NATIONAL EDUCATION POLICY-2020

Common Minimum Syllabus for all Uttarakhand State Universities and Colleges for First Three Years of Higher Education

PROPOSED STRUCTURE OF
UG - BIOTECHNOLOGY
SYLLABUS

2021

Curriculum Design Committee, Uttarakhand

Sr.No.	Name & Designation	
1.	Prof. N.K. Joshi Vice-Chancellor , Kumaun University Nainital	Chairman
2.	Prof. O.P.S. Negi Vice-Chancellor , Uttarakhand Open University	Member
3.	Prof. P. P. Dhyani Vice-Chancellor , Sri Dev Suman Uttarakhand University	Member
4.	Prof. N.S. Bhandari Vice-Chancellor, Soban Singh Jeena University Almora	Member
5.	Prof. Surekha Dangwal Vice-Chancellor, Doon University, Dehradun	Member
6.	Prof. M.S.M. Rawat Advisor, Rashtriya Uchchatar Shiksha Abhiyan, Uttarakhand	Member
7.	Prof. K. D. Purohit Advisor, Rashtriya Uchchatar Shiksha Abhiyan, Uttarakhand	Member

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EXPERT COMMITTEE

Name	Designation	Affiliation
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Prof. N. K. Singh	Professor	Department of Plant Breeding &Genetics, College of Agriculture, G. B. P. U. A. & T. Pantnagar
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Semester-wise Titles of the Papers in B.Sc. Biotechnology

Year	Sem.	Course Code	Paper Title	Theory/Practical	Credits
Certificate in Basic Biotechnology					
1	I	UBT01-(T/P)	Introductory Microbiology	Theory + Practical	4+2
		UBT02-(T/P)	Biology of Plants	Theory + Practical	4+2
		UBT03-T	Basics of Genetics	Theory	6
		-	Vocational		2
	II	UBT04-(T/P)	Elementary Molecular Biology	Theory + Practical	4+2
		UBT05-T	Elementary Mathematics for Biologists	Theory	6
		UBT06-(T/P)	Chemical Science I	Theory + Practical	4+2
		-	Elective		6
		-	Vocational		2
				Total	46
Diploma in Biotechnology					
2	III	UBT07-T	Basic Cell Biology	Theory	6
		UBT08-(T/P)	Chemical Science II	Theory + Practical	4+2
		UBT09-(T/P)	Fundamental Biochemistry	Theory + Practical	4+2
		-	Vocational		2
	IV	UBT10-(T/P)	Basic Genetic Engineering	Theory + Practical	4+2
		UBT11-(T/P)	Fundamentals of Computers	Theory + Practical	4+2
		UBT12-T	Elementary Physics for Biologist	Theory	6
		-	Elective		6
		-	Vocational		2
				Total	46
Degree in Bachelor of Science (Biotechnology)					
3	V	UBT13-(T/P)	Basics of Immunology	Theory + Practical	4+2
		UBT14-T	Introductory Animal Biotechnology	Theory	6

		UBT15-T	Environmental Biotechnology	Theory	6
		UBT16-(T/P)	Biology of Animals	Theory + Practical	4+2
	VI	UBT17-(T/P)	Introductory Plant Biotechnology	Theory + Practical	4+2
		UBT18-(T/P)	Bio Analytical Techniques	Theory + Practical	4+2
		UBT19-T	Microbial Genetics	Theory	6
		UBT20-T	Medical Biotechnology	Theory	6
				Total	48

ELECTIVE PAPERS OFFERED			
Course Code	**Paper Title**	**Theory/Practical**	**Credits**
UBTE01-T	Evolution & Introduction to Developmental Biology	Theory	6
UBTE02-(T/P)	Industrial and Environmental Biotechnology	Theory+Practical	4+2
UBTE03-T	Food Biotechnology	Theory	6
UBTE04-(T/P)	Food Microbiology	Theory+Practical	4+2
UBTE05-T	Elementary Industrial Microbiology	Theory	6
UBTE06-T	Molecular Cancer Biology	Theory	6

Subject Prerequisite

The candidate should have passed (10+2) examination in science stream with PCB (Physics, Chemistry, Biology and/or Biotechnology) or PCM (Physics, Chemistry and Maths) or any other science subject.

PROGRAM OBJECTIVES:

1. Students after completion of the program will be eligible for pursuing higher courses in biotechnology and related fields.

