion, green house effect and acid rain

Unit III Environmental toxicology 10 h

Toxic chemicals in the environment (air and water) – their effects and biochemical interactions; Pesticides in water, biochemical aspects of arsenic, cadmium, lead, mercury, carbon monoxide, ozone and PAN pesticide. Mode of entry of toxic substances in environment, its breakdown and detoxification. Biotransformation of xenobiotics.

Unit IV Xenobiotics and Bioremediation 11 h

Xenobiotics in environment - biodegradation of hydrocarbons, pesticides, lignin and synthetic dyes - azo dyes. Bioremediation & Phytoremediation: Applications of bioremediation. Bioabsorption and Bioleaching of heavy metals (Mercury, Chromium and Lead), advantages and disadvantages of bioleaching. Application of biotechnology in xenobiotic bioremediation.

Unit V Environmental Monitoring 08 h

Environmental Monitoring Programme - Bioindicators of environment, Environment Management, Environment Laws (National and international) and National Environmental Policies.

Text Books

1 Prohit SS, 2003, "Ecology and environment and pollution", 1st Edition, Agrobios publications, India.

2 Varma PS, 1998, "Concept of ecology", 1st Edition, Chand & Co Ltd, India.

References

1 Dash MC, 1998, "Fundamentals of Ecology", 2nd Edition, Tata McGraw Hill, India.

2 Scragg A, 2007, "Environmental biotechnology", 2nd Edition, Oxford University Press, India.

3 Kumar R, 2017, "Advances in Environmental Biotechnology", 3rd Edition, Springer, USA.

4 Singh RL, 2016, "Principles and Applications of Environmental Biotechnology for a Sustainable Future", 1st Edition, Springer, USA.

Course Code	Course Name	Category	L	T	P	Credit
233BT2A2CD	BIOPROCESS TECHNOLOGY	CORE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- Fundamentals of fermentation technology
- Bioprocess paradigm and scale-up
- Development of fermentation products and their regulations

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Analyze the concepts of microbial culture collection and preservation	K4
CO2	Distinguish the types of fermentation process	K4
CO3	Evaluate the concept and mechanism of different types of fermenters	K5
CO4	Compare the purification of fermentation products	K5
CO5	Conclude the recent development in microbial product production	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

COURSE FOCUSES ON

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability	✓	Innovations
✓	Intellectual Property Rights		Gender Sensitization
	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

233BT2A2CD	BIOPROCESS TECHNOLOGY	SEMESTER II

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I Introduction to Bioprocess Technology 09 h

Bioprocess - Microbial biomass; Screening and selection of organisms for bioprocess; Strain improvement of industrially important microorganisms; Preservation of cultures after strain improvement programme. Fermentation inoculum preparation for bacterial and fungal processes.

Unit II Media formulation and upstream process 09 h

Fermentation media - Natural and synthetic. Sources of Carbon, Nitrogen, vitamins and other elements;. Types of Fermentation: Solid Substrate, Submerged, Batch, continuous and Fed-Batch fermentation. Optimization of fermentation process and fermentation process parameters: measurement of temperature, pressure, pH, dissolved oxygen and foam.

Unit III Bioreactor configurations and Microbial growth kinetics 10 h

Bubble column, airlift reactor, packed bed, fluidized bed, trickle bed, membrane reactor, photobioreactor, solid state fermenter, animal and plant cell bioreactors. Scale up and Scale down studies of bioreactors. Phases of cell growth, Kinetic model for cell growth: Monod's model, Haldane's model and factors affecting cell growth. Molecular mass balances for bioreactors and design equations.

Unit IV Downstream Processing 10 h

Biomass separation by centrifugation, filtration, micro, ultrafiltration, flocculation and other methods. Cell disintegration: physical, chemical and enzymatic methods. Separation of solid and liquid phases. Isolation and purification techniques for proteins and other products. Principles of bioprocess control, bioprocess automation and application of IoT in bioprocessing.

Unit V Microbial products in pharmaceutical, food and agriculture industry 10 h

Pharmaceutical Products – Enzymes (Protease and amylase), Antibiotics (Penicillins and Tetracycline), Vitamins (B2, B12), Aminoacids (lysine, glutamic acid), Organic acids (acetic acid, lactic acid); Food Products - probiotics, cheese, cultured meat, Single Cell Protein (SCP). Agricultural Products - Biofertilizer

(*Rhizobium* and *Pseudomonas*) and Biopesticides (*Bacillus thuringiensis*).

Text Books

1 Pelczar MJ, 1993, "Microbiology", 5th Edition, Tata McGraw Hill, New Delhi.

2 Patel AH, 2008, "Industrial Microbiology", 3rd Edition, PB Books, New Delhi.

References

1 Casida LE, 1997, "Industrial Microbiology", 4th Edition, New Age International Private Limited, New Delhi.

2 Prescott L, 1999, "Microbiology", 4th Edition, WCB McGraw-Hill, New Delhi.

3 Crueger A, 1990, "Biotechnology: A textbook of Industrial Microbiology", 2nd Edition, Sinauer Associates Inc, United States.

4 Michael L Shuler and Fikret Kargi, 2002, "Bioprocess Engineering: Basic Concepts", 2nd Edition, Pearson Publishers, USA

233BT2A2CP	CORE PRACTICAL - III: IMMUNOTECHNOLOGY AND BIOPROCESS TECHNOLOGY	SEMESTER II

Total Credits: 2
Total Instructions Hours: 48 h

S.No	Contents
1.	Collection of Blood, separation of serum and plasma.
2.	Blood grouping and Rh Typing.
3.	Single Radial Immuno diffusion.
4.	Ouchterlony Double Immunodiffusion.
5.	Rocket Immunoelectrophoresis.
6.	Purification of IgG antibodies using affinity chromatography.
7.	Latex agglutination test.
8.	Immobilization of bacterial cells and enzyme assay.
9.	Production & estimation of biomass (SCP).
10.	Wine production and estimation of alcohol content.
11.	Demonstration of acetic acid oxidation (vinegar production).

References

1 Frank C Hay, Olwyn MR and Westwood, 2002, "Practical Immunology", 4th Edition, Blackwell Publication, USA.

2 James G Cappucino and Natalie Sherman, 2014, "A Laboratory Manual on Microbiology", 1st Edition, Pearson Publication, USA.

3 Dubey RC and Maheswari DK, 2002, "Practical Microbiology", 2nd Edition. Chand Publications, India.

4 Delves PJ, Artin ISJ, Burton IDR and Roitt IIM, 2006, "Essential Immunotechnology", 12th Edition, Wiley & Blackwell, USA.

233BT2A2CQ	CORE PRACTICAL - IV: GENETIC ENGINEERING AND ENVIRONMENTAL BIOTECHNOLOGY	SEMESTER II

Total Credits: 3
Total Instructions Hours: 72 h

S.No	Contents
1.	Extraction of genomic DNA from bacteria
2.	Extraction of DNA from Fungi
3.	Extraction of DNA from goat liver
4.	Extraction of DNA from Plant sample
5.	Isolation of plasmid DNA from bacteria
6.	Agarose gel electrophoresis & Estimation of DNA purity and Quantification
7.	Restriction digestion and ligation of Lambda phage DNA
8.	Isolation of RNA and separation in denaturing gel
9.	Water quality Analysis–color, pH, MPN and acidity
10.	Total Hardness by EDTA titrimetric method and chloride estimation
11.	Estimation of total alkalinity, carbonate and bicarbonate
12.	Determination of Chemical Oxygen Demand (COD)
13.	Metal analysis from environment samples by flame photometry
14.	Isolation and screening of dye degrading bacteria from industrial waste water

References

1 Alan Scragg, 2007, "Environmental Biotechnology", 2nd Edition, Oxford university press, UK.

2 Tyler Miller G, Scott JR, Spoolman E, 2010, "Environmental Science", 13th Edition, Yolandacossio publisher, USA

3 Sandhya Mitra, 1996, "Genetic Engineering Principles and Practice" 1st Edition, Macmillan, India.

4 Joseph Sambrook, Fritsch EF, Tom Maniatis, Chris Nolan, 1989, "Molecular Cloning: A laboratory Manual", 2nd Edition, Cold Spring Harbor laboratory, USA.

Course Code	Course Name	Category	L	T	P	Credit
233BT2A2DA	FORENSIC BIOTECHNOLOGY	DSE	3	1	-	3

PREAMBLE

This course has been designed for students to learn and understand

- Basics and fundamentals of the sample collection and examination in forensic aspects
- Different types of DNA profiling and DNA databases used in Forensic analysis
- Applications of Forensic Biotechnology in various fields

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Describe the sample collection for forensic examinations.	K2
CO2	Know the methods to characterize the different samples on forensic prospective.	K3
CO3	Interpret and examine forensic evidence by DNA profiling methods	K3
CO4	Analyze and interpret the forensic DNA Statistics and Database	K4
CO5	Conclude the significance and applications of Forensic Biotechnology	K4

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓		✓
CO2		✓	✓	✓	✓
CO3	✓	✓		✓	✓
CO4	✓	✓			
CO5	✓	✓			✓

COURSE FOCUSES ON

✓	Skill Development		Entrepreneurial Development
✓	Employability		Innovations
	Intellectual Property Rights		Gender Sensitization
✓	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

233BT2A2DA	FORENSIC BIOTECHNOLOGY	SEMESTER II

Total Credits: 3

Total Instruction Hours: 48 h

Syllabus

Unit I Introduction and Forensic Sample Collection 08 h

Forensic science - History, scope, branches and functions. Forensic science in international perspectives, including set up of INTERPOL and FBI. Duties of forensic scientists. Forensic laboratories in India-Central Forensic Science Laboratory. Collection and Preservation of Blood, Semen, Saliva, Urine, Faeces and Milk samples for forensic examinations.

