MODERN EDUCATION SOCIETY'S
Nowrosjee Wadia College, Pune
(Autonomous)

SYLLABUS OF
M. Sc. BIOTECHNOLOGY (Part-II)

As per National Education Policy 2020, To be implemented from Academic Year 2024-2025

Structure and Credit Distribution of the PG Biotechnology Degree Program

Vide G.R. No. NEP-2022 /CR No. 09/VISHI-3 / शिकाना dated April 20, 2023, the Directive, covering the Credit distribution structure for Four Year UG Honours/ Honours with Research Degree Programme with Multiple Entry and Exit options, was issued. In Continuation of Section 8 of this GR- 'Design of PG Master's Programmes', the Illustrative Table depicting the Credit Distribution for Two Year PG Programme with one Exit Option/ One Year PG Programme is as given below:

Illustrative Credit distribution structure for Two Years/ One Year PG (M.A./M.Sc./M.Com.) and Ph. D. Programme

Year (2 Yr PG)	Level	Sem. (2 Yr)	Major		RM	OJT / FP	RP	Cum. Cr.	Degree
			Mandatory	Electives					
I	6.0	Sem I	12-14 (2*4 +2*2 or 3*4+2)	4	4			20-22	PG Diploma (after 3 Yr Degree)
		Sem II	12-14 (2*4 +2*2 or 3*4+2)	4		4		20-22	
Cum. Cr. For PG Diploma			**24-28**	**8**	**4**	**4**	-	**40-44**	
Exit option: PG Diploma (40-44 Credits) after Three Year UG Degree									
II	6.5	Sem III	12-14 (2*4 +2*2 or 3*4+2)	4			4	20-22	PG Degree After 3-Yr UG Or PG Degree after 4-Yr UG
		Sem IV	10-12 (2*4 +2 or 3*4)	4			6	20-22	
Cum. Cr. for 1 Yr PG Degree			**22-26**	**8**			**10**	**40-44**	
Cum. Cr. for 2 Yr PG Degree			**46-54**	**16**	**4**	**4**	**10**	**80-88**	
2 Years-4 Sem. PG Degree (80-88 credits) after Three Year UG Degree or 1 Year-2 Sem PG Degree (40-44 credits) after Four Year UG Degree									
	8.0		Course Work Min. 12 (3*4)		Training in Teaching / Education/ Pedagogy: 4			**16 + Ph. D. Work**	**Ph.D. in Subject**

Abbreviations: Yr.: Year; Sem.: Semester; OJT: On Job Training: Internship/ Apprenticeship; FP: Field projects; RM: Research Methodology; Research Project: RP; Cumulative Credits: Cum. Cr.

(a) With effect from Academic Year 2023-24, Two years Master's Degree Program was be revamped as per the Illustrative Credit Distribution given in the above table.

(b) Credits offered per Semester will be a Minimum of 20 and a Maximum of 22. While minimum credits are mandatory as per National Credit Framework, the Universities can evolve the mechanism for providing Semester/ Level wise credit attainment flexibility within the broad framework.

(c) Under the One-year PG Diploma program, and two-year master's Degree program, the students must complete on-the-job training/internship of 04 credits during summer break, after completion of the second semester of the first year in the respective Major Subject.

(d) The 4 Credits Research Methodology Component is mandatory in the First Year.

(e) Since the Master's Programme is based on DSC Specialisation, the PG curricular framework will not include Minor Subject. Electives selected in the PG program may be **Relevant to OR Supportive of** the Major Subject chosen. The Statutory authorities of the University or Autonomous College can take a decision in this regard.

(f) The students will have to undertake a research project of 4 credits in Semester III and a research project of 6 credits in Semester IV in the second year of the two-year master's degree program. This is also applicable to the students admitted to one year PG program after completion of four year UG Program.

(g) Colleges already having permission and recognition for the PG degree programme along with UG degree programme in the same Major shall be automatically allowed to continue PG degree programme in the same Major without undergoing any additional procedures. Similarly, the colleges with approved PG programme and Ph.D. Research Centre in the same Major shall be automatically allowed to continue PG and Ph. D. Degree programme without undergoing any additional procedures.

(h) The exit option at the end of one year of the Master's degree program will commence from AY 2024-25. Students who have joined a two-year Master's degree program may opt for exit at the end of the first year and earn a PG Diploma.

(i) The PG Diploma may be awarded to a student provided they have earned the requisite credits in one year including on-the-job training of 04 credits during summer break, after completion of the second semester of the first year in the respective Major Subject.

(j) The one-year Master's Degree Program will begin with effect from Academic Year 2027-28.

(k) Re-entry to complete the PG degree, after taking the exit option, will be permissible up to 05 years from the date of admission to the PG program.

(l) With regards to the Eligibility criteria and Procedure for admission to the Ph.D. Programme, Duration of the Ph.D. Programme, Eligibility and Allocation of Research Supervisor, Course Work (Credit requirements, number, duration, syllabus, minimum standards for completion), Research Advisory Committee and its Functions, Academic, research, administrative, and infrastructure requirements to be fulfilled by Colleges for getting recognition for offering Ph.D. Programme, Award of Ph. D. Degree etc, the Universities and Autonomous Colleges must comply UGC (Minimum Standards and Procedure for Award of Ph.D. Degree) Regulations, 2022, dated Nov. 7, 2022.

(m) The University and Autonomous College must adopt this GR within 10 days after its issue

Preamble of the course:

Biotechnology has grown, extensively in last two of decades. This advanced 'interdisciplinary' life science branch encompasses areas viz. molecular biology, genetics, biochemistry, microbiology, immunology, virology, plant and animal tissue culture, chemistry, and engineering. It is a fast emerging "cutting edge" science with distinctive advantages as it finds applications in practically all aspects of life. The subject offers exciting opportunities in various fields from basic research to industry-oriented career. Global and local focus has slowlyshifted to using knowledge of life Science for innovative technology development that is being used for betterment of human life. Many fundamental research fields from cell biology to molecular biology, from genetic engineering to stem cell research, from bioinformatics to genomics-proteomics, from environmental biology and to biodiversity, from microbiology to bioprocess engineering, from bioremediation to drug discovery etc. comes under the umbrella of Biotechnology.