2. Graduates will get competency in the subject and would contribute to the growth of the country in different disciplines related to biotechnology

3. Students will pursue career paths in teaching or research at suitable levels.

PROGRAM SPECIFIC OUTCOMES (PSOs)	
CERTIFICATE IN BIOTECHNOLOGY	
First Year	This course introduces the knowledge of genetics, molecular biology and microbiology; along with achieving the basic foundation in Mathematics, Biology and Chemistry. **PSO1.** After completion of this certificate course, students will be able to demonstrate and apply their knowledge of genetics, molecular biology and microbiology related to the field of biotechnology **PSO2:** Understand the basic concepts of genetics and molecular biology such as inheritance pattern, DNA replication, transcription and translation **PSO3:** Understand how genetic information is transmitted in organism **PSO4.** Acquire knowledge about the application of various types of microscopes, staining techniques, culture techniques, sterilization, preservation etc. **PSO5:** Perform experiments of DNA isolation, agarose gel electrophoresis, spectroscopy, PCR etc **PSO6:** apply for job at technical positions in different research laboratories, diagnostic centers and industries.
Second Year	**DIPLOMA IN BIOTECHNOLOGY**
	After completion of diploma course, students will be able to- **PSO1:** Learn the chemistry, structure and functions of major bio-molecules and metabolism of carbohydrate, protein etc. **PSO2**: Understand the significance of Biochemistry and basics of enzymes. **PSO3:** Familiarize with basic laboratory instruments and understand the principle of measurements using those instruments with experiments in Biochemistry. **PSO4:** Understand different biochemical tools and techniques such as chromatography, electrophoresis etc. **PSO 5.** Know the chemical structure of nucleotides including their components, describe primary, secondary structure of DNA and RNA **PSO 6:** Perform different experiments based on the techniques such as chromatography, electrophoresis, centrifugation etc. **PSO 7:** Would be able to understand Morphology and cell structure; Various subcellular bodies, their interaction and trafficking etc **PSO 8:** Understand the foundations of modern biotechnology and explain the principles that form the basis for recombinant technology & understand and perform various recent molecular and recombinant DNA technology techniques; perform experiments of DNA isolation, gene cloning, transformation etc.

Third Year	DEGREE IN BACHELOR OF SCIENCE (Biotechnology)
	After completing the three years degree course in Biotechnology, the students will be able to: **PSO1:** Understand the principles, practices and applications of plant biotechnology, transgenic plant generation, plant tissue culture, plant genomics, and genetic transformation. **PSO2:** Perform and analyze the results of experiments using basic laboratory techniques of immunology, animal and plant biotechnology, Bioanalytical techniques, medical biotechnology, Microbial genetics and Environmental biotechnology. **PSO3**: Learn different gene delivery methods to deliver foreign gene in plants and animals **PSO4:** Familiarize with the principles, practices and application of animal biotechnology in Transgenesis, Tissue Engineering, and biopharmaceuticals. **PSO5:** Develop an ability to properly understand the technical aspects of existing technologies that help in addressing the various challenges faced by humankind. **PSO6**. learn fundamentals of Environmental Biotechnology and understand the importance of clean (pollution free) environment **PSO7:** Understand biotechnological solutions to address environmental issues including pollution, mineral resource winning, renewable energy and water recycling **PSO8:** Understand and also able to perform different immunological techniques like agglutination reaction, ABO typing and ELISA. **PSO9:** Demonstrate principle and application of Chromatography (Column chromatography, Ion-exchange chromatography, Gel-permeation (molecular sieve, chromatography, Affinity chromatography, Paper chromatography, Thin-layer chromatography and HPLC *etc*) **PSO10:** Demonstrate knowledge for in-depth analytical and critical thinking to identify, formulate and solve the issues related to Biotechnology research, Biotechnology Industry, Pharma industry, Medical or hospital related organizations, and Academia. **PSO 11:** Exhibit ability to do research independently as well as in collaboration in the area of Biotechnology Industry, Pharma industry, Medical or hospital related organizations, and Academia**.**

Subject: Biotechnology							
Year	**Semester**	**Theory Paper**	**Units**	**Practical Paper**	**Units**	**Research Project**	**Total Credits of the Year subject**
1	I	**INTRODUCTORY MICROBIOLOGY**	5 Units	**INTRODUCTORY MICROBIOLOGY**	1. Preparation of nutrient agar slants, plates and nutrient broth and their sterilization 2. Inoculation of agar slants, agar plate and nutrient broth 3. Culture of micro-organism using various techniques 4. Simple and differential staining procedures, endospore staining, flagellar staining, cell wall staining, Capsular staining, negative staining 5. Bacterial colony counting 6. Microscopic Observation of different vegetative, capsular and spore forms of bacteria and fungus under 7. Isolation of microbes from soil samples and determination of the number of colony forming units 8. Study of growth curve of E. coli	NIL	4+2=6
		BIOLOGY OF PLANTS	5 Units	**BIOLOGY OF PLANTS**	1. Specimen of Algae, Fungi, Bryophyta, Pteridophyla & Gymnosperms. 2. Section cutting of leaf/stem/root. 3. Study of inflorescence, fruits & seeds. 4. Families- Malvaceae, Cruciferae, Compositae.	NIL	4+2=6