Unit II Forensic Sample Examination 10 h

Forensic characterization: Hair- morphology and types, their importance, nature, location, collection, evaluation and tests for their identification. Blood- Properties and blood grouping, presumptive and confirmatory tests. Sperm-composition, morphology of spermatozoa, presumptive and confirmatory tests (including Azoospermic semen stains), seminal fluid isozymes typing, forensic significance of sperm, collection and analysis of evidences in rape cases.

Unit III Forensic Sample DNA Profiling 10 h

DNA Profiling: Introduction, history of DNA typing, molecular biology of DNA, variations, polymorphism, DNA extraction-organic and inorganic extraction. Comparison of extraction methods and commercial kits. DNA typing systems-RFLP, PCR amplifications and Sequence polymorphism. Analysis of SNP, YSTR and mitochondrial DNA. Ancient DNA typing and evaluation of DNA typing results.

Unit IV Statistics and DNA databank 10 h

DNA Statistics: frequency estimate calculations, interpretations, allele frequency determination, Paternity/Maternity index, Sibling index, Probability of match. Human Genome Project: introduction, history, goals, benefits, social, ethical and legal issues. DNA forensic databases, ethical, legal, and social issues associated with DNA Data banking, potential benefits of DNA Data banking, quality control, certification and accreditation.

Unit V Applications of Forensic Biotechnology 10 h

Forensic significance of DNA profiling: Applications in disputed paternity cases, child swapping, missing person's identity- civil immigration, veterinary, wildlife and agriculture cases. Legal perspectives- legal standards for admissibility of DNA profiling, procedural and ethical concerns, status of development of DNA profiling in India and abroad. New and future technologies: SNPs, DNA chips, DNA Barcoding and limitations of DNA profiling.

Text Books

1 Richard Saferstein E, 2020, "Forensic Science Handbook", 2nd Edition, Prentice Hall, New Delhi.

2 Allan Jamieson and Scott Bader, 2016, "A Guide to Forensic DNA Profiling", 10th Edition, John Wiley & Sons, UK.

References

1 John Butler M, 2005, "Forensic DNA Typing - Biology, Technology, and Genetics of STR Markers", 2nd Edition, Academic Press, United States.

2 John Butler M, 2009, "Fundamentals of Forensic DNA Typing", 1st Edition, Academic Press, United States

3 Stuart James H and William Eckert G, 1993, "Interpretation of blood stain evidence at Crime scenes", 2nd Edition, CRC Press, US.

4 William Tilstone J, Kathleen Savage A and Leigh Clark A, 2006, "Forensic Science: An Encyclopedia of History, Methods and Techniques", 1st Edition, ABC - CLINO Inc, California.

Course Code	Course Name	Category	L	T	P	Credit
233MB2A2DA	BIONANOTECHNOLOGY	DSE	3	1	-	3

PREAMBLE

This course has been designed for students to learn and understand

- The role of microbes and other eukaryotes in the synthesis of nanoparticles
- Advanced methods of characterization of nano particles
- Educate the potential applications of nano particles/ materials in a variety of areas.

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Explore the basics of Nanosciences and its applications	K3
CO2	Synthesize nanoparticles at the laboratory scale	K4
CO3	Analyze the nanoparticles by spectral and electron microscopic techniques	K4
CO4	Apply bionanomaterials in drug development and delivery	K4
CO5	Criticize the merits and demerits of nanomaterial applications	K4

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓		✓	✓	✓
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓		✓
CO5	✓	✓		✓	✓

COURSE FOCUSES ON

☑ Skill Development	☑ Entrepreneurial Development
☑ Employability	☑ Innovations
☑ Intellectual Property Rights	Gender Sensitization
Social Awareness/ Environment	Constitutional Rights/ Human Values/ Ethics

233MB2A2DA	BIONANOTECHNOLOGY	SEMESTER II

Total Credits: 3

Total Instruction Hours: 48 h

Syllabus

Unit I Introduction to bionanotechnology 9 h

History – concept and future prospects – application in Life Sciences. Terminologies – nanotechnology, bionanotechnology, nanobiomaterials, biocompatibility, nanomedicine, nano tube, nanowires, quantum Dots, nanocomposite, nanoparticles, nanosensors, Nanofiber, Dendrimeter. Emergence of Bionanotechnology.

Unit II Synthesis of nanoparticles 10 h

Synthesis - Top-down approach & bottom-up approach - Types of nanoparticles production - principle and mechanism of synthesis – physical - Sonicator, Ball mill, ablation, evaporation-condensation; chemical - reducing method - chemical reduction, irradiation, electrochemical, photoreduction; biological - microbes, plants. Green synthesis

Unit III Characterization of Nanoparticles 10 h

Physical and chemical properties of nanoparticles. Characterization– UV-Vis spectroscopy, particle size analyzer, Electron Microscopy – HRTEM, SEM, AFM, EDS, XRD. Other tools and techniques required for bionanotechnology: X- Ray crystallography, FTIR, NMR.

Unit IV Applications of bionanotechnology 10 h

Targeted drug delivery, biosensors and biomarkers, food and agriculture, DNA nanotech, nanoviricides, tissue engineering, gene delivery. Antibacterial activities of nanoparticles. Toxicology in nanoparticles – Dosimetry. Molecular nanotechnology – nanomachines – collagen.

Unit V Merits and demerits of nanoparticles 9 h

Health and safety implications from nanoparticles: Health issues – Environmental issues – Need for regulation – Societal implications - Possible military applications- Potential benefits and risks for developing countries – Intellectual property issues. Bioinformatic tools in nanotechnology: molecular modeling, docking, computer assisted molecular design.

Case study- merits and demerits of nanoparticles in health and environment safety

Text Books

1. Parthasarathy BK. 2007, "Introduction to Nanotechnology", Isha Publication.
2. Elisabeth Papazoglou and Aravind Parthasarathy. 2007, "Bionanotechnology", Morgan and Claypool Publishers, New Delhi.

References

1. Bernd Rehm, 2006, "Microbial Bionanotechnology: Biological Self-assembly Systems and Biopolymer-based Nanostructures". Horizon Scientific Press.
2. DavidE Reisner and Joseph D Bronzino,2008, "Bionanotechnology: Global Prospects", CRC Press, New Delhi.
3. Ehud Gazit, 2006, "Plenty of Room for Biology at the Bottom: An Introduction to Bionanotechnology", Imperial College Press.
4. Kamali Kannangara, 2005, "Nanotechnology: Basic science and Emerging technologies", Mick Wilson, Overseas Press.

Course Code	Course Name	Category	L	T	P	Credit
233BC2A2DA	BIOCHEMISTRY OF TOXICOLOGY	DSE	3	1	-	3

PREAMBLE

This course has been designed for students to learn and understand

- The biochemical basis of toxicology.
- The effects & amp; metabolism of toxins
- General toxicology, methods of toxicity testing, toxins from microbes, carcinogenic & teratogenic toxins, pesticide, metal and chemical toxicology.

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Conclude the importance of toxicology.	K5
CO2	Distinguish and evaluate the biochemical effects of toxic agents on cellular macromolecules and tissues.	K5
CO3	Compare and perceive different genetic methods used for testing toxicity.	K5
CO4	Assess the effects and metabolism of various microbial Toxins, teratogens and carcinogens.	K5
CO5	Justify the mode of action of toxic pesticides, heavy metals, chemicals and air pollutants.	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

COURSE FOCUSES ON

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability	✓	Innovations
✓	Intellectual Property Rights		Gender Sensitization
✓	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

233BC2A2DA	BIOCHEMISTRY OF TOXICOLOGY	SEMESTER II

Total Credits: 3

Total Instruction Hours: 48 h

Syllabus

Unit I Introduction to Toxicology 9 h

Definition and scope of toxicology, Classification of toxic agents. Dose-response relationship: Synergism and Antagonism, Determination of ED50 and LD50. Acute and chronic exposures, Factors influencing toxicity - Abiotic and Biotic factors, Chemical interactions - Bioaccumulation and Bio-magnification.

Unit II Biochemical basis of Toxicology 9 h

Toxicokinetics–ADME (Absorption, Distribution, Metabolism and Excretion) and Toxicodynamics. Mechanisms of Toxicity, Interaction of toxicant with target molecules -Disturbance of excitable membrane function. Altered calcium homeostasis. Covalent binding to cellular macromolecules. Organ toxicology, Genetic and reproductive toxicology, Toxicogenomics.