The proposed choice-based credit curriculum and grading system will cater to the existing interdisciplinary nature of biotechnology can also offer many courses to the other branches of life science. The generative power of biological data is effectively harnessed by biotechnology like no other field. Economic and social renaissance is staged on biotechnology especially, since it's biomedical and cutting-edge technological applications are tremendously powerful in shaping this century and exciting bio future. Keeping in view the expanse and applications of Biotechnology in every field, there is going to be a perpetual demand for resource personnel with Biotechnology specialization. The post graduate program is aimed to cater to this ever-increasing demand and to groom the students to excel in their future career. Education and research sectors require such interdisciplinary trained workforce to develop future generations of science leaders.

Introduction:

Masters in Biotechnology course syllabus is revised as per NEP guidelines 2020 to offerthe needs of changing scenario in biological science. The changing scenario of higher educationin India and abroad is taken into consideration while formulation this syllabus and more oriented towards current need of modern research and industrial sectors. The present syllabusis as per National Education Policy 2020, which encompasses the fundamental academics at one end and latest technologies in life science at the other. Theory courses will help students develop their knowledge sets on various topics of biotechnology, to which, they are introduced at the undergraduate level. Extensive practical courses are designed to supplement the theory courses with hands on experimentation in wet-lab and on fields. Empowerment of students to face research and industrial outlets is at the center of this syllabus. Students having to select their own courses will develop the depth in specialization and make them ready to face the upcoming scientific advances in the world without any further training. M.Sc. syllabus hasbeen prepared keeping in vision the undergraduate curriculum. At the undergraduate level, students were introduced to many fundamental topics in life sciences such as molecular biology, developmental biology, fermentation technology, biodiversity, bioinformatics, andtissue culture etc. At the post graduate level, they will be also be acquainted with

the thrust/new areas of biotechnology like bioinformatics, clinical research, data base management, IPR, Food Technology etc. to give the students the advantage of not only learning these subjects but also give them the edge over others in their employability. A research project/ industrial training Modules are incorporated to provide a buffer zone for budding biotechnologists eager to enterthe life science sector.

Objectives:

- To help the students to build interdisciplinary approach
- To empower students to excel in various research fields of Life Sciences
- To inculcate sense of scientific responsibilities for social and environment awareness.
- To acquaint the students with thrust areas of biotechnology
- To adapt the internationally acknowledged Choice Based Credit System (CBCS) that offers opportunities to learn core subjects and to explore additional avenues of learning beyond the core subjects for complete development of an individual.

Eligibility for the course M.Sc. Biotechnology.

Any candidate completed B.Sc. in Biotechnology from any recognized university.

Examination pattern

70 Marks for end semester examination and 30 marks for continuous evaluation pattern

35 Marks for External Practical examination and 15 Marks for Internal practical examination

Passing marks

Passing marks will be 40 % in each paper of continuous evaluation and end semester examseparately.

Procedure for continuous evaluation

Written test	20 marks
Assignment	5 Marks
Seminar/ attendance	5 Marks
	30 Marks

Nature of question paper for End semester examination

Que. No.	Type	Max marks
1	2 marks x 7 questions (Any 6)	12
2	4 marks x 4 questions (Any 3)	12
3	5 marks x 4 questions (Any 3)	15
4	5 marks x 4 questions (Any 3) Short notes type	15
5	8 marks x 3 questions (Any 2)	16
	Total	70 marks

Revaluation

There shall be a revaluation of answer scripts of end semester examination (out of 70 marks) of theory papers only, but not of internal or continuous evaluation papers as per Ordnance no. 134 A and B

Grading system

Percentage	Grade	Grade Point
80-100	O: Outstanding	10
70-79	A+: Excellent	9
60-69	A: Very Good	8
55-59	B+: Good	7
50-54	B: Above Average	6
45-49	C: Average	5
40-44	P: Pass	4
0-39	F: Fail	0
-	Ab: Absent	0

Course Structure Semester I (First Year)

Course Type	Course	Course / Paper Title	Hours / Week	Credit	CIA	ESE	Total
Major Mandatory (4 + 2)	Major Paper 1 (Theory)	**PBTMJ111** Advanced Biological Chemistry	2	4	30	70	100
	Major Paper 2 (Theory)	**PBTMJ112** Genetics and Molecular Biology	2	4	30	70	100
	Major Paper 3 (Practical)	**PBTMJ113** Practicals in Advanced Biological Chemistry	4	2	15	35	50
	Major Paper 4 (Practical)	**PBTMJ114** Practicals in Genetics and Molecular Biology	4	2	15	35	50
Major Electives	Major Paper 5(A) (Theory)	**PBTMJ115(A)** Biostatistics OR	2	4	30	70	100
	Major Paper (B) (Theory)	**PBTMJ115(B)** Food Biotechnology	2	4	30	70	100
	Research Methodology	**PBTRM116** Research methodology	2	4	30	70	100
	OJT / FP	NA	--	--	--	--	--
	RP	NA	--	--	--	--	--
Total Credits				20			

CIA- Continuous Internal assessment

ESE- End Semester Examination

Course Structure Semester II (First Year)

Course Type	Course	Course / Paper Title	Hours / Week	Credit	CIA	ESE	Total
Major Mandatory (4 + 2)	Major Paper 6 (Theory)	**PBTMJ121** Recombinant DNA Technology	2	4	30	70	100
	Major Paper 7 (Theory)	**PBTMJ122** Biophysics	2	4	30	70	100
	Major Paper 8 (Practical)	**PBTMJ123** Practicals in Recombinant DNA Technology	4	2	15	35	50
	Major Paper 9 (Practical)	**PBTMJ124** Practicals in Biophysics	4	2	15	35	50
Major Electives	Major Paper 10(A) (Theory)	**PBTMJ125(A)** Intellectual Property Right and Bioethics	2	4	30	70	100
	Major Paper 10(B) (Theory)	OR **PBTMJ125(B)** Pharmaceutical Biotechnology	2	4	30	70	100
	Research Methodology	NA	--	--	--	--	--
	OJT / FP	**PBTOJT126 /PBTFP126** On the Job training /field project*	120	4	30	70	100
	RP	NA	--	--	--	--	--
Total Credits				20			

On-the-job training/field project* Internship/project/hands-on training in any recognized research institute for 120 hours