		BASICS OF GENETICS	5 Units	**NONE**	NA	NIL	6
	II	**ELEMENTARY MOLECULAR BIOLOGY**	5 Units	**ELEMENTARY MOLECULAR BIOLOGY**	1. Estimation of DNA content in the given sample by diphenylamine method 2. Estimation of RNA content by the Orcinol method 3. Isolation of DNA from bacterial or plant or animal cell 4. Spectrophotometric Quantitation of DNA. 5. DNA Hyperchromacity.	NIL	4+2=6
		ELEMENTARY MATHEMATICS FOR BIOLOGISTS	5 Units	**NONE**	NA	NIL	6
		CHEMICAL SCIENCE I	4 Units	**CHEMICAL SCIENCE I**	1. Volumetric Analysis: Acid-Base, Oxd-Red, Iodometric Titration, Potassium dichromate. 2. Determination of surface tension/ viscosity 3. Calculation of parachor 4. Separation of the organic binary mixture and identification of the compounds.	NIL	4+2=6

2	III	**BASIC CELL BIOLOGY**	4 Units	**NONE**	NA	NIL	6
		CHEMICAL SCIENCE II	5 Units	**CHEMICAL SCIENCE II**	1. Preparation of organic compound, Nitration, Bromination, Acetylation etc. 2. Preparation of Inorganic compound. 3. Paper, Thin layer and column chromatography of sugars, Amino acid, phenols etc. 4. Qualitative analysis of inorganic mixture containing not more than six ionic species. (excluding insoluble substances)	NIL	4+2=6
		FUNDAMENTAL BIOCHEMISTRY	6 Units	**FUNDAMENTAL BIOCHEMISTRY**	1. Estimation of Carbohydrates 2. Estimation of Proteins 3. Separation of Amino acids by Paper Chromatography 4. Thin layer Chromatography 5. Gel Electrophoresis 6. Assay of enzyme activity and Enzyme kinetics 7. Saponification of Fats	NIL	4+2=6
	IV	**BASIC GENETIC ENGINEERING**	5 Units	**BASIC GENETIC ENGINEERING**	1. Isolation of Plasmid DNA 2. Restriction digestion with EcoRI' HindIII or any other restriction enzyme available 3. Agarose gel electrophoresis of Restricted and Unrestricted DNA fragments.	NIL	4+2=6

		FUNDAMENTALS OF COMPUTERS	5 Units	**FUNDAMENTALS OF COMPUTERS**	1. Introduction to C^{++} 2. Introduction to Array 3. For loop and while loop 4. IF Statement 5. Basic, Networking.	NIL	4+2=6
		ELEMENTARY PHYSICS FOR BIOLOGISTS	6 Units	**NONE**	NA	NIL	6
3	V	**BIOLOGY OF ANIMALS**	5 Units	**BIOLOGY OF ANIMALS**	1. Dissection of cranial nerves of scoliodon. 2. Dissection of nervous system of prawn. 3. Study of museum specimens; slides of chordates and non-chordates. 4. Dehydration procedure.	NIL	4+2=6
		BASICS OF IMMUNOLOGY	5 Units	**BASICS OF IMMUNOLOGY**	1. Demonstration of immunization techniques and bleeding of experimental animals. 2. Separation of serum. 3. Antibody and Antigen interaction- Agglutination, Precipitation, Ochterlony double diffusion 4. ELISA	NIL	4+2=6
		INTRODUCTORY ANIMAL BIOTECHNOLOGY	5 Units	**NONE**	NA	NIL	6
		ENVIRONMENTAL BIOTECHNOLOGY	5 Units	**NONE**	NA	NIL	6

	VI	**INTRODUCTORY PLANT BIOTECHNOLOGY**	5 Units	**INTRODUCTORY PLANT BIOTECHNOLOGY**	1. Plant tissue culture, Media preparation 2. Ex plant selection and sterilization 3. Callus culture 4. Callus splitting and Regeneration 5. Rooting and Shooting of callus using Auxins and Cytokinins 6. Hardening of the tissue culture generated plantlets	NIL	4+2=6
		BIO ANALYTICAL TECHNIQUES	5 Units	**BIO ANALYTICAL TECHNIQUES**	1. Gravimetric estimation of barium, zinc, iron, copper, sulphate and chromium 2. Organic Mixture: Separation of two component organic mixtures (water soluble), systemic analysis of each component.	NIL	4+2=6
		MICROBIAL GENETICS	6 Units	**NONE**	NA	NIL	6
		MEDICAL BIOTECHNOLOGY	6 Units	**NONE**	NA	NIL	6

Pattern of examination theory papers

A. Theory (External)

*Each theory paper shall consist two sections **A** and **B**.*
***Section A**: (Short answers type with reasoning); 45 marks, eight questions of nine marks each, any five have to be attempted.*
***Section B**: (Long answers type); 30 marks, two questions of fifteen marks each. Both the questions are compulsory with internal choice.*

B. Internal assessment

For each theory paper internal assessment shall be conducted periodically (in the form of class tests and/or assignments/ group discussion/ oral presentation/ overall performance) during the semester period. Total marks allotted to internal assessment shall be 25. The evaluated answer sheets/assignments have to be retained by the Professor In-Charge for the period of six months and can be shown to the students if students want to see the evaluated answer sheets. The marks obtained by the students shall be submitted to the Head of concerned department/ the Principal of the College for uploading onto the University examination portal.