Unit III Principles and procedures of testing for acute toxic effects 10 h

Toxicity testing - Genetic toxicity testing and mutagenesis assays - In-vitro test systems - Bacterial mutation tests: Reversion test, Fluctuation tests, Ames test, Eukaryotic mutation test. In-vivo mammalian mutation tests - Host mediated assay and Dominant lethal test. Use of drosophila in toxicity testing. DNA Repair assays, Chromosome damage test. Toxicity testing in animals. Toxicological evaluation of Recombinant DNA – derived proteins.

Unit IV Effects and Metabolism of toxins 10 h

Fungal toxins, Mycotoxins - Aflatoxins, Bacterial toxins – Exotoxins and Endotoxins, Viral toxins, Algal toxins, Teratogens, Carcinogens, Mutagens, Snake venom toxin, Spider, Scorpion and Jellyfish toxins, Antivenom. Xenobiotic metabolism: Phase 1– III reactions, Cytochrome-P450. Free radical theory of oxygen toxicity.

Unit V Pesticide toxicology, Metal toxicology, Chemical toxicology, Air and water pollutants 10 h

Mechanism and site of action of Chlorinated organics (DDT, BHC), organophosphates and carbamates. Fungicides, Herbicides. Environmental consequences of pesticide toxicity. Biopesticides, Mode of action of toxic heavy

metals - arsenic, mercury, cadmium and lead. Biochemical effects of ozone, peroxyacetyl nitrate (PAN) carbon monoxide, nitrogen oxides, sulphur dioxide and cyanide. Drug induced toxicity -example- Paracetamol. Common air pollutants, water pollutants and their sources, air pollution due to methyl - isocyanate (MIC) and asbestos. Toxicology of food additives, case studies

Text Books

1 Klaassen Curtis D, 2019, "Casarett and Doull's Toxicology - The basic Science of Poisons", Ninth edition, McGraw Hill Education, London.

2 Cockerham L.G and Shane B.S, 2019, "Basic Environmental Toxicology", First edition, CRC Press, New York.

References

1 Robert S.M and James R.C, 2015, "Principles of Toxicology: Environmental and Industrial Applications", Third Edition, John Wiley and Sons, New York.

2 De A.K, 2017, "Environmental Chemistry", Eighth Edition, Newage International Publishers, NewDelhi.

3 Gupta P.K, 2016, "Fundamentals of Toxicology – Essential concepts and Applications", First edition, Academic Press, Cambridge, USA.

4 Gupta R, 2019, "Biomarkers in Toxicology", Second Edition, Academic Press, Cambridge, USA.

17/10/23
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BoS- 16th 17/10/23
AC - 16th 13/10/23
GB - 21st 05/01/24

Course Code	Course Name	Category	L	T	P	Credit
233BT2A3CA	RESEARCH METHODOLOGY & IPR	CORE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The importance of research and validate data.
- The value of research in the course.
- Patenting and licensing expertise.

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Comprehend the concepts of research	K3
CO2	Inculcate the importance of scientific validation	K4
CO3	Interpret the reports of research findings	K4
CO4	Infer the information of Intellectual Property Rights.	K4
CO5	Elucidate filing and licensing of Patents	K4

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓		✓	✓
CO5	✓	✓			✓

✓	Skill Development		Entrepreneurial Development
✓	Employability		Innovations
✓	Intellectual Property Rights		Gender Sensitization
✓	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

233BT2A3CA	RESEARCH METHODOLOGY & IPR	SEMESTER III

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I Research Concepts and Data Collection 09 h

Definition of Research, Qualities of Researcher, Components of Research Problem, Various Steps in Scientific Research, Types of Research and Research Design. Sampling- Types of sampling - design - procedure of sampling. Data - Primary and Secondary data.

Unit II Scientific Communication 10 h

Scientific writing skills - Importance; Plagiarism; Scientific publication writing: Elements of a scientific paper including Abstract, Introduction, Materials & Methods, Results, Discussion, References; Publishing scientific papers - peer review process and problems.

Unit III Research Reports and Research Funding 10 h

Structure and Components of Research Report, Types of Reports, Styles of reporting, Steps in drafting reports, editing and evaluation of final draft, Pictures and Graphs; Research proposal/Grant- definition, structure, budget allocation, specific aims, background and significance. Hierarchy of funding agencies in India and their operations.

Unit IV Intellectual Property Rights 10 h

Types of IP in India - Patents, Trademarks, Copyright and Related rights, Industrial Design, Geographical indications and Protection of Plant varieties. Importance of IPR; Legal protection of Biotechnological inventions; World Intellectual Property Rights Organization (WIPO); Protection of GMOs; Relevance of IP in Biotechnology.

Unit V Patent 10 h

History of Indian Patent System and Law; Types of Patent; Patentable and Non-Patentable items; Patent Search; Forms for Patent filing; Patent file procedures; Precautions during patenting; Checking the status of patent applications; Patent Cooperation Treaty (PCT); Patent and compulsory licensing. Indian Patent Act 1970 and Recent Amendments; GATT and TRIPS agreement; WIPO Treaties.

Text Books

1 Ranjit Kumar, 2019, "Research Methodology: A Step-by-Step Guide for Beginners", 5th Edition, SAGE Publishers.

2 Kothari CR, 2010, "Research Methodology: Methods and Techniques", 2ndEdition, New Age International.

References

1 Gurumani N, 2006, "Research Methodology for Biological Science", MJP Publishers, Chennai.

2 Holmes D, Moody P, Dine D et al., 2017, "Research Methods for theBiosciences", 3rd Edition, Oxford University Press.

3 Glass DJ, 2014, "Experimental Design for Biologists", 2ndEdition, Cold Spring Harbor Laboratory Press.

4 Daniel PS, Sam AG, 2011, "Research Methodology", 1st Edition, Gyan Publishing House.

Course Code	Course Name	Category	L	T	P	Credit
233BT2A3CB	GENOMICS AND PROTEOMICS	CORE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The scope of Bioinformatics.
- Focus on Protein and Genome analysis using Bioinformatics tools.
- Importance of gene sequencing.

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Summarize about Bioinformatics and Databases	K4
CO2	Design Data interpretation using Alignment Algorithms	K4
CO3	Evaluate Genome Analysis and Principles of Docking	K5
CO4	Formulate Proteome analysis, tools & databases available	K5
CO5	Compos concept of proteomics & with their applications	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2		✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓		
CO5	✓	✓	✓		✓

✓	Skill Development		Entrepreneurial Development
✓	Employability	✓	Innovations
	Intellectual Property Rights		Gender Sensitization
	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

233BT2A3CB	GENOMICS AND PROTEOMICS	SEMESTER III

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I Bioinformatics and Databases 09 h

Bioinformatics – Introduction and History. Biological Databases. Primary and secondary databases with examples. Data generation - large scale molecular biology data, BIOSEQ. Nucleic acid sequence databases- Gene bank, Protein sequence databases - Swiss-Prot, PDB & PIR. Rasmol - Molecular modeling. Steps to retrieve sequence and structure of a protein. Homology searching and annotation of genomic sequences. Applications of Bioinformatics.

Unit II Genomics 09 h

Introduction and classification of genomics- Functional genomics, structural genomics. Sequencing of genomes and DNA Sequencing Technologies - Sanger sequencing, Next-generation sequencing (NGS) platforms, Single-molecule sequencing technologies and Preprocessing and quality control of NGS data. Structure, organization and composition of prokaryotic genomes. Microbial genomics and genome epidemiology. Metagenomics and methods of Metagenomics.

Unit III Genome Analysis and Docking 10 h

Genome analysis of Microbes, plants and animals; Accessing and retrieving genome project information from web; Comparative genomics, Identification and classification using molecular markers-16SrRNA & 18SrRNA typing/sequencing, Fragment Assembly- ESTs, Genomic Data Analysis - Data quality control and preprocessing, Genome assembly, prediction and annotation, Variant calling and analysis, Comparative genomics and phylogenetics. Codon optimization tools and its advantages. Microarray and its applications. Gene Expression Profiling. GENSCAN. Molecular docking & Molecular simulation principles.

Unit IV Tools in Proteomics 10 h

Protein analysis - Proteomics classification. 1D-SDS- PAGE and 2D-SDS PAGE. Detection and quantitation of proteins in gels. Pros and cons of various staining methods. Basics of mass spectrometry. MALDI - TOF and ESI and their application in proteomics. UPLC and its applications. Tandem MS/MS spectrometry - Peptide sequencing by tandem mass spectrometry. Protein Data visualization and interpretation - Q-TOF, Orbitrap. Quantitative Proteomics - Label-based techniques

(SILAC, iTRAQ, TMT) & Label-free techniques (MS1-based, MS2-based, spectral counting.

Unit V Pharmacogenomics and other omics 10 h

High content screening in genome for drug discovery- identification of gene targets Pharmacogenetics; Pharmacogenomics - classical and non- classical. Medical genomics, personalized medicine and Pharmacogenomics of genetic diseases - hypertension and Cancer. Metabolomics-techniques involved. Nutrigenomics and its applications. Other omics - lipidomics, transcriptomics, metagenomics, toxicogenomics, venomics, epigenomics, epigenetics, functional proteomics and its applications. Integration of multi-omics data. Basics of CADD and its importance.