CIA- Continuous Internal assessment

ESE- End Semester Examination

Course Structure Semester III (Second Year)

Course Type	Course	Course / Paper Title	Hours / Week	Credit	CIA	ESE	Total
Major Mandatory (4 + 2)	Major Paper 11 (Theory)	**PBTMJ231** Plant and Animal Biotechnology	2	4	30	70	100
	Major Paper 12 (Theory)	**PBTMJ232** Immunology	2	4	30	70	100
	Major Paper13 (Practical)	**PBTMJ233** Practicals in Plant and Animal Biotechnology	4	2	15	35	50
	Major Paper 14 (Practical)	**PBTMJ-234** Practicals in Immunology	4	2	15	35	50
Major Electives	Major Paper 15(A) (Theory)	**PBTMJ235(A)** Genomics and Proteomics	2	4	30	70	100
	Major Paper 15(B) (Theory)	OR **PBTMJ235 (B)** Nanobiotechnology	2	4	30	70	100
	Research Methodology	NA	--	--	--	--	--
	OJT / FP	NA	--	--	--	--	--
	RP	**PBTRP236** Research project	120	4	3	70	100
Total Credits				20			

Research project*hands on training/Wet lab work in any recognized research /academic institute for 120 contact hours

CIA- Continuous Internal assessment

ESE- End Semester Examination

Course Structure Semester IV (Second Year)

Course Type	Course	Course / Paper Title	Hours / Week	Credit	CIA	ESE	Total
Major Mandatory (4 + 2)	Major Paper 16 (Theory)	**PBTMJ241** Bioinformatics	2	4	30	70	100
	Major Paper 17 (Theory)	**PBTMJ242** Bioprocess Engineering	2	4	30	70	100
	Major Paper 18 (Practical)	**PBTMJ243** Practical in Bioinformatics and Bioprocess Engineering	4	2	15	35	50
Major Electives	Major Paper 19(A) (Theory)	**PBTMJ244(A)** Medical and Forensic Biotechnology OR **PBTMJ244(B)** Virology and Toxicology	2	4	30	70	100
	Major Paper 19(B) (Theory)		2	4	30	70	100
	Research Methodology	NA	--	--	--	--	--
	OJT / FP	NA	--	--	--	--	--
	RP	**PBTRP245** Research project	180	6	45	105	150
Total Credits				20			

Research project*hands on training/Wet lab work in any recognized research /Academic institute for 180 contact hours

CIA- Continuous Internal assessment

ESE- End Semester Examination

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Master of Science in Biotechnology		
SEMESTER –III Major Paper 11 (Theory)		
Year – II	**Paper No- PBTMJ231** **Name of Paper- Plant and Animal Biotechnology**	**Credits 4**
Semester - III		**Hours 60**

Course Outcomes (COs)
On completion of the course, the students will be able to:

- Learn tissue culture techniques
- Know different methods of gene transfer and different molecular markers.
- Knowledge of transgenic plants and their pros and cons
- The students will gain an insight into the concepts and techniques of animal biotechnology and itswide industrial and medicinal applications.
- Do further research works

Sr. No.	COURSE CONTENT / SYLLABUS	Lectures
Unit -I	**Introduction to Plant and Animal Tissue Culture** • Totipotency, Pluripotency Differentiation, and Redifferentiation • Basic concept • Callus Culture, Organogenesis, Embryogenesis • Suspension Culture • Micropropagation • Primary and secondary cell culture, development cell lines orestablished cultures. • Biological characterization of cell cultures, contact inhibition, celltransformation, cancer cells, indefinite cell lines.	9
Unit -II	**Advanced techniques in Plant & Animal tissue culture** • Somatic Embryogenesis, artificial seeds • Endosperm Culture • Soma clonal Variations • Secondary Metabolite production using elicitors • Protoplast: Isolation, fusion, somatic hybridization, hybridization and • their applications • cloning vectors, viral vectors methods of genetic transformation **Hybridoma technology-** Hybridomas, HAT selection, Selection of Hybrid clones,	9

Unit -III 38	**Genetic transformation Methods**: • Ti plasmid and Ri Plasmid vectors. Mechanism of T-DNA transfer to plants, *Agrobacterium tumefacient* infection, Plant viral vectors. • Physical Methods: electroporation, microinjection, and Gene gun method	8
Unit -IV	**Transgenic Plants and Animals** • Introduction, • Transgenic plants for biotic and abiotic stress, • GM plants for crop improvement • Increase in productivity by manipulation of photosynthesis and nitrogen fixation • Transgenic animals and its applications – Mice and other animals • Biosafety regulations • Guideline for research I transgenic animal • Public awareness of the processes of producing transgenic organism	10
Unit -V	**Gene Therapy and Crop Improvement** • Potential of marker-assisted selection for Crop improvement • Practical applications of MAS. • MAS for major genes or improvement of qualitative and quantitative traits • Marker-assisted backcrossing: MABC procedure and theoretical and practical considerations • Methods of gene therapy:- Somatic and germ cell • Ethical issues in animal biotechnology	10
Unit -VI	**Applications of Plant Biotechnology** • molecular farming (improvement in protein, lipids, carbohydrates), vaccines, antibodies, therapeutic proteins, • Biopolymer production through transgenic plants Single-cell protein production • Use of Nano fertilizers	7
Unit -VII	**Application of Animal Biotechnology** • Artificial animal breeding, • Cloning and transgenic animals • Medicines, vaccines, diagnosis of diseases and disorders • Forensic application • Identification of Wild animal species using DNA-based methods	7