C. Practical

*The laboratory work of the students has to be evaluated periodically. The breakup of marks for practical examination for **each semester** would be as follows:*

Practical exam: 20% marks
Viva voce: 20% marks
Lab record: 20% marks
Spotting: 30% marks
Attendance: 10% marks
Total: 50 marks (each semester)

Marks obtained in the practical examination have to be submitted to the Head of the department/ Principal of the College. The Head of the Department/Principal of the College will make necessary arrangement for uploading the marks onto the University exam portal. The hard copy of the award list from portal has to be submitted to the Controller of Examination, Kumaun University, Nainital.

Year	Sem.	Course Code	Paper Title	Theory/Practical	Credits
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		UBT02-(T/P)	Biology of Plants	Theory + Practical	4+2
		UBT03-T	Basics of Genetics	Theory	6
		-	Vocational		2
	II	UBT04-(T/P)	Elementary Molecular Biology	Theory + Practical	4+2
		UBT05-T	Elementary mathematics for Biologists	Theory	6
		UBT06-(T/P)	Chemical Science I	Theory + Practical	4+2
		-	Elective		6
		-	Vocational		2
				Total	46

Semester-I
Paper-I (Theory+ practical)
Course Title: Introductory Microbiology

Course Objective: Students will get general idea of common microorganisms; they will also learn basics of laboratory safety. They will have idea of basic laboratory techniques and would be able to apply the knowledge gained towards research, diagnostic, and therapeutic purposes.

Credits:4+2	Compulsory
Max. Marks: 100 + 25 (practical)	Min. Passing Marks:……

Total Number of Lectures = 60

Unit	Content (Theory)	Number of lectures
1	• History of microbiology: Importance & scope of microbiology • Classification and nomenclature of Microbes • Importance & scope of microorganisms in human welfare	**10**

2	• Characteristics and examples of *Archaebacteria,* eubacteria, viruses, viroids and prions. • Size, shape and arrangement of bacterial cells, cell wall, cytoplasmic membrane (Protoplasts, spheroplasts), flagella, pili, spores and cysts. • Bacteriophage – lytic and lysogenic cycle; Staining techniques – simple (Monochrome and negative) and differential (Gram and acid fast).	**15**
3	• Control of microorganisms – Methods of sterilization, disinfection, sanitation, pasteurization, physical and chemical methods of control. • Staining techniques – Simple (Monochrome and negative) and differential (Gram and acid fast).	**10**
4	• Bacterial nutrition – Nutritional classes of microorganisms. • Microbial media and its types. • Isolation of pure culture from natural sources and its maintenance	**10**
5	• Microbial growth – Growth curve, conditions affecting growth. • Batch and continuous culture; Measurement of bacterial growth. • Introduction to microbial pathogens & diseases (Cholera, tuberculosis, tetanus, measles & Mumps, influenza, rabies, Poliomyelitis, toxoplasmosis, HIV, Candidiasis etc.)	**15**

Books Recommended:

- Tortora, Gerard J., Berdell R. Funke, and Christine L. Case. 2004. Microbiology: an introduction: Pearson
- Pelczar, M. J., Jr, & etc. (1993). Microbiology: Concepts and Applications (6th ed.). London, England: McGraw-Hill Education (ISE Editions).
- Madigan, M. M., Martinko, J. M., Parker, J., Messley, K., & Norrell, S. (2003). *Brock biology of microorganisms: (international edition) with microbiology lab manual*. Upper Saddle River, NJ: Pearson.

Suggested online links:

- https://nptel.ac.in/courses/102/103/102103015/
- https://dth.ac.in/medical/courses/Microbiology/block-1/1/index.php
- https://onlinecourses.swayam2.ac.in/cec19_bt11/preview
- https://ocw.mit.edu/courses/find-by-topic/#cat=science&subcat=biology&spec=microbiology

Semester-I
Paper-I (Practical)
Course Title: Introductory Microbiology

Total Number of Hrs = 60

Unit	Content (Practical)	Number of Hrs.
1	Preparation of nutrient agar slants, plates and nutrient broth and their Sterilization	8
2	Inoculation of agar slants, agar plate and nutrient broth	7
3	Culture of micro-organism using various techniques	7
4	Simple and differential staining procedures, endospore staining, flagellar staining, cell wall staining, Capsular staining, negative staining	8
5	Bacterial colony counting	7
6	Microscopic Observation of different vegetative, capsular and spore forms of bacteria and fungus under	7
7	Isolation of microbes from soil samples and determination of the number of colony forming units	8
8	Study of growth curve of *E. coli*	8

Semester-I
Paper-II (Theory + Practical)
Course Title: Biology of Plants

Course objective: Students will learn basics of plant classification, anatomy, morphology and physiology etc. The background of plant science would enable the students to apply biotechnological tools in agricultural crops and other plants.