Text Books

1 Rao SD, 2010, "Bioinformatics", 2nd Edition, Biotech Pharma Publications, India.

2 Pevsner J, 2015,"Bioinformatics and Functional Genomics", 3rd Edition, Wiley Blackwell Publications.

References

1 Campbell AM and Heyer LJ, 2007, "Discovering Genomics, Proteomics and Bioinformatics", 2ndEdition, Pearson Education.

2 Tramontano A, 2005,"The Ten Most Wanted Solutions in Protein Bioinformatics", 1stEdition, CRC Press, USA.

3 Miguel Rudolph, 2019, "Genomics and Proteomics: Functional and Computational Aspects"1st Edition, Syrawood Publishing House, USA.

4 Semwal KP, 2021, "Discovering Genomics, Proteomics and Bioinformatics", 1st Edition, Random Publishing UK Ltd.

Course Code	Course Name	Category	L	T	P	Credit
233BT2A3CC	MARINE BIOTECHNOLOGY	CORE	4	-	-	3

PREAMBLE

This course has been designed for students to learn and understand

- The ecology and biodiversity of marine environment
- Explore the Biotechnological methods and understand the diverse richness of ocean bioresources
- Understand about the detailed bio-potentials of marine resources and its applications

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Identify the features of marine ecosystems and organisms in marine environment.	K3
CO2	Analyze the marine based products and its applications	K4
CO3	Learn the biotechnological aspects to improve the trait of marine organisms and the safety measures.	K3
CO4	Infetr the various disease diagnosing techniques	K4
CO5	Learn the applications and conservation of marine resources	K3

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2		✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓		
CO5	✓	✓	✓		✓

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability	✓	Innovations
	Intellectual Property Rights		Gender Sensitization
	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

233BT2A3CC	MARINE BIOTECHNOLOGY	SEMESTER III

Total Credits: 3

Total Instruction Hours: 48 h

Syllabus

Unit I Marine Ecology 10 h

Introduction to marine environment-Marine Flora (phytoplankton, seaweeds, sea grasses and mangroves), Marine fauna (Zooplankton), Marine invertebrates (crustaceans & sponges), Vertebrates -Fishes (bony, cartilaginous, jawless fishes) - Marine tetrapods (amphibians, reptiles)- marine mammals (dolphin and whales). Bio-communication in oceans, Microbe-microbe interaction, Marine Biofouling.

Unit II Blue Biotechnology 10 h

Marine Biotechnology- applications of marine biotechnology (marine natural medicinal products (Antibiotics, Antitumor Compounds and peptides) - Marine Neutraceuticals (Marine Lipids, Probiotics and Pigments), marine cosmetics (Marine ingredients for moisturizing, anti-ageing) and Metabolic engineering of microalgae for biofuel production.

Unit III Genetic Engineering methods-Issues and Safety concerns 8 h

Transgenic fish production- Techniques (Microinjection, Electroporation and Retroviral Vector). Sterile fish production (artificial insemination, in-vitro fertilization). Issues related to Transgenic Fish and measures to resolve issues. Gene manipulations to improve strains. Hormonal influence in fish breeding technology.

Unit IV Disease diagnosis and Prevention techniques 10 h

Fish and Shrimp Diseases: Bacterial, fungal, viral and parasitic (EHP, WSSV, RMS, WFS). Gene probes. Molecular diagnosing – Fluorescent in-situ hybridization (FISH), Polymerase Chain reaction (PCR). Microarray diagnosis. Detection of toxic substances and pathogenic microbes- biosensors for toxin detection- Antibiotic residual analysis techniques. Fish vaccines, antimicrobial peptides, natural preservatives for preservation of fish.

Unit V Applications and Conservations 10 h

Aquaculture, Ornamental fish, Single cell protein from Spirulina, vitamins, minerals and Omega-3 fatty acids from micro-algae. Green fluorescent protein (GFP) &Red Fluorescent Protein (RFP) characteristics and their applications, Green mussel adhesive protein. Conservation and management-in situ and ex situ, IUCN categorization; Marine biosphere reserves; Marine parks - heritage sites.

Text Books

1 Josep M Gasol and David L Kirchman, 2018, "Marine ecology of the oceans", 3rd edition, John Wiley and Sons. Inc.

2 Se-kwon Kim, 2015, "Handbook of Marine Biotechnology", Springer.

References

1 Jeffrey S Levinton, 2001, "Marine Biology: Function, Biodiversity, Ecology", 2nd edition, OUP, USA.

2 Le Gal Y, Ulber R, and Antranikian G, 2005, "Marine Biotechnology", 1st edition, Springer.

3 Se-Kwon Kim, 2013, "Marine Microbiology: Bioactive Compounds and Biotechnological Applications", 1st edition, Wiley-VCH publishers.

4 Fingerman M and Nagabhushanam R, 2002, "Recent Advances in Marine Biotechnology (Series) Seafood Safety and Human Health", Science Publishers, USA.

Course Code	Course Name	Category	L	T	P	Credit
233BT2A3CD	PLANT BIOTECHNOLOGY	CORE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- Various *in vitro* culture techniques.
- Gene transfering mechanisms.
- The applications of gene transfer technologies and bioprospecting.

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Explain plant culture media types and the role of different media constituents	K3
CO2	Gain insight on plant genome organisation	K3
CO3	Infer knowledge on *Agrobacterium* biology and transgenic technology	K4
CO4	Compile various types of resistance and green house technology concepts	K5
CO5	Analyze bioprospecting aspects of plants	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓		✓	✓
CO5	✓	✓			✓

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability	✓	Innovations
	Intellectual Property Rights		Gender Sensitization
	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

233BT2A3CD	PLANT BIOTECHNOLOGY	SEMESTER III

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I **Plant Tissue Culture** 10 h

Introduction, Laboratory organization, media composition (MS, LS, White's, Knudson C), Sterilization techniques. Micropropagation (Callus, Nodal, Shoot tip, Meristem). Somatic embryogenesis, Artificial seed production, Haploid culture (Anther, Pollen, ovary, ovule). Protoplast isolation and somatic hybridization. Secondary metabolite production- suspension culture. Germplasm conservation-cryopreservation.

Unit II **Genome organization** 08 h

Nuclear genome, chloroplast genome, mitochondrial genome, CMS, Protein targeting to chloroplast and mitochondria, Heat shock proteins, seed storage proteins.

Unit III **Plasmids,Vectors and Nuclear Transformation** 10 h

Features of Ti and Ri plasmids, uses of Ti and Ri as vectors, binary vectors, use of 35S and other promoters, plant viral vectors, use of reporter genes. Transgenic biology - methods of nuclear transformation – physical, chemical and biological gene transfer methods in plants.

Unit IV **Plant Resistance** 10 h

Engineering of plants for herbicide resistance, insect resistance, disease resistance, fungal resistance, nematode resistance, stress tolerant plants. Molecular Breeding, Genome editing techniques for crop improvement - Long shelf life of fruits and flowers – antisense RNA technology, Green house technology.

Unit V **Bioprospecting aspects of Plant Biotechnology** 10 h

Extraction & purification of phytochemicals. Industrial phytochemical products from plants- alkaloids, Biodegradable Plastics, Therapeutic proteins, plantibodies, plant vaccines, herbal drugs, bioethanol and biodiesel.

Text Books

1 SinghBD, 2006, "Plant Biotechnology", 1st Edition, Kalyani Publishers.

2 Chawla HS, 2013,"Introduction to Plant Biotechnology", 3rd Edition, Oxford & IBH publishing company.

References

1 Grierson D and Covey SV, 1988, "Plant Molecular Biology", 2nd Edition, Blackie Publishers.

2 Bhojwan SS, 1996,"Plant tissue culture - Theory and Practice", 1st Edition, Elsevier Publishers.

3 Gamborg, Olug, Phillips, Gregory (Eds.), 1995, "Plant Cell, Tissues and Organ Culture- Fundamental Methods", Springer- Verlag Berlin Heidelberg.

4 Slater A, Scott N and Fowler M, 2003, "Plant Biotechnology: The genetic manipulation of plants", Oxford University Press.

Course Code	Course Name	Category	L	T	P	Credit
233BT2A3CE	ANIMAL BIOTECHNOLOGY	CORE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The essentials of animal tissue culture.
- In vitro studies to replace *in vivo* models.
- Applications of animal tissue culture.

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Comprehend basics of setting up animal tissue culture lab	K3
CO2	Develop the scaling up process in tissue culture	K4
CO3	Understanding of establishment of organ culture	K3
CO4	Application of tissue and cell culture	K4
CO5	Gain knowledge in tissue culture and its applications	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2		✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓		
CO5	✓	✓	✓		✓

✓	Skill Development		Entrepreneurial Development
✓	Employability	✓	Innovations
✓	Intellectual Property Rights		Gender Sensitization
	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

233BT2A3CE	ANIMAL BIOTECHNOLOGY	SEMESTER III

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I Basics of Animal Tissue Culture Lab 10 h

Planning and Construction of ATC lab – infrastructure, equipment, culture vessels. Dos and Don'ts of ATC labs. Culture media, Balanced Salt Solution and simple growth medium, functions of difference constituents of culture medium. Role of carbon dioxide, serum, growth factors, glutamine in cell culture, Serum and protein free defined media and applications.