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2. Davies K (Ed) (2004) – Plant pigments and their manipulation – Annual plantreviews, vol 14 (Blackwell Publ)
3. Altman A, Hasegawa PM (Ed) (2012) – Plant Biotechnology and agriculture.Prospects for the 21st Century (Academic Press).
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5. Slater A, Scott NW, Fowler MR (2008) – Plant Biotechnology: The Genetic Manipulation of plants (Oxford Press)
6. Vasil IK, Thorpe TA (1994) – Plant cell and tissue culture (Springer)
7. H K Das Textbook of Biotechnology 4th edition
8. Plant Cell and Tissue Culture. A Laboratory manual 1994. Reinert J and Yeoman MMSpringer
9. Biotechnology in Crop Improvement, HS Chawla. International BookDistributingCompany 1998
10. Practical Application of Plant Molecular Biology. RJ Henry. Chapman and Hall 1997
11. R. Ian Freshney. Culture of Animal Cells, 5rd Edition, 2010. A John Wiley and Sons, Inc., Publications, USA
12. R.W.Masters. Animal Cell Culture- Practical Approach, 3rdEdithion,2000, Oxford University Press. USA
13. Robert Lanza et al. Essentials of Stem Cell Biology", Academic Press, 2nd edition, 2006.USA
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15. https://youtu.be/zB9Vyh9eiaQ?si=ObXGDbuSvG05K70B
16. Introduction to Plant Biotechnology (bcrti.co.in)
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Master of Science in Biotechnology		
SEMESTER –III Major Paper 12 (Theory)		
Year – II	**Paper No- PBTMJ232** **Name of Paper- Immunology**	**Credits 4**
Semester - III		**Hours 60**

Course Outcomes (COs)

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

- Gain knowledge about the working mechanisms of the immune system.
- Learn concepts of antibodies, MHC, complement system, cytokines, hypersensitivity, and immune biology of organ transplant.
- Acknowledge the role of Antibodies/Antigen in disease diagnosis

Sr. No.	COURSE CONTENT / SYLLABUS	Lectures
Unit I	**Overview of Immune System** ● Historical Perspective ● Important Concepts (Infection, Invasion, Pathogen, Immunity, Immune Response, Antigen, Antibody)	7
Unit II	**Organization of the immune system** ● Cells of the immune system- hematopoiesis, cell of myeloid lineage,lymphoid lineage. ● Primary Lymphoid Organs ● Secondary Lymphoid Organs	7
Unit III	**Types of Immunity** ● Innate Immunity (Barriers- Anatomical, Physiological, Phagocytic, and Inflammatory) ● Adaptive Immunity (Active and Passive) **Immune Response** Primary and Secondary lines of defense	8
Unit IV	**Components of Immune System** ● Immunogen ● Antigens (Types and Properties) ● Hapten ● Immunoglobulins (Structure and Types)	8

Unit V	• T-cell Activation, Differentiation, and Memory • B-cell Activation, Differentiation, and Memory generation • Major Histocompatibility Complex (Structure and Function) • Complement System	8
Unit VI	**Antigen-Antibody Interaction** • General characteristics of Antigen-Antibody Interactions **Experimental Systems and Methods** • Antibody Generation – monoclonal and polyclonal • Immunoprecipitation – based techniques • Agglutination reactions • Radioimmunoassay (RIA) • Enzyme Linked Immuno Sorbent Assay (ELISA) • ELISPOT Assay • Western blotting • Immunohistochemistry Immunocytochemistry	7
Unit VII	**Clinical Immunology** • Hypersensitivity Reactions (Types and clinical manifestations) • Autoimmunity (Mechanism and types of Autoimmune diseases) • Immunodeficiency disorders	7
Unit VIII	**Scope of Immunology** • Immunotherapy • Transplantation Immunology • Vaccines- a) *In situ* vaccine design b) Types of vaccines • Interferons • Anticancer drugs	8

Reference books:

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Master of Science in Biotechnology

SEMESTER –III Major Paper 13 (Practical)

Year – II	**Paper No- PBTMJ233**	**Credits 4**
Semester - III	**Name of Paper- Practicals in Plant and Animal Biotechnology**	**Hours 60**

Course Outcomes (COs)
On completion of the course, the students will be able to:

- Learn *In vitro* induction of somatic embryogenesis.
- Learn Induction of Androgenesis *in vitro*
- Initiate Micro-propagation technique
- Perform preservation of in vitro cultures
- Develop of Suspension culture

Sr. No.	COURSE CONTENT / SYLLABUS	No of practical
1.	*In vitro* induction of somatic embryogenesis and preparation of artificial seeds	2
2.	Protoplast isolation and Fusion from plant material	2
3.	Micro-propagation: Initiations, multiplication, subculture, and Hardening	2
4.	*Agrobacterium-mediated* gene transformation	1
5.	Preparation of animal cell culture media.	1
6.	Isolation and culture of splenocytes.	1
7.	Cell counting and viability.	1
8.	Primary cell culture using chick embryo.	1
9.	Cell passaging.	1
10.	Cryopreservation of cell.	1
11.	Nuclear and mitochondrial staining of cells. Cell	1
12.	viability assay using MTT.	1

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Master of Science in Biotechnology

SEMESTER –III Major Paper 14 (Practical)

Year – II	**Paper No- PBTMJ234**	**Credits 4**
Semester - III	**Name of Paper- Practical's in Immunology**	**Hours 60**

Course Outcomes (COs)
On completion of the course, the students will be able to:

- Analyze antigen antibody interactions.
- Acknowledge quantitative and qualitative techniques

Sr. No.	COURSE CONTENT / SYLLABUS	No of practical
1	Determination of blood groups and Rh factor.	1
2	Determination of agglutination reaction with reference to the Widal test	1
3	Determination of precipitation with reference to VDRL.	1
4	Determination of haemagglutination *Treponema pallidum* Haemagglutination test.	1
5	Detection, Identification, and Quantification of antibodies by ODD (Ouchtlerlony Double Diffusion).	1
6	Separation and characterization of serum-by-serum electrophoresis method.	1
7	Demonstration of Antigen-Antibody reaction by counter-current Immunoelectrophoresis and Rocket Electrophoresis.	2
8	Separation and characterization of lymphocytes from blood.	1
9	Determination of Antigen-Antibody reaction by ELISA- DOT and PLATE	2
10	Immunoprecipitation	
11	Determination of Rapid Plasma Reagin (RPR)	1
12	Purification of IgG from Bovine Serum Albumin	1
	Differential count of WBC	1
	Detection, Identification, and Quantification of Antibodies Single Radial Immunodiffusion	1

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SEMESTER –III Major Paper 15(A) (Theory)		
Year – II	**Paper No- PBTMJ235(A)** **Name of Paper- Genomics and Proteomics**	**Credits 4**
Semester - III		**Hours 60**

Course Outcomes (COs)