Credits: 4+2	**Compulsory**	
Max. Marks: 100+25 (Practical)	Min. Passing Marks:……	
Total Number of Lectures = 60		
Units	**Content (Theory)**	**Number of Lectures**
1	• Plant Kingdom. The classification up to the level of genus and species, important characters of each class with suitable examples. • Mechanism of Photosynthesis, photophosphorylation. • Mechanisms and significance of respiration.	**15**
2	• Plant- water relations, absorption movement and transpiration of water. • Translocation of minerals and nutrients.	**10**

3	• Dicot and monocot root and stem, structure and function of different cells (Angiosperms and Gymnosperms) • Inflorescence and their types with example, fruit and their types with example. • Secondary growth of stem • Development of seed, Seed germination and dormancy	**15**
4	• Plant growth hormones- introduction and functions. • Major auxin & Cytokinin, their functions and application • Vernalization, Photoperiodism	**10**
5	• Apomixis • Parthenocarpy, Polyembryony • Ecobiology of the medicinally and aromatically important plants.	**10**

Books Recommended:

- Smith, A. M., Coupland, G., Dolan, L., Harberd, N., Jones, J., Martin, C., Amey, A. (2009). Plant Biology. Boca Raton, FL: CRC Press.
- Bowsher, C., Steer, M., & Tobin, A. (2008). Plant Biochemistry. London, England: Garland Science.
- Godwin, H. (2015). Plant biology: An outline of the principles underlying plant activity and structure. Cambridge, England: Cambridge University Press.
- Sharma, H. P. (2009). Plant embryology: Classical and experimental. Oxford, England: Alpha Science International.

Suggested online links:

- https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=1p0OY7YTBClr5D2KEqnvVg==
- https://onlinecourses.swayam2.ac.in/cec21_bt03/preview
- https://onlinecourses.swayam2.ac.in/cec19_bt01/preview
- https://onlinecourses.nptel.ac.in/noc19_bt17/preview
- https://onlinecourses.swayam2.ac.in/cec19_bt09/preview

Semester-I
Paper-II (Practical)
Course Title: Biology of Plants

Total Number of Hrs = 60

Unit	Contents	Number of Hrs
1	Specimen of Algae, Fungi, Brypphyta, Pteridophyla & Gymnosperms.	**15**
2	Section cutting of leaf/stem/root.	**15**
3	Study of inflorescence, fruits & seeds.	**15**
4	Families- Malvaceae, Crucifereae, Compositae	**15**

Semester-I
Paper-III (Theory)
Course Title: BASICS OF GENETICS

Course Objective: Students will learn basic concepts in genetics and microbial genetics. They will learn genetic inheritance through historical experiments and get knowledge of chromosome organization.

Credits: 6	**Compulsory**	
Max. Marks: 100	Min. Passing Marks:……	
Total Number of Lectures = 90		
Units	**Content (Theory)**	**Number of Lectures**
1	• Modern concept of gene & genome • Introduction of genetics, genotype, phenotype and other genetic terminology • Mendel's laws of inheritance and their molecular interpretation. • DNA as genetic material-experimental proof	**20**
2	• Chromosomes- structural organization of prokaryotic and eukaryotic chromosomes, Kinds of chromosomes based on chromosomal aberration- structural & numerical.	**15**
3	• Mutation: spontaneous and induced, chemical and physical mutagens, induced mutations in plants, animals and microbes for economic benefits, Replica plating techniques. • Hereditary defects- Kleinfelters syndrome, Down's syndrome, Turners syndrome	**20**
4	• Microbial genetics- Recombination in bacteria; Molecular mechanism of recombination, Transformation Transduction, Conjugation ,replica, plating.	**15**
5	• Concept in Monosomy, trisomy, nullisomy & others introduction • Introduction to Genetic & physical maps • Classical experiment of genetics in drosophila for establishing linkages and crossing over. • Biochemical genetics – *Neurospora crassa* experiments	**20**

Books Recommended:

1. Gardner EJ, Simmons MJ, Sunstad DP. **Principles of Genetics**. 8th Edition. John Wiley and Sons.
2. Hartl, D. L., & Jones, E. W. (1998). **Genetics: Principles and Analysis**. Sudbury, MA: Jones and Bartlett.
3. Pierce, B. A. (2005). **Genetics: a Conceptual Approach**. New York: W.H. Freeman.
4. Smith, J. M. (1998). **Evolutionary Genetics.** Oxford: Oxford University Press Genetics: Principles and Analysis – Hartl and Jones.

5. Snustand DP, Simmons MJ. **Principles of Genetics**. (2016) 7th Edition. John Wiley and Sons.
6. Verma PS, Agarwal VK. **Cell Biology, Genetics, Molecular Biology, Evolution and Ecology**. (2004). S Chand and Company Ltd.