Unit II Cell Culture techniques and Cryopreservation 10 h

Primary cell culture and its establishment – mechanical disaggregation, enzymatic disaggregation, identification of viable and non viable cells. Secondary cell lines – passages - Risks in a tissue culture laboratory and safety – biohazards. Cryopreservation – protocol – ATCC the global bioresource.

Unit III Animal cell culture scale up 8 h

Scaleup in suspension stirrer culture, continuous flow culture, air lift fermentor, scaleup in monolayer – roller bottle culture, multisurface culture, multiarray disks, spiral sand tubes – monitoring of cell growth - measurement of cell death.

Unit IV Tissue and organ culture 10 h

Organ culture- whole embryo culture – specialized culture techniques – Advantages and limitations of Tissue and organ culture – medical/pharmaceutical products of animal cell culture – genetic engineering of animal cells and their applications.

Unit V Tissue engineering 10 h

Design and engineering of tissues – tissue modeling – 3D bioprinting – characteristics -requirements - types – advantages and limitations. Embryonic stem cell engineering – ES cell culture to produce differential cells – Human embryonic stem cell research.

Text Books

1 Freshney RI, 2005, "Culture of Animal Cells – A Manual of Basic Techniques", 5th Edition, John Wiley and Sons, New York.

2 Davis JM, 2005, "Basic Cell Culture - A Practical Approach", 2nd Edition, Oxford University, New York.

References

1 Singh B, Gautam SK and Chauhan MS, 2015, "Textbook of animal Biotechnology", The Energy Resource Institute, TERI press, New Delhi, India

2 Srivastava AK, Singh RK, Yadav MP, 2009, "Animal Biotechnology", Oxford and IBH Publishing Company.

3 Ranga MM, 2007, "Animal Biotechnology", 3rd Edition, Agrobios, India.

4 Butler M, 2004, "Animal Cell Culture Technology – Basics", 1st Edition, Academic Press, New York

233BT2A3CP	CORE PRACTICAL - V: PLANT, ANIMAL, MARINE BIOTECHNOLOGY, GENOMICS & PROTEOMICS	SEMESTER III

Total Credits: 3
Total Instructions Hours: 72 h

S.No	Contents
1	In vitro Seed Germination and Artificial Seed Production
2	Callus Induction and Micropropagation
3	Isolation and Fusion of Protoplast
4	*Agrobacterium* mediated gene Transfer
5	Preparation of primary cell culture & trypsinization
6	Determining cell number and viability with a haemocytometer and trypan blue staining
7	Detection of sea food associated pathogens
8	Screening of marine micro organisms for production of antibiotics
9	Extraction of Biomolecules from sea weeds
10	Retrieving of nucleotide sequences and Construction of phylogenetic tree
11	Retrieving structural data of a protein and a drug molecule
12	Selection of target and ligand for molecular docking & Molecular Simulation

References

1. Satish Kumar Sinha, 2012, "Plant tissue culture: Theory and Practice", 1st Edition, Oxford University Press.
2. Ian Freshney R, 2015, "Culture of Animal Cells", 7th Edition, Wiley Blackwell
3. Tramontano, A., 2005,"Ten Most Wanted Solutions In Protein Bioinformatics", 1st Edition, CRC Press. USA
4. Lesk, A.M., 2014, "Introduction to Bioinformatics", 4th Edition, Oxford Publications.

Course Code	Course Name	Category	L	T	P	Credit
233BT2A3DA	MOLECULAR THERAPEUTICS	DSE	3	1	-	3

PREAMBLE

This course has been designed for students to learn and understand

- The types of gene therapy and drug delivery.
- The importance of cell therapy and recombinant therapy.
- The basis of microbial pathogenesis and various immunological approaches.

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Sketch the process of drug targeting and gene therapy	K3
CO2	Evaluate the use of stem cells and tissue engineering in therapy	K4
CO3	Summarize recombinant gene therapy	K5
CO4	Integrate pathogenic diseases and metabolic disorders	K5
CO5	Design the concept of immunotherapy and its applications	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓		✓	✓
CO5	✓	✓			✓

✓	Skill Development		Entrepreneurial Development
✓	Employability	✓	Innovations
	Intellectual Property Rights		Gender Sensitization
	Social Awareness/ Environment	✓	Constitutional Rights/ Human Values/ Ethics

233BT2A3DA	MOLECULAR THERAPEUTICS	SEMESTER III

Total Credits: 3

Total Instruction Hours: 48 h

Syllabus

Unit I Concepts of Gene Therapy and Drug Delivery 09 h

Introduction to Gene Therapy, Drug targeting and drug delivery system. Intracellular barriers of gene delivery, gene therapy for inherited and acquired diseases, virus mediated gene transfer. Liposome and Nanoparticles mediated gene delivery.

Unit II Stem cells and Tissue Engineering 10 h

Introduction to Cellular therapy. Stem cells: definition, properties and potency of stem cells; Sources: embryonic and adult stem cells, Role of adult and embryonic stem cells in therapy. Concept of tissue engineering; Role of scaffolds; Role of growth factors in tissue engineering. Clinical applications and Ethical issues.

Unit III Recombinant Gene therapy 10 h

Introduction to Recombinant therapy, Clinical application of recombinant technology, Erythropoietin, insulin analogs and its role in diabetes, Recombinant human growth hormone, streptokinase and urokinase in thrombosis. Recombinant coagulation factors.

Unit IV Microbial Pathogenicity 10 h

General concept of infectious disease, types of infectious diseases. Progression of Infection and Disease -Entrance (Portal of entry), Colonization (Adherence; Adhesion; Attachment), Prevention of Host Defenses, Antigenic Variation, Penetration into Host Cytoskeleton, Damage to Host Cells, Production of Toxins.

Unit V Immunotherapy 09 h

Introduction to Immunotherapy, Monoclonal antibodies and their role in cancer treatment, role of recombinant interferons, Immunostimulant and Immunosupressors in organ transplants, role of cytokine therapy in cancer. MAMP, RAMP and DAMP triggered immunity. Vaccines: types, recombinant vaccines and their clinical applications.

Text Books

1. Palsson, B. and Bhatia, S. N, 2004, "Tissue Engineering", 2nd Edition, Prentice Hall, USA.
2. Greenwell, P. and McCulley, M, 2008, "Molecular Therapeutics: 21st century Medicine", 1st Edition, Wiley-Blackwell, USA.

References

1. Coleman, W.B. and Tsongalis, G.J, 2006, "Molecular Diagnostics for the Clinical Laboratory", 2nd Edition, Humana Press, USA.
2. Leonard, DGB, 2016, "Molecular Pathology in Clinical Practice", 2nd Edition, Springer International Publishers, USA.
3. Whitehouse, D. and Rapley, R, 2012, "Molecular and Cellular Therapeutics", 1st Edition, Wiley – Blackwell Publications, USA.
4. Quesenberry, P.J. and Stein, G.S, 1998, "Stem Cell Biology and Gene Therapy", 1st Edition, John Wiley and Sons Publications, USA

Course Code	Course Name	Category	L	T	P	Credit
233MB2A3DA	MEDICAL LABORATORY TECHNIQUES	DSE	3	1	-	3

PREAMBLE

This course has been designed for students to learn and understand

- The organization of clinical laboratory
- The processing of clinical samples
- The importance of SOP in laboratory testing

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Understand the organization of clinical laboratory	K1
CO2	Apply suitable antiseptics and disinfectants in laboratory conditions	K1
CO3	Analyze various clinical samples.	K2
CO4	Calibrate the instruments for quality assurance.	K2
CO5	Formulate SOP in clinical laboratory	K3

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓		✓
CO2		✓	✓	✓	✓
CO3	✓	✓		✓	✓
CO4	✓	✓			
CO5	✓	✓			✓

Course Focuses on

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability		Innovations
	Intellectual Property Rights		Gender Sensitization
	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

233MB2A3DA	MEDICAL LABORATORY TECHNIQUES	SEMESTER III

Total Credits: 3

Total Instruction Hours: 48 h

Syllabus

Unit I Introduction to Clinical laboratory 9 h

Basic laboratory principles - Organization of clinical laboratory - Biosafety in containment laboratory - National and International GLP (Good laboratory Practices) - Role of medical laboratory technician - personnel hygiene and safety measures.

Unit II Antiseptics & Disinfectants 9 h

Definition -Types - Mode of Action – Uses. Antimicrobial agents and Antibiotics: Introduction, mechanism of action, classification and uses, Antibiotic susceptibility testing - Stokes, Kirby-Bauer method, Minimal Inhibitory Concentration and Minimal Bactericidal Concentration.

Unit III Collection and processing of blood 10 h

Collection and processing of blood sample- separation of serum and plasma - Sampling errors - Preservation of samples. Determination of Total Count, Differential Count, Erythrocyte Sedimentation Rate, Hemoglobin concentration (Hb), Bleeding Time & Clotting Time. ABO Blood group system. Detection of blood glucose, Urea, Cholesterol and Bilirubin. Profiling - Liver function test, Renal function tests. Hormones - T3, T4, TSH, FSH, LH, Prolactin, Insulin.