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

- Learn Genome mapping with the help of different techniques
- Know the applications of genomics and proteomics in different fields of Biotechnology
- Apply the knowledge in research

Sr. No.	COURSE CONTENT / SYLLABUS	Lectures
Unit –I	**Basics of genomics and proteomics** • Brief overview of prokaryotic and • Eukaryotic genome organization; Chromatin organization; • Extra-chromosomal DNA: bacterial plasmids, mitochondria andchloroplast.	5
Unit –II	**Types of genomics** • Comparative genomics - Goals, bioinformatics of • Genome annotation, methods and limitations. • Structural genomics –Goals, methods, applications. • Functional genomics –Goals, methods, applications.	7
Unit –III	**Genome mapping** • Genetic and physical maps; • Methods and techniques used for gene mapping, • Physical mapping, linkage analysis, cytogenetic techniques, • FISH technique in gene mapping, comparative gene mapping	8
Unit –IV	**Applications of genomics** • Metagenomics • Toxicogenomic • Pharmacogenomics • Basic research • Medical Genetics	8

Unit –V	**Introduction and concept of proteomics** Protein structure –Function relationship, Types of Proteomics: ● Protein expression proteomics ● Structural Proteomics, ● Functional Proteomics	8
Unit -VI	**Techniques in Proteomics** ● Protein Isolation and Separation techniques ● Structural analysis of proteins- X-ray crystallography and ● NMR spectroscopy ● 2 D electrophoresis ● Peptide mapping and sequencing ● Mass Spectrometry: Matrix Assisted Laser Desorption/Ionization –Timeof Flight (MALDI-TOF), ESI Tandem, ● Ion Trap, Peptide mass fingerprinting ● LC-MS, (SILAC) - Chemical tagging, fluorescence, radiolabeling	8
Unit -VII	**Functional genomics and proteomics** ● Transcriptome analysis, ● functional annotation of genes, ● Contig assembly, mining functional genes in the genome, ● gene function ● protein-protein and protein-DNAinteractions; ● protein chips and functional proteomics; clinical and biomedical	8
Unit -VIII	**Applications of Proteomics** ● Protein expression profiling ● Protein-protein and Protein-DNA interaction (Chip ● Technique) ● Methods for detection of protein-protein interactions - ● Yeast 1, 2 and 3 `hybrid systems – Phage display – ● Proteomics and Protein microarrays, databases and alliedbioinformatics tools	8

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Master of Science in Biotechnology		
SEMESTER –III Major Paper 15(B)(Theory)		
Year – II	**Paper No- PBTMJ235(B)** **Name of Paper- Nanobiotechnology**	**Credits 4**
Semester - III		**Hours 60**

Course Outcomes (COs)

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

- Learn the Basics of Nanoscience technology
- Enhance knowledge of synthesis and characterization of nanoparticles
- Learn advanced applications of Nanobiotechnology
- Acquire the knowledge of review writing and casestudies of research related to nanobiotechnology.

Sr. No.	COURSE CONTENT / SYLLABUS	Lectures
Unit –I	**Introduction to Nano-biotechnology** • History of nanotechnology and its emergence, Concept of Nano-biotechnology, • Types of nanoparticles and Their Properties: Quantum dots, Polymeric nanoparticles, • Metal nanoparticles, Nano materials, metal oxide nanoparticles, Dendrimers, Liposomes, Composites • Nanopore Technology • Current developments in Nano biotechnology	8
Unit –II	**Methods for synthesis of Nano materials** • Top Down and Botton Up Approach · Physical methods – Mechanical and vapour method • Chemical method – Colloids and colloids in solution Synthesis by colloid method, Sol-Gel Methods, • Biological synthesis – Use of Microorganisms like Fungi, yeast (eukaryotes), or bacteria actinomycetes (prokaryotes) Use of Plant extract and enzyme Using DNA templates, membranes, viruses, diatoms Animal resources for nanoparticle synthesis	10

Unit –III	**Physiochemical characterization of Nanomaterials** ● Optical, Electron, Scanning, Photon, Ion Particle, thermodynamic Probe characterization ● SEM, TEM, X-ray diffraction, light scattering- DLS, NTA; Zeta potential	8
Unit –IV	**Environmental impact of nanomaterial** ● Exposure and risk assessment–Mechanism of toxicity, health impact ● Genotoxicity, cytotoxicity, ecotoxicity	8
Unit -V	**Applications of Nano-Materials in Medicine** ● Nanomedicines, Targeted Drug Delivery, Disease diagnosis at proteomic level, Biosensors (Nucleic acid based, protein-based) ● Applications in Gene therapy ● Cancer Biology. Bionanomachines and current research ● Nanobiotechnology in enhancing CRISPR-mediated detection ● Protein Targeting - Small Molecule/Nanomaterial - Protein Interactions ● Nanomaterial-cell interactions of Surface Modification, enhanced permeation through various anatomical barriers ● Nanotechnology for surgeons	10
Unit -VI	**Applications of Nanobiotechnology in Agriculture** ● Nanosensors ● Nanoencapsulation ● Recycling Agricultural Waste ● Soil improvement ● Water purification ● Nano-fertilizers	8
Unit -VII	**Other applications** ● Defense sector ● Fabrics and textiles industries ● Water pollutants from industry waste and current research ● Space science and engineering ● Food industry (Food Processing, Food Packaging, detection of pathogens)	8

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	MODERN EDUCATION SOCIETY'S **Nowrosjee Wadia College, Pune (Autonomous) NEP**	
Master of Science in Biotechnology		
SEMESTER –IV Major Paper 16 (Theory)		
Year – II	**Paper No- PBTMJ241** **Name of Paper-Bioinformatics**	**Credits 4**
Semester - IV		**Hours 60**

Course Outcomes (COs)

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

- Know the basics of bioinformatics
- Develop Python modules for bioinformatics applications
- Access wide variety of biologically relevant data
- Identify sequence similarity
- Evaluate the phylogenetic relationship of an organism and identify genes, Repeats, domains from sequences using bioinformatics tools.