Suggested online links:

- https://nptel.ac.in/noc/courses/noc19/SEM1/noc19-bt05/
- https://www.classcentral.com/course/swayam-principles-of-genetics-23082
- https://onlinecourses.nptel.ac.in/noc21_bt02/preview
- https://ocw.mit.edu/courses/find-by-topic/#cat=science&subcat=biology&spec=genetics
- https://nptel.ac.in/courses/102/103/102103012/
- https://nptel.ac.in/courses/102/106/102106025/
- https://nptel.ac.in/courses/102/103/102103015/

Semester-II
Paper-I (Theory + Practical)
Course Title: **ELEMENTARY MOLECULAR BIOLOGY**

Course Objective: Students will understand molecular logic of life; they will understand the organization and functions of DNA, RNA, and proteins. They would also learn the biochemical and molecular regulation of various biological processes

Credits: 4+2		**Compulsory**
Max. Marks: 100+25 (Practical) (Practical)		Min. Passing Marks:……
Total Number of Lectures = 60		
Units	**Content (Theory)**	**Number of Lectures**
1	• Control Dogma of Molecular Biology • Recapitulation of Nucleic acid structure forms. Nucleic acid as genetic material (Avery *et al*'s experiment & Hershey &Chase's experiment) • DNA polymerases in Prokaryotes & Eukaryotes • Replication of DNA: Semi conservative replication of DNA (Messelsen & Stahl experiment), Uni–directional bi–directional replication of DNA &rolling circle DNA replication, DNA replication in prokaryotes (Initiation, elongation & termination), DNA replication in eukaryotes (Initiation, elongation & termination)	**12**

2	• Transcription: Transcription in prokaryotes (Promoter sites, initiation & elongation, termination), Transcription in Eukaryotes (Promoter, enhancer & silencer sites for initiation, transcription factors, elongation & termination), RNA polymerase in prokaryotes & Eukaryotes. • RNA processing- capping, tailing & splicing, ribozyme, RNA editing.	**12**
3	• Protein Synthesis: Translation in Prokaryotes & Eukarytoes (Formation of aminoacyl tRNA, Initiation, Elongation & Termination of polypeptide). Post translational Modification of proteins. • Genetic code: Properties of genetic code, chain initiation & chain termination codons, wobble hypothesis.	**12**
4	• Concept of gene and its organization • Regulation of gene expression: Positive & Negative regulation, The operon model for transcriptional regulation (*Lac* operon & *Trp* operon) control of lac operon, regulation of *Trp* operon.	**12**
5	• Organization of genetic material: Chromosomal DNA content & C-Value paradox, Repetitive DNA, satellite DNA, (reassociation Kinetics, Chemical complexity & Kinetic complexity) • Homologous recombination, Holliday model	**12**

Books Recommended:

1. Nelson, David L., and Michael M. Cox. (2017). Lehninger Principles of Biochemistry. 7th ed. New York, NY: W.H. Freeman.
2. Howell, S. H. (Ed.). (2014). Molecular Biology (2014th ed.). New York, NY: Springer.
3. Verma, P. S., & Agarwal, V. K. (2010). Molecular Biology. New Delhi, India: S Chand.
4. Cox, M. M., & O'Donnell, M. (2015). Molecular biology: Principles and practice (1st ed.). New York, NY: W.H. Freeman.

Suggested online links:

- https://onlinecourses.swayam2.ac.in/cec20_ma13/preview
- https://ocw.mit.edu/courses/find-by-topic/#cat=science&subcat=biology&spec=molecularbiology
- https://ocw.mit.edu/courses/biology/7-28-molecular-biology-spring-2005/
- https://www.ncbi.nlm.nih.gov/books/NBK9855/

Semester-II
Paper-I (Practical)
Course Title: **ELEMENTARY MOLECULAR BIOLOGY**

Total Number of Hrs = 60		
Units	**Content (Theory)**	**Number of Hrs**
1	Estimation of DNA content in the given sample by diphenylamine method	12
2	Estimation of RNA content by the Orcinol method	12
3	Isolation of DNA from bacterial or plant or animal cell	12
4	Spectrophotometric Quantitation of DNA.	12
5	DNA Hyperchromacity.	12

Semester-II
Paper-II (Theory)
Course Title: ELEMENTARY MATHEMATICS FOR BIOLIGISTS

Course Objective: The course would provide basic background to the students for its application in various domains of biotechnology. Understanding statistical principle will help them in designing experiments, understanding different models and analyzing data.

Credits: 6	**Compulsory**	
Max. Marks: 100	Min. Passing Marks:……	
Total Number of Lectures = 90		
Units	**Content (Theory)**	**Number of Lectures**
1	• Algebra- Simultaneous equations (linear and quadratic) upto two variables only; Determinants- properties of determinants; Matrices- definition and types, Arithmetic operation on matrices, Partial fraction. • Complex number and De moiver's theorem	**15**