Unit IV Processing of Urine, Stool and Sputum sample 10 h

Collection, transport and Storage of Urine, Stool and Sputum sample. Macroscopic and Microscopic examination - Urine: sugar, albumin, bile salts, bile pigments and ketone bodies - Pregnancy Test. Stool – Cyst, Ova, Mucus, Pus, RBC, Reduced sugar, Occult blood. Sputum –Petroff's method, AFB staining.

Unit V Maintenance of Laboratory 10 h

Maintenance of Laboratory Equipment's – Centrifuge, calorimeter, microscope, incubator, autoclave. Laboratory Certification process – National Accreditation Board for Laboratories, Indian Standard Organization - Standard Operating Procedure - Clinical Laboratory records. Biomedical waste management – Bureau of Indian Standards- danger signs and Symbols.

Case study: A patient comes to you with a doctor's prescription asking you to analyze the thyroid profiling of the patient. The patient has memory issues, drying of skin, hair fall, weight gain etc. What are the tests that you would perform under thyroid profiling? What could probably be the ailment surrounding the patient with your limited knowledge on the patient and his history. Based on your report, what could probably the doctor prescribe the patient?

Text Books

1 Ananthanarayanan R and CK Jayaram Panicker, (2020). Textbook of Microbiology. (11Edn.) Delhi: Orient Longman..

2 Monica Cheesbrough, (2018). District Laboratory Practice in Tropical Countries. (2Edn.) USA: Cambridge University Press..

References

1 Bailey and Scotts,. (1994). Diagnostic Microbiology. (9 Edn.) New Delhi: Baron and FinegoldCVMosby Publications.

2 Jawetz E Melnic JL and Adel berg EA,. (1998). Review of Medical Microbiology. (10 Edn.) USA: Lange Medical Publications.

3 Mackie and McCatney,. (1994). Medical Microbiology. (14 Edn.) New Delhi: Church will Livingston.

4 Patrick.K.Murray,I.N. (2012). Medical Microbiology. (4 Edn.) USA: Mosboy Publishers.

Course Code	Course Name	Category	L	T	P	Credit
233BC2A3DA	FREE RADICALS AND ANTIOXIDANT SYSTEM	DSE	3	1		3

PREAMBLE

This course has been designed for students to learn and understand

- the concepts of free radicals, ROS& RNS, and their chemical characteristics.
- the importance of enzymic antioxidants in preventing oxidative damage.
- the role of antioxidants as immunomodulators and their impacts on body.

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Demonstrate the formation of free radicals, ROS, and RNS in biological systems and their sources	K3
CO2	Examine the effects of free radicals in various disease conditions and effect of exercise on antioxidants	K4
CO3	Analyze the chemistry, mechanism and effect of enzymic and synthetic antioxidants	K4
CO4	Evaluate the chemistry, mechanism and functions of different non-enzymic antioxidants	K5
CO5	Assess the role of antioxidant in therapeutics and gain insights into future perspectives and challenges in the field	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

✓	Skill Development		Entrepreneurial Development
✓	Employability		Innovations
	Intellectual Property Rights		Gender Sensitization
✓	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

233BC2A3DA	FREE RADICALS AND ANTIOXIDANT SYSTEM	SEMESTER III

Total Credits: 3

Total Instruction Hours: 48 h

Syllabus

Unit I **Introduction to Free Radicals and Oxidative Stress** 10 h

Definition of free radicals, Reactive Oxygen Species (ROS) and Reactive Nitrogen Species (RNS). Formation and physiological roles of free radicals. Mechanism of oxidative damage to biomolecules (DNA, proteins, lipids). Techniques for measuring ROS/RNS levels.

Unit II **Reactive Oxygen Species and Disease** 10 h

Oxidative stress in atherosclerosis,obesity and metabolic syndrome, hypertension, Alzheimer's, Parkinson's, Mitochondrial dysfunction, skin aging processes,Air pollution and respiratory diseases.Exercise-induced ROS production, Redox balance and muscle recovery. Effects of exercise on antioxidant defense systems.

Unit III **Enzymic Antioxidants and synthetic Antioxidants** 8 h

Enzymic antioxidants- Chemistry, mechanism, antioxidant effect of superoxide dismutase (SOD), Catalase, Glutathione Peroxidase and the glutathione system
Synthetic antioxidants: BHA (butylated hydroxyanisole), BHT (butylated hydroxytoluene), TBHQ (tert-butylhydroquinone), and their chemical properties.

Unit IV **Non Enzymic Antioxidants** 10 h

Non Enzymic antioxidants- source, chemistry, toxicity, biochemical functions, bioavailability, bioassays, Antioxidant effects of Vit A, Vit C (ascorbic acid), Vit E (tocopherols and tocotrienols), glutathione and selenium.

Unit V **Emerging Topics in Free Radicals and Antioxidant system** 10 h

Mitochondrial-targeted therapeutics .Antioxidants as immunomodulators. Antioxidant strategies for stem cell therapy. Redox modulators in cancer therapy- Redox-active compounds in drug discovery. Clinical trials and future perspectives. Antioxidant supplementation and disease prevention. - Personalized nutrition and antioxidant requirements.

Text Books

1 Steven I Baskin, Harry Salem, 2020 "Oxidants, Antioxidants, and free Radicals", 1st Edition, CRC Press, Florida.

2 Donald Armstrong, 1994, "Free Radicals in Diagnostic Medicine: A systems approach to Laboratory Technology, Clinical Correlations and Antioxidant Therapy; v. 366", 4th edition, Springer Science, LLC.

References

1 Barry Halliwell and John M.C. Gutteridge, 1998, "Free Radicals in Biology and Medicine", 3rd Edition,Oxford University Press, United Kingdom.

2 Vibila Rani, 2015, "Free Radicals in Human health and Disease", 5th edition, Springer, New York, USA.

3 Helmut Sies, 1991, "Oxidative Stress: Oxidants and Antioxidants", 2nd edition, Academic Press, London, United Kingdom.

4 Dietmar Spengler, 2015, "The Redox Theory of Aging: Physiological Roles and Mechanisms of Aging", 3rd edition, Springer, New York, USA.

233BT2ASSA	SELF STUDY - FOOD BIOTECHNOLOGY	SEMESTER III

Total Credit: 1

Syllabus

Unit I Food Biotechnology

Introduction and Scope; Production of Single cell protein and Baker's yeast; Mushroom cultivation. Food and dairy products: Cheese, bread and yogurt. Fermented vegetables – Saurkraut; Fermented Meat – Sausages.

Unit II Novel Microorganisms

LAB (Probiotics), Cyanobacteria, methylotrophs enzyme biotransformations. Role of Plant tissue culture for improvement of food additives; color and flavor. Genetic modifications of microorganisms; detection and rapid diagnosis. Genetically modified foods and crop.

Unit III Food Borne Infections And Intoxications

Food borne infections and intoxications; with examples of infective and toxic types – Clostridium, Salmonella, Staphylococcus. Mycotoxins in food with reference to Aspergillus species. Food preservation: canning, dehydration, ultrafiltration, sterilization, irradiation. Chemical and naturally occurring antimicrobials; Biosensors in food industry.

Unit IV Types of beverages and their importance

Synthetic beverages- carbonated, low-calorie and dry beverages; isotonic and sports drinks; soft drinks.

Unit V Quality assurance

Microbiological quality standards of food, Intellectual property rights and animal welfare. Government regulatory practices and policies. FDA, EPA, HACCP, ISI. Risk analysis; consumer and industry perceptions

Text Books

1 Lee B.H.V., 1996, Fundamentals of Food Biotechnology, 1st Edition, C H Publishers, Inida.

2 Roger, A., 1989, Food Biotechnology, 1st edition, Elsevier Applied Sci. Pub., USA.

References

1 Goldberg I., 1994, Functional Food, . 1st edition. Chapman & Hall Publishers, India.

2 Anthony P. et al, 2005. Food Biotechnology. 2nd edition. CRC Publication, USA.

3 Casida, L.E. 1997. Industrial Microbiology. 6th edition. New Age International Publishers, India.

4 Presscott, L. M. Harley, J. P. and Klein, D. A. 1999. Microbiology, 4th edition, WCB Mc Graw-Hill, India.

233BT2ASSB	SELF STUDY - DEVELOPMENTAL BIOLOGY	SEMESTER III

Total Credit: 1

Syllabus

Unit I Concepts of Development

Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development.

Unit II Gametogenesis

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

Unit III Morphogenesis and Organogenesis in Animals

Cell aggregation and differentiation in Dictyostelium; axes and pattern formation in Drosophila, amphibia and chick; organogenesis – vulva formation in Caenorhabditis elegans; eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development - larval formation, metamorphosis; environmental regulation of normal development; sex determination. Programmed cell death and aging

Unit IV Morphogenesis and Organogenesis in Plants

Organization of shoot and root apical meristem; shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems, floral development and senescence in Arabidopsis and Antirrhinum

Unit V Techniques for the Study of Development

Techniques for the study of development: Microscopy - Study of gene expression by biochemical methods – Study of gene expression by in situ methods – Microinjection – Cell-labeling methods – Cell sorting

Text Books

1 Jonathan, MW, 2006, Essential developmental biology, Wiley-Blackwell, USA.

2 Schatten GP, 2006, Current topics in developmental biology, Academic press, USA.

References

1 Wallace A., 2000, The origin of animal body plans: a study in evolutionary developmental biology, Cambridge university press, UK.