Sr. No.	COURSE CONTENT / SYLLABUS	Lectures
Unit -I	**Outline of Bioinformatics and AI** • Introduction and Applications of Bioinformatics. • Introduction to single letter code of amino acids, Symbols used innucleotides. • Data retrieval from Entrez and SRS. • Artificial Intelligence (AI) Introduction: Definition, Challenges and Applications. Role of AI in bioinformatics.	05
Unit -II	**Biological Databases** • Types of databases (Primary, Composite, and Secondary) • Nucleic acid databases (NCBI, DDBJ, GENBANK and EMBL). • Protein databases (PDB, Swissprot, and UniProt). • Structure databases (CATH, SCOP, and PDBsum) • Literature database: PubMed, MEDLINE • plasmoDB ,ECDC, TIGR, TAIR ,Hovergen	10
Unit -III	**Sequence Alignment** • Introduction to sequence alignment, • scoring matrices:- PAM , BLOSUM, Dot blot • Local and Global alignment, Needleman- wunsch algorithm, Smith-waterman algorithm, Multiple sequence alignment, FASTA, BLAST.	08

Unit -IV	**Phylogenetic Analysis** • Evolutionary analysis – steps and construction of Phylogenetic tree-Cladistics and Phenetic methods-Clustering methods - Rooted andUnrooted tree representation. • Methods for constructing phylogenetic tree:- distance-based methods, neighbor-joining, maximum parsimony, fitch and Margoliash method,UPGMA Method	8
Unit -V	**Introduction to Python** • Starting with Python variable, lists, tuples, operators, conditional statements, loop and loopstatements, file handling and operations FASTA, CSV file fast	8
Unit -VI	**Data Generation Tools** • What is data generation and its significance • Basic tools of data generation: (NGS Genome Sequencing,Protein sequencing, NMR Spectroscopy, and Microarray)	4
Unit -VII	**Sequence Visualization Soft wares** Rasmol, SPDBV **Homology Modelling** • Comparative modeling of proteins, comparison of 3D structure, homology, steps in homology modeling, tools, database, side chainmodeling, loop modeling	8
Unit -VIII	**Drug Designing:** • General approach to discovery of new drugs, lead discovery, lead modification, ' • Physiochemical principles of drug action , • Drug stereo chemistry, drug action, • 3D database search, computer aideddrug design, • Docking, molecular modeling in drug design, structure based drug design, pharma, cophores QSAR	9

References:

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	MODERN EDUCATION SOCIETY'S **Nowrosjee Wadia College, Pune (Autonomous) NEP**	
Master of Science in Biotechnology		
SEMESTER –IV Major Paper 17 (Theory)		
Year – II	**Paper No- PBTMJ242** **Name of Paper- Bioprocess Engineering**	**Credits 4**
Semester - IV		**Hours 60**

Course Outcomes (COs)

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

- Learn different methods and engineering aspects of fermentation processes.
- Clear mathematical concepts of scale up its significance in techno commercial feasibility at industrial level.
- Gain an insight into fundamentals and carry out elementary calculations regarding scale up.

Sr. No.	COURSE CONTENT / SYLLABUS	Lectures
Unit -I	**Historical development of bioprocess technology:** • An overview of traditional and modern applications of biotechnological processes, General requirements of fermentation processes, Basic design and construction of fermenter and ancillaries, Main parameters for monitoringand control of fermentation processes	4
Unit -II	**Bioreactors:** • Operation of bioreactors; Batch, Fed-batch and Continuous bioreactors, • Immobilized bioreactor operation, Sterilization, Aeration, Agitation and types of impellers, sparger, oxygen transfer in bioreactors and power requirement.	3

Unit -III	**Engineering principle of bioprocessing-** • Upstream and downstream production, Bioprocess design, and development from lab to industrial scale. • Microbial, animal and plant cell culture platforms, Different raw materials used in fermentation industry and their pretreatment, Mediumfor plant cell culture and animal cell culture. • Medium design of commercial media for industrial fermentations- Plackett burman design, response surface methodology, simplex design	8

Unit -IV	**Scale up, Operation and Control of Bioreactors:** • Concepts of variousbioreactor configurations, scale-up, various criteria for scale-up, scale-down, bioreactor instrumentation and Control.	7
Unit -V	**Kinetics of substrate utilization and product formation:** • Ideal reactorsfor kinetics measurements. High-performing reactors and industrial reactors. • Kinetics of balanced growth. Structured kinetic models. Product formation kinetics. • Segregated kinetic models of growth and product formation.	8
Unit -VI	**Microbial strain improvement:** • Important strains and pathways - Mutation, Protoplast fusion, parasexual cycle and genetic engineering for strain improvements, product formation,inhibition pathways and their regulations. • Applications in medicine, Agriculture and Industry. • Industrially important microorganisms – preservation and Culture collection centers. **Aeration and agitation:** • Effect of aeration and agitation on fermentation, Oxygen requirement and oxygen supply, Oxygen transfer kinetics; Determination of KLa value; Effect of agitation and microbial biomass on KLa value; Newtonian and non-Newtonian fluids; Foam and antifoams, their effect on oxygen transfer.	8

Unit -VII	**Modeling of fermentation processes and Process Economics:** • Installation Qualification (IQ), Operational Qualification (OQ) and Performance Qualification (PQ) for laboratory instruments. Methods ofvalidation and calibration of equipment. • Documentation-importance and significance. • Description of industrial processes for Bio-chemicals production, Processflow sheeting and Process economics. Fermentation economics- market potential, some effects of maintenance of legislations on production of antibiotics and recombinant proteins.	7

References:

1, Encyclopedia of bioprocess technology. Vol 1-5. (1999). Flickinger, M.C. and Drew, S.W.(Ed).
2. Casida LE. (1991). Industrial Microbiology.1st edition. Wiley Eastern Limited.
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	MODERN EDUCATION SOCIETY'S **Nowrosjee Wadia College, Pune (Autonomous) NEP**	
Master of Science in Biotechnology		
SEMESTER –IV Major Paper 18 (Practical)		
Year – II	**Paper No- PBTMJ243** **Name of Paper-** **Practicals in Bioinformatics and Bioprocess Engineering**	**Credits 4**
Semester - IV		**Hours 60**

Course Outcomes (COs)

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

- Gain knowledge of basic of animal tissue culture technique
- Knowledge of media, there fundamentals, preservations etc.
- Acquire the practical aspects of bioprocess engineering.
- Learn process of Lab scale production of metabolites.
- Acquire the knowledge of fermentation media, inoculum preparation, Scale up processes and with the various downstream processes of fermentation industries

Sr. No.	COURSE CONTENT / SYLLABUS	No of Practical
1	Introduction to Biological databases and retrieving the Information Sequence.	1
2	Similarity searching using BLAST	1
3	Multiple Sequence alignment and Phylogenetic analysis.	1
4	Counting of Hydrophobic and Hydrophilic amino acid in a protein sequence using Biopython.	1
5	Protein structure visualization using Pymol.	1
6	Molecular Docking.	1
7	Demonstrate of Sequence submission process in NCBI-Genebank	1
8	Study of Bioreactor and its essential parts.	1
9	Screening for biomolecule producers (amylase/ acetic acid/lactic acid/antibiotic).	2
10	To study lab scale production of any two biomolecules (Antibiotics, Lactic acid, citric acid, acetic acid, enzymes etc.)	