2	• Differential Calculus- Differentiation, Differentiation of Standard function including functions of a function (chain rule), Differentiation of implicit functions; Logarithmic differentiation. • Integral calculus- Integration of parts, substitution of partial fractions, Integration of algebric function; The definite integral-properties of definite integral.	**20**
3	• Frequency distribution- graphical representation of frequency distribution using bar chart, pie chart, histograms, frequency polygon, frequency curve and cumulative frequency curve. • Mean, Median and Mode and their characteristics; quartiles, range, dispersion, mean deviation, standard deviation, standard error of mean; Coefficient of variation.	**20**
4	• Correlation and regression- definition, Karl – Pearson's coefficient of correlation, line of regression, regression coefficient.	**15**
5	• Sampling- An idea of probability; large samples, Test of significance of large samples at 5% and 1% levels of significance; t-test, chi square test and F test.	**20**

Books Recommended:

- Rosner, B. (2000). **Fundamentals of Biostatistics**. Boston, MA: Duxbury Press.
- Daniel, W. W. (1987). **Biostatistics, a Foundation for Analysis in the Health Sciences**. New York: Wiley
- Mariappan P. (2013) **Biostatistics**. Pearson
- Rastogi VB.(2015). **Biostatistics** (3rd Edition). MedTec
- Anthony W. Knapp, Basic Algebra, Second Edition, 2016; East Setauket, New York
- Marvin L. Bittinger, David J. Ellenbogen, Barbara L. Johnson; Elementary and Intermediate Algebra Graphs and Models; Example Product Manufacturer; 4th edition
- Udesh K Shah & Subhash Chand Garg; A Textbook of Algebra; S. Chand & co

Suggested online links:

- https://ocw.mit.edu/resources/res-18-001-calculus-online-textbook-spring-2005/textbook/
- https://nptel.ac.in/courses/102/101/102101067/
- https://www.khanacademy.org/math/calculus-1
- https://nptel.ac.in/courses/111/104/111104144/
- https://nptel.ac.in/courses/102/101/102101056/
- https://openstax.org/details/books/calculus-volume-1
- https://open.umn.edu/opentextbooks/textbooks/13

Semester-II
Paper-III (Theory + Practical)
Course Title: CHEMICAL SCIENCE I

Course Objective: To understand the basic principles of atomic structure, nomenclature, reaction kinetics, electrochemistry, ionic strength and pH etc, for their application in biotechnology related disciplines.

Credits: 4+2	**Compulsory**	
Max. Marks: 100+25 (Practical)	Min. Passing Marks:……	
Total Number of Lectures = 60		
Units	**Content (Theory)**	**Number of Lectures**
1	• Atomic structure, chemical bonding, hybridization, valence shell electron pair repulsion (VSEPR) theory. To NH_3, H_3O^+, SF_4, ClF_3 and H_2O, Molecular orbital theory (MOT), • Periodic properties: viz. ionization potential, electron affinity, electronegativity etc. study of s, p and d- block elements.	**15**
	• Coordination compound: Werners theory and IUPAC nomenclature of coordination compounds valence bond theory and discussion of inner and outer orbit complexes.	
2	• Acids and bases: elementary ideas of Bronsted – Lowery and Lewis concept of acid and bases. SHAB (soft and hard acid and base), buffer solution, pH, pKa and pKb values, • Solution: Henrys law, Roults law, osmotic pressure and its measurement, effect of solute on B.P. and F.P. of solution. Vapour pressure, surface tension, viscosity, parachor, Rheochor and their applications	**15**
3	• Chemical kinetics: 1^{st} 2^{nd} and 3^{rd} order reactions, determination of order of reaction, molecularity and order of reaction, Energy of activation, Arhenus equation, half- life period, catalyst and composite reaction. • Electrochemistry: Galvanic cells, EMF, type of electrodes, reference electrodes, electroanalytical methods viz; potentiometry, conductometry, polarography, weak and strong electrolyte, degree of hydrolysis of salts.	**15**
4	• Ionic and Liquid crystals • Nuclear chemistry: concepts of nuclides, isotopes, isobars, isotones, radioactivity, nuclear reaction, • Colloidal solutions: properties of collides, Tyndel effect, flocculation, Hardy –Sultze rule.	**15**

Books Recommended:

- Lee, J.D., "Concise, Inorganic Chemistry", Oxford University Press, 2008, India, 5^{th} edition.
- Madan, R.L., "Chemistry for Degree Students, B. Sc. First Year", S. Chand Publishing, New

Delhi, India, 2011, 3rd edition.
- Madan, R.D., Malik, U.M. and Tuli, G.D., "Selected topics in Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2010.
- Chandra, S., "Comprehensive Inorganic Chemistry" New Age International Publishers, India, 2018, 1st edition.
- Prakash, S., Tuli, G.D., Basu, S.K. and Madan, R.D., "Advanced Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2000, Vol 1.
- Finar, I.L., "Organic Chemistry", Pearson Education India, 2002, 6th edition.
- Eliel, E.L. and Wilen, S.H., "Stereochemistry of Organic Compounds", Willey, 1994,1st edition.
- Bahl, A., Bahl, B.S. and Tuli, G.D., "Essential of Physical Chemistry", S. Chand Publishing, India, 2010.
- Bariyar, A., Singh, R.P. and Dwivedi, A., "Text Book for B. Sc. Chemistry I", Anu Books, 2019.