2 Werner A. Muller. 1997. Developmental biology. Springer.

3 Lodish, H. & Baltimore D, 1994, Molecular Cell Biology, 2nd edition, American Scientific Books, USA.

4 Alberts, B., 1998, Essential Cell Biology, 1st edition. Garland Publishers, USA.

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Course Code	Course Name	Category	L	T	P	Credit
233BT2A4CA	PHARMACEUTICAL BIOTECHNOLOGY	CORE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The pharmaceutical parameters of current biotechnology products
- The parameters related to stability and formulation
- The applications of bioprospecting in relation to pharma industry

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Gain knowledge on importance of enzymes and applications in drugs	K5
CO2	Provide in-depth understanding of active constituents	K5
CO3	Focus on natural sources for synthesis of drugs	K5
CO4	Gain knowledge vaccine types and production	K4
CO5	Analyze the toxicity levels and measurement	K4

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓				✓
CO2	✓		✓		✓
CO3	✓		✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability	✓	Innovations
	Intellectual Property Rights		Gender Sensitization
✓	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

233BT2A4CA	CORE: PHARMACEUTICAL BIOTECHNOLOGY	SEMESTER IV

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I Enzymes in Pharmaceutical Biotechnology 09 h

Properties – dynamics of enzymatic activity, sources, extraction and purification, pharmaceutical applications of enzymes. Production of amyloglucosidase, glucose isomerase, amylase and trypsin. Limitations in the enzyme production. Immobilization – applications – perspectives of enzyme engineering.

Unit II Active Drug Constituents 10 h

Introduction to active constituents - isolation, classification, properties. Systematic pharmacognostic study of a) Carbohydrates and derived products: agar, guar gumm acacia, honey, Isabgol, pectin, s tarch and sterculia b) Lipids: Bees wax, Castor oil, Cocoa butter, Cod-liver oil, Kokum butter, Lard, Rice Bran oil, Shark liver oil and Wool fat.

Unit III Sources of drugs 09 h

Herbal Medicines – Characteristics, Efficacy, importance, allergic reactions of phytoconstituents. Principles - Ayurveda, Unani, Siddha, Homeopathy. Drugs derived from Animal –Gelatin, Glycerin, Heparin, Lanolin, Premarin, Animal vaccines. Pharmaceutics from Marine source – Cytarabine, Zicomotide, Omega – 3- acid ethyl ester, Trabectodin, Brentuximab vadotin. Bioavailability of pharmaceuticals. Biosimilar drugs and AI in drug development.

Unit IV Vaccines and Related Products Production 10 h

DNA Vaccine - construction and immunology, DNA vaccine expression, plasmid delivery of DNA vaccines. Bacterial vaccines – preparation and applications. mRNA vaccines, Peptide vaccines and Antitoxins. Serum–immune blood derivatives. Gene Pharming.

Unit V Immunogenicity 10 h

Estimation of toxicity LD 50 and ED 50. Immunogenicity of biopharmaceuticals: Factors contributing to immunogenicity (product-related factors, host- related factors), Measurement of immunogenicity. Consequence of immunogenicity to biopharmaceuticals. Neutraceuticals. Economics of drug development.

Text Books

1. Crommelin D, Sindelar R and Meibohn B, 2008, "Pharmaceutical Biotechnology – Fundamentals and Applications", 3rd edition, Informa Press, USA.
2. Kokate J and Hurakadle, 2011, "Textbook of Pharmaceutical Biotechnology, 1st edition, Elsevier Pres, USA.

References

1. Kayser O and Müller RH, 2005, "Pharmaceutical Biotechnology: Drug Discovery and Clinical Applications", 1st Edition, Wiley Publishers, USA.
2. Rho J and Louie, SG, 2003, "Hand book of Pharmaceutical Biotechnology", 1st Edition, CRC Press, USA
3. Goodman and Gilman, 2006, "The Pharmacological Basis of Therapeutics",11th Edition, Mc Graw Hill Medical Publishing Division, India.
4. Heinrich Klefenz, 2002, "Industrial Pharmaceutical Biotechnology", 1st edition, WILEY-VCH Publication, USA.

233BT2A4CP	CORE PRACTICAL: PHARMACEUTICAL BIOTECHNOLOGY	SEMESTER IV

Total Credits: 3
Total Instructions Hours: 72 h

S.No	Contents
1	Isolation of Animal Tissues: Intestinal Muscle Preparations.
2	Isolation of Animal Tissues: Skeletal Muscle Preparations, Cardiac Muscle Preparations
3	*In-Vitro* Evaluation of Hepatoprotective Drugs
4	Evaluation of Antioxidant Activity Using Cell Based Assay Method
5	Sterility Testing of Pharmaceutical Drugs
6	*In-Vitro* Genotoxicity Assay
7	Mouse Lymphoma Assay (L5178Y TK+/- mouse lymphoma cells)
8	Evaluation the extent of DNA damage by In-Vitro Comet assay
9	*In-Vitro* Teratogenicity Testing of the drug
10	Pathological Condition Analysis of Animal Tissues by Histopathology
11	Extraction of Omega -3 Fatty acids from algae
12	Determination of Enzyme activity

References

1. Patra Jayanta Kumar, Das Swagat Kumar, Das Gitishree, Thatoi Hrudayanath, 2019, "A Practical Guide to Pharmacological Biotechnology", 1st edition, Springer Nature Pvt Ltd., Singapore.
2. Prasad GS, Sailam KS, 2019, "Pharmaceutical Microbiology: A Laboratory Manual", 1st edition, PharmaMed Press, India.
3. Crommelin Daan JA, Sindelar Robert, Meibohm Bernd, 2019, "Pharmaceutical Biotechnology; Fundamentals and Applications", 5th edition, Springer International Publishing, USA.
4. Groves, 2018, "Pharmaceutical Biotechnology", Routlegde Taylor and Francis Group, USA

Course Code	Course Name	Category	L	T	P	Credit
233BT2A4DA	STEM CELL TECHNOLOGY	DSE	3	1	-	3

PREAMBLE

This course has been designed for students to learn and understand

- The types of Stem cells
- Characteristics of different stem cells in animals and plants
- Applications of stem cells in various dimensions.

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Know the process of stem cell and storage	K3
CO2	Understand the stem cell importance in plants	K4
CO3	Gain knowledge on the stem cells in animals	K5
CO4	Interpret the role of haemopoietic stem cell	K5
CO5	Analyze the stem cell therapies and its application	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓		✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓		✓	✓	✓
CO4	✓	✓			
CO5	✓	✓	✓	✓	✓

COURSE FOCUES ON

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability		Innovations
	Intellectual Property Rights		Gender Sensitization
✓	Social Awareness/ Environment	✓	Constitutional Rights/ Human Values/ Ethics

233BT2A4DA	DSE: STEM CELL TECHNOLOGY	SEMESTER IV

Total Credits: 3

Total Instruction Hours: 48 h

Syllabus

Unit I **Stem Cells and Cellular Pedigrees** 11 h

Scope of stem cells – definition of stem cells – concepts of stem cells – differentiation, maturation, proliferation, pluripotency, self maintenance and self renewal – problems in measuring stem cells – preservation protocols.

Unit II **Stem Cell Concept in Plants** 9 h

Stem cell and founder zones in plants – particularly their roots – stem cells of shoot meristems of higher plants. Isolation and harvesting of plant stem cells and their limitations.

Unit III **Stem Cell Concept in Animals** 10 h

Skeletal muscle stem cell – Mammary stem cells – intestinal stem cells – keratinocyte stem cells of cornea – skin and hair follicles –Tumour stem cells, Embryonic stem cell biology - factors influencing proliferation and differentiation of stem cells – hormone role in differentiation.

Unit IV **Haemopoietic Stem Cell** 9 h

Biology – growth factors and the regulation of haemopoietic stem cells. Haematopoietic Stem Cells harvesting and limitations, Applications of haematopoietic Stem cells.

Unit V **Potential Uses of Stem Cells** 9 h

Cellular therapies – vaccines – gene therapy – immunotherapy – tissue engineering – blood and bone marrow – Fc cells.

Text Books

1 Potten CS, 1997, "Stem cells", Elsevier, USA.

2 Robert Paul Lanza , 2006, "Essentials of stem cell biology", 2nd edition, Academic Press, USA.

References

1 Song Li, Nicolas L'Heureux, Jennifer Elisseeff, 2011, "Stem Cell and Tissue Engineering", 1st Edition, World Scientific Publishers, Singapore.

2 Robert Lanza, John Gearhart, Brigid Hogan, 2006, "Essentials of Stem Cell Biology", 2nd Edition, Macmillan Publishing Solutions, USA.

3 Low WC and Verfaillie CM, 2007, "Stem Cell and Regenerative Medicine", 1st Edition, World Scientific Publishers, Singapore. .

4 Lanza R and Atala A, 2007, "Essential of Stem Cell Biology", 3rd Edition, Academic Press, USA.

Course Code	Course Name	Category	L	T	P	Credit
233MB2A4DA	MOLECULAR DIAGNOSTICS AND BIOINFORMATICS	DSE	3	1	-	3

PREAMBLE

This course has been designed for students to learn

- Microbes and its involvement in causing life threatening diseases
- The identification and characterization of microbes using different molecular techniques
- The basics of bioinformatics and its tools.