11	To study the effect of various factors (pH, Temperature, agitation, etc.) on ● Biomass production ● Product Formation ● Substrate utilization	2
12	Recovery and Assay of product formed (Bioassay or Enzyme assay).	1
13	Paper chromatography of fermentation broth for the presence of sugars and amino acids	1
14	Visit to fermentation industry and Report writing.	1

	MODERN EDUCATION SOCIETY'S **Nowrosjee Wadia College, Pune (Autonomous) NEP**	
Master of Science in Biotechnology		
SEMESTER –IV Major Paper 19(A)((Theory)		
Year – II	**Paper No- PBTMJ244(A)** **Name of Paper-Medical and Forensic Biotechnology**	**Credits 4**
Semester - IV		**Hours 60**

Course Outcomes (COs)

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

- Gain the knowledge of History, Different Domains, Needs, and Scope of Forensic Science
- Advancement in the field of medical science and its application to forensic Biotechnology
- Know the Medico-legal Aspects and Recent trends in forensic science

Sr. No.	COURSE CONTENT / SYLLABUS	Lectures
Unit -I	**Basic of Forensic Science:** ● Introduction, Definition, need, signification, and scope of ForensicScience. Principles of Forensic Science ● History and Development of Forensic Science in India and Abroad. ● Organization set up of Forensic Science Laboratory: Structure andfunction of State and regional Forensic Science Laboratory, CentralForensic Science Laboratory and facility provided, Mobile ForensicScience Laboratory. ● Directorate of Forensic Science Service. Police and Forensic scientist relationship, the role of FSL in criminal investigation, the relationship betweenforensic expert and judiciary officer, Importance of FSL, National andInternational scenario of FSL, facilities provided in forensic science laboratory.	8
Unit -II	**Domains in Forensic Science:** ● Forensic Biology, Forensic Medicine, Forensic Toxicology, ForensicOsteology and Odontology, Forensic Physics, Forensic Photography,Ballistics, Fingerprint, Questioned Documents, Forensic Psychology,Forensic Anthropology, Wildlife Forensic, DNA profiling, ComputerForensics, etc., Functions of Forensic Scientist, Police officers, Prosecution, Judicial Officers and Medico-legal expert etc. **Ethical issue in Forensic Science:** ● Definition of ethics, professional standards for the practice of Criminalistics,sanction against experts for unethical conduct.	7

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Unit -III	**Microbial Forensics** ● Definition of microbial forensics, Applications ● Microbes of forensic importance (*Bacillus anthracis, Yersinia pestis,Francisella tularensis, Brucella spp., Burkholderia Pseudomallei, Clostridium botulinum, Listeria monocytogenes*) ● Fungi of forensic importance (Opportunistic mycoses, *Chytridiomycotazygomycota, Aspergillus fumigates, microsporidum, pneumocytosis jiroveci, Asp.flavus* and *Candida* sp.) ● Microbial forensic tools. ● Dynamics of disease transmission and Outbreak Investigation. ● Deliberate introduction of a biological agent. ● Forensic Aspects of Biological Toxins ● Microbial Forensic Analysis of Trace and Unculturable Specimens	8
Unit -IV	**Medico-legal Autopsy:** ● Death and its Causes- External examination of deceased body- InternalExamination Determination of time since death and cause of death. ● Injuries-Classification-Medico-legal aspects of injuries. ● Post-mortem changes collection of post-mortem samples andPreservation.	7
Unit -V	**Forensic Analysis:** ● Examination of Biological Materials: Examination of Hair, Fibres,Diatoms, plants materials, human tissues. ● Examination of Body Fluid: Blood, Semen and Saliva. ● Forensic Importance of Insects: Insects of forensic importance. indicators of time of death stages of insect development and comparativedecomposition of human body colonization - Evidence collection of insects - Territorial and Aquatic Insects. ● DNA Fingerprint Technique and Examination of Biological Traces:Liquid blood, blood stains, and swabs, semen, Seminal stains, tissues,Bones, Hairs, Teeth, Saliva, Skeletal remains. ● Toxicological Investigations: Poisons - Definition, Forms of Poison - Physical, Chemical and Mechanical state. Introduction with examples of-Neurotoxic Poisons-Cerebral and Spinal, Cardiovascular Poisons, Asphyxiants, miscellaneous poisons - Pesticides, Pharmaceutical drugs,Petroleum poisons, Food poisons, radioactive poisons.	8

Unit -VI	**Forensic Medicine:** ● Introduction to Forensic Medicine: Definitions of Forensic Medicine. ● Medical Jurisprudence: Definition, aims, concept, fundamental aspects ● Scope of medical Jurisprudence, Legal procedure in criminal court, medical evidence and medical witness, Legal aspects of medical practices, medical negligence, Consent in medical practices. ● Medical evidence documentation	7
Unit -VII	**Emerging Microbial Forensic Techniques-** ● PCR, Terminal Restriction Fragment Length Polymorphism (TRFLP), ● Amplified Fragment Length Polymorphism (AFLP), ● Single Stranded Conformation Polymorphism Analysis (SSCP), ● Thermal and Desaturating Gradient Gel Electrophoresis (TGGE, DGGE), Amplified Ribosomal DNA Restriction Analysis (ARDRA), ● Randomly Amplified Polymorphic DNA (RAPD). ● Non-PCR DNA Fingerprinting Techniques with Applicability in Forensic Studies- Restriction Fragment Length Polymorphisms (RFLP)and Ribotyping. ● Forensic Interpretation of DNA Data, Isotopic Testing and Correlationto Contaminant Source	8
Unit -VIII	**Recent Trends in Forensic Science-** ● Environmental Forensics: Definition, Legal processes involving environmental forensic science. Geo-forensics Global PositioningSystem; Basic principles and applications. ● Biometrics in Personal Identification: Introduction, Concepts of Biometric Authentication, Role in person Identification, Techniques and Technologies (Finger Print Technology, Face Recognition, IRIS, RetinaGeometry, Hand Geometry, Speaker Recognition, Signature Verificationand other forensic related techniques). ● Bioterrorism: Definition, Concepts of Biosecurity and microbial forensics, Weapons of mass destruction (WMD), mass-casualty weapons (MCW), NBC and CBRNE, Dirty Bombs.	7

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3. Forensic Biology by Mr.Srikant Ladha,Dr.Trupti Khedkar and Dr.Rukmani Krishnamurthy
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MODERN EDUCATION SOCIETY'S
Nowrosjee Wadia College, Pune (Autonomous) NEP

Master of Science in Biotechnology

SEMESTER –IV Major Paper 19(B)(Theory)

Year – II	**Paper No- PBTMJ244(B)**	**Credits 4**
Semester - IV	**Name of Paper- Virology and Toxicology**	**Hours 60**

Course Outcomes (COs)
On completion of the course, the students will be able to:

- Study the scope of Toxicology
- Acquire knowledge on the types of Toxicology
- Know Metabolism and testing of Toxicology
- Learn the basic concepts of plant animals, Viruses, and bacteriophages along with their multiplication in host cells

Sr. No.	COURSE CONTENT / SYLLABUS	Lectures
Unit -I	**History:** History, origin, and evolution of viruses, pioneers of Virology. **Nomenclature and classification of viruses:** ● Criteria used for naming and classification, ● Current ICTV classification of viruses of bacteria, plants and animals, and humans. **Morphology and properties of viruses:** ● Physical- morphology and structure, ● sedimentation, electrophoretic mobility, buoyant density; Biochemical-chemical ● composition, nucleic acids, proteins, enzymes, lipids, carbohydrates, polyamines, cations, ● virus stability; Biological- Host range, inclusion bodies, transmission. **Transmission of viruses:** Non-vector and vector mode of transmission ofviruses	8
Unit -II	**Isolation, cultivation, and maintenance of viruses:** ● Isolation and cultivation of plant and animal viruses (experimental plants and tissue culture, experimental animals, embryonated eggs, organ cultures, primary and secondary cell cultures, suspension and monolayer cell cultures, cell strains, cell lines). **Purification of viruses:** ● Extraction of viruses from tissues, clarification, and concentration of viruses in clarified extracts by physical and chemical methods, further purification of viruses by rate zonal / equilibrium density gradient centrifugation, Criteria of virus purity, Quantitation, and Preservation of purified virus preparations.	7

Unit -III	**Major characteristics of Virus families:** ● Adenoviridae, Bromoviridae, Bunyaviridae, Caulimoviridae,Flaviviridae, Geminiviridae, Hepadnaviridae, Herpesviridae,Orthomyxoviridae, ● Biology of sub-viral agents: Satellite viruses, sat-RNAs, DI particles,viroids, virusoids, and prions.	7
Unit -IV	**Bacteriophages:** ● Biology of major RNA (MS2, Qβ) and DNA (T4, lambda, Øx174, M13) Bacteriophages, ● Replication of M13, T4 and lambda phages; biology of cyanophages. **Plant Viruses:** ● TMV- general characters- morphology-replication-RNA as its initiator of infection. Cauliflower mosaic virus; Transmission of plant viruses; ● Common viral diseases of crop plants- paddy, cotton, tomato, andsugarcane. Viruses of cyanobacteria, algae, fungi, and insects. ● Epidemiology, Diagnosis, and Treatment of Viral Diseases; ViralVaccines and Antiviral agents **Animal Viruses:** • Biology and pathogenesis of SARS, Hepatitis A and B Viral Infections. • Comet assay	8
Unit -V	**Introduction to toxicology:** ● History and scope of toxicology ● Source of toxicants ● Classification of toxic agents **Mechanism of toxicity:** ● Toxicant delivery, reaction with the target molecule, cellular dysfunction, inappropriate repair, and adaptation. ● Cytotoxicity mechanisms of cell death mitochondrial dysfunction. ● various branches of toxicology ● Different types of toxicities (acute, sub-acute, chronic, sub-chronictoxicity) **Types of Toxicology:** General Toxicology, Generic Toxicology, Organ Toxicity	7
Unit -VI	**Metabolism of toxicants:** ● Phase I Reactions: Microsomal oxidation Nonmicrosomal oxidations Reduction Reactions, Hydrolysis, Epoxide Hydration. cooxidation. ● Phase II Reactions: Conjugation reactions, Methyl transferases and Acylation. ● Reactive Metabolites: nature, stability, and fate of reactive metabolites, ● Elimination of Toxicants: renal, hepatic, and respiratory elimination. ● Non target organ toxicity: Chemical carcinogenesis mechanisms Of carcinogens.	8

Unit -VII	**Toxicology Testing:** ● Food toxicology: introduction, safety standards for foods and food ingredients and contaminants. ***In Vivo* Toxicology:** ● Testing of acute, sub chronic and chronic toxicity. ***In Vitro* testing:** ● Cell Culture Methods, Ames forward mutation assay, Assessing genotoxicity: mitotic index, chromosomal aberrations, micronucleus assay, cytotoxicity, and apoptosis assay. Neurotoxicity testing. ● A brief outline of methods of toxicity assessment. Animal use in toxicology and animal welfare.	7
Unit -VIII	**Carcinogenicity and Genotoxicity** ● Causes of cancers ● History ● What is a Carcinogen? ● Tumor types ● Classical Mechanism of Tumor Formation ● Testing for Cancer ● Toxicity of Cancer Treatments ● Overview of genotoxicity	8

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11. Carcinogenicity assessment: Addressing the challenges of cancer and chemicals in the environment - PMC (nih.gov)
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