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Recognize the concept of molecular diagnosis of Infectious diseases and apply the immunoglobulins for molecular diagnosis.	K3
CO2	Identify the disease by using Nucleotides and Sequencing	K3
CO3	Experiment the nucleic acid amplification by PCR and Analyze the molecules by hybridization process	K3
CO4	Able to explore the biological data to solve several issues in healthcare Domains.	K4
CO5	Apply the knowledge of computational tools to address the clinical problems	K3

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓		✓
CO2	✓	✓	✓	✓	✓
CO3		✓	✓	✓	✓
CO4	✓	✓	✓	✓	
CO5	✓	✓		✓	✓

COURSE FOCUS ON:

☑ Skill Development	☐ Entrepreneurial Development
☑ Employability	☐ Gender Sensitization
☐ Intellectual Property Rights (IPR)	☐ Social Awareness / Environment
☐ Innovations	☐ Constitutional Rights / Human Values / Ethics

233MB2A4DA	DSE: MOLECULAR DIAGNOSTICS AND BIOINFORMATICS	SEMESTER IV

Total Credits: 3

Total Instruction Hours: 48 h

Syllabus

Unit I **Introduction to Molecular diagnosis and Immunoglobulin's in diagnosis** 12 h

History and Transcending of diagnostics over time – Traditional and molecular diagnostics – Significance of molecular diagnostics – Scope for Molecular diagnostics - Rise of diagnostic industry in Indian and global scenario. Monoclonal and polyclonal antibodies. Agglutination - RIA, ELISA's, chemiluminescence, immunofluorescence,Western blots.

Unit II **Molecular Diagnosis using Nucleotides** 9 h

Automated DNA sequencing- Principles, Methods and InstrumentationAdvances in DNA sequencing - Whole Genome Sequencing, Target Sequencing, New Generation sequencing Methods, Pyrosequencing, Microarrays, Metagenomics.

Unit III **PCR and Hybridization** 12 h

Nucleic acid amplification methods and types of PCR: Reverse Transcriptase-PCR, Real-Time PCR, Inverse PCR, Ligase Chain Reaction. RACE, RNA fingerprinting. Nucleic acid and Protein extraction and analysis (AGE & PAGE); Western Blot, Southern, northern, dot/slot blot; electrophoresis, nucleic acid probe preparation

Unit IV **Introduction to bioinformatics** 8 h

Definition, Basics of Bioinformatics, Scope and Applications. Introduction and types: Biological data bases, Importance of databases, DNA sequence databases (NCBI, EMBL, DDBJ, Genbank)- Protein databases (UniProt, Swissprot, PROSITE) and Structural databases (PDB, CATH).

Unit V **Bioinofrmatics tools** 7 h

Drug designing Softwares (AutoDock, Schrodinger, ChemSketch) - DNA and Protein similarity searching: BLAST and FASTA, Multiple sequence alignment (ClutalW). Phylogenetic tree types and construction (MEGA).

Text Books

1. William B Coleman, Gregory J Tsongalis, 2005, Molecular Diagnostics: For the Clinical Laboratorian, 2nd Edition, Hanuma Publishers, New Delhi.
2. Thomas J Kindt, Barbara A Goldsby, Richard Osborne 2018, Kuby's, Immunology, 8th Edition, W. H. Freeman Publishers, New York.

References

1. George P. Patrinos (Editor), Wilhelm Ansorge (Editor), Phillip B. Danielson Dr. (Editor),. 2016, Molecular Diagnostics, 3rd Edition, Academic press, USA.
2. Lele Buckingham and Maribeth L. Flaws, 2019, Molecular Diagnostics: 2 Fundamentals, Methods & Clinical applications, 3rd Edition, F. A. Davis Company, Philadelphia.
3. Keith Willson and John Walker, 2010, Principles and Techniques of 3 Biochemistry and Molecular Biology, 7th Edition, Cambridge University Press, US.
4. TK Attwood and DJ Parry-Smith, 2003. Introduction to Bioinformatics Pearson PLC Publisher, UK.
5. S.C. Rastogi, 2008, Bioinformatics Concepts Skills and Application, PHI Learning, New Delhi.
6. Jenny Gu, Philip E. Bourne, 2011, Structural Bioinformatics, 2nd edition, Wiley-Blackwell, Publishers, US.
7. https://microbenotes.com/bioinformatics-databases-software-tools/
8. https://www.lkouniv.ac.in/site/writereaddata/siteContent/202003291612341467kuaum_yadav_Bioinformatics.pdf

Course Code	Course Name	Category	L	T	P	Credit
233BC2A4DA	NEUROBIOLOGY	DSE	3	1	-	3

PREAMBLE

This course has been designed for students to learn and understand

- Overview of nervous system organization and function.
- Neuronal transmission in the body.
- Pathways and mechanisms of neuronal disorders.

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Analyze the morphogenesis of the central nervous system and histology of the nervous system.	K4
CO2	Examine the functioning of the components of the nervous system	K4
CO3	Elaborate the role of different neurotransmitters in nerve impulse conduction	K5
CO4	Evaluate the process of vision, olfaction and taste sensation in detailed pathways	K5
CO5	Explain the neurologic process behind the different neurological diseases	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓			
CO2	✓	✓	✓		
CO3	✓	✓	✓		
CO4	✓	✓			
CO5	✓	✓	✓		✓

✓	Skill Development		Entrepreneurial Development
✓	Employability		Innovations
	Intellectual Property Rights		Gender Sensitization
	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

233BC2A4DA	DSE: NEUROBIOLOGY	SEMESTER IV

Total Credits: 3

Total Instruction Hours: 48 h

Syllabus

Unit I **Morphogenesis of central nervous system and Histology of the Nervous System** 10 h

Morphogenesis of central nervous system: Early aspects of development, The spinal cord, The brain(Myelencephalon, Metencephalon, Mesencephalon, Prosencephalon, Diencephalon, Telencephalon, Basal Ganglia, Commissures).

Histology of the Nervous System: The neuron: nerve cell body, nucleus, cytoplasm, dendrites, axon. Axonal Transport: fast anterograde, slow anterograde and fast retrograde transport. Types of neurons: multipolar, bipolar, pseudo-unipolar, and unipolar. Neuroglia: astrocytes, oligodendrocytes, microglia, and ependymal cells. Myelinated axons.

Unit II **Design and functioning of the Nervous System** 11 h

Neuron, Sensory Receptors, Effectors, information processing, memory. Major Levels of Central Nervous System Function: spinal cord level, lower brain level and higher brain level. Structure and permeability of neuronal membrane: membrane transport proteins, mode of transport, synapse: types (chemical and electrical), Physiologic Anatomy of the Synapse: Presynaptic Terminals, Action Potential and propagation, equilibrium membrane potential, resting membrane potential, Receptor Proteins, Ion Channels (properties and classification), Second Messenger system, Excitation/inhibition in post synaptic membrane.

Unit III **Neurotransmitters** 10 h

Neurotransmitters: definition, properties, classes, mechanism of neurotransmitter release. Synthesis, release, physiological and clinical considerations of acetyl choline, GABA, dopamine, norepinephrine, epinephrine, serotonin, histamine, nitric oxide and other novel neurotransmitters. Receptors: nicotinic acetyl choline, NMDA and opioid receptors. Mechanisms of Regulation of Receptors: Desensitization and Down- Regulation

Unit IV **Visual, Olfaction and Taste system** 8 h

Visual system: components of eye, different layers of retina, photoreceptors, phototransduction, processing of signals by retinal cells, color vision, visual and retinal fields, visual pathways, visual reflex Olfaction and Taste: organisation,

receptors, sensory transduction, central pathways for olfaction and taste.

Unit V Neurological diseases 9 h

Description, neurochemistry, pathology, clinical intervention, and biochemical principles of management of neurological diseases: Parkinson's disease, schizophrenia, Huntington's disease, Alzheimer's disease, epilepsy and depression disorder.

Text Books

1 Allan Siegel, Hreday N. Sapru, 2018, "Essential Neuroscience", 4th Edition, Lippincott Williams & Wilkins, a Wolters Kluwer business, United States.

2 John E. Hall, Arthur C. Guyton, 2021, "Guyton and Hall Textbook of Medical Physiology", 14th edition, Saunders, an imprint of Elsevier Inc., United States.

References

1 Alan Longstaff, 2011, "Instant notes. Neuroscience",3rd edition, Taylor & Francis Group, United Kingdom.

2 Dale Purves, GeorgeJ. Augustine, David Fitzpatrick, William C. Hall Anthony-Samuel lamantia, James O. Mcnamara, S. Mark Williams, 2017, " Neuroscience", 6th edition, Sinauer Associates, Inc.USA

3 Kim E. Barrett, Susan M. Barman, Scott Boitano, William F. Ganong Heddwen L. Brooks, 2019, "Ganong's Review of Medical Physiology", 26th edition, McGraw Hill Education, United States

4 Harald Sontheimer, 2015, "Diseases of the Nervous System",1st Edition, Academic Press, United States.

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