Suggested online links:

- https://ocw.mit.edu/courses/chemistry/5-111sc-principles-of-chemical-science-fall-2014/unit-ii-chemical-bonding-structure/lecture-14/
- https://onlinecourses.swayam2.ac.in/nce19_sc15/preview
- http://www.ocw.titech.ac.jp/index.php?module=General&action=T0300&GakubuCD=3&GakkaCD=332100&KeiCD=21&KougiCD=202102333&Nendo=2021&lang=EN&vid=03
- https://www.openlearning.com/courses/introduction-to-physical-chemistry/?cl=1
- https://www.careers360.com/university/indian-institute-of-technology-bombay/chemistry-of-main-group-elements-certification-course
- https://onlinecourses.swayam2.ac.in/cec20_lb01/preview
- https://nptel.ac.in/courses/104/103/104103071/
- http://test.open.uci.edu/lectures/chem_1c_lec_20_general_chemistry_electrochemistry_pt_5.html

Semester-II
Paper-III (Practical)
Course Title: CHEMICAL SCIENCE I

Total Number of Hrs = 60		
Units	**Content (Theory)**	**Number of Hrs**
1	Volumetric Analysis : Acid-Base, Oxd-Red, Iodometric Titration, Potassium dichromate.	**15**
2	Determination of surface tension/ viscosity	**15**
3	Calculation of parachor	**15**
4	Separation of the organic binary mixture and identification of the compounds.	**15**

Year	Semester	Course Code	Paper Title	Theory/Practical	Credits
DIPLOMA IN BIOTECHNOLOGY					
2	III	UBT07-T	Basic Cell Biology	Theory	6
		UBT08-(T/P)	Chemical Science II	Theory + Practical	4+2
		UBT09-(T/P)	Fundamental Biochemistry	Theory + Practical	4+2
		-	Vocational		2
	IV	UBT10-(T/P)	Basic Genetic Engineering	Theory + Practical	4+2
		UBT11-(T/P)	Fundamentals of Computers	Theory + Practical	4+2
		BT12-T	Elementary Physics for Biologist	Theory	6
		-	Elective		6
		-	Vocational		2
				Total	46

Semester-III
Paper-I (Theory)
Course Title: BASIC CELL BIOLOGY

Course objective: Students will understand basic cellular structure and function of cell-organelles. They will also get introduced to concepts of cell division and cell-death.

Credits: 6		**Compulsory**
Max. Marks: 100		Min. Passing Marks:……
Total Number of Lectures = 90		
Units	**Content (Theory)**	**Number of Lectures**
1	• Cell as a unit of living system. The cell theory; Precellular evolution; Eukaryotic and Prokaryotic cells. • Biochemical composition of cells (Protein, lipids, carbohydrates, nucleic acids).	**20**
2	• Structure and functions of various cell organelles; ultrastructure of plasma membrane; cell wall, endoplasmic reticulum, mitochondria, Golgi body, chloroplast, lysosomes, peroxisomes & glyoxisomes.	**30**
3	• Structure of nucleus, nucleolus and chromosomes; Giant chromosomes (lampbrush & polytene). • Cytoskeletal structures (actin, microtubules intermediate filament	**20**
4	• Cell division (Mitosis and Meiosis); Cell cycle; Difference between cancerous and normal cells. • Cell senescence, cell death and apoptosis.	**20**

Books Recommended:

- Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). Molecular Biology of the Cell (6th Ed.). New York: Garland Science
- Cooper, G. M., and Hausman, R. E. (2013). The Cell: a Molecular Approach (6th Ed.). Washington: ASM ; Sunderland.
- Karp, G. Cell and Molecular Biology. Concepts and experiments. John Harris, D., Wiley & sons, New York
- Iwasa J., Marshal W. Karp's Cell Biology(2018) (8th edition) Wiley & Sons, NY
- Iwasa J., Marshal W. Karp's Cell and Molecular Biology: Concepts and experiments. (2015) (8th edition) Wiley & sons, New York
- Watson, J. D. Baker TA, Bell, SP Gann, A. Levine, M. Losick R. (2008). Molecular Biology of the Gene (5th ed.). Pearson
- Lodish, H F. Berk, A. Kaiser, CA, Krieger, M. Bretscher, A. Ploegh, H. Aman, A. Martin, K. (2016). Molecular Cell Biology (8th Ed.). New York: W.H. Freeman
- Gupta P.K. Cell and Molecular Biology 2018. 5th edition Rastogi Publication India.

Suggested online links:

- https://ocw.mit.edu/courses/biological-engineering/20-310j-molecular-cellular-and-tissue-biomechanics-spring- 2015/readings/MIT20_310JS15_Kamm2.2.pdf
- https://ocw.mit.edu/courses/find-bytopic/#cat=science&subcat=biology&spec=cellbiology
- https://onlinecourses.swayam2.ac.in/cec19_bt12/preview
- https://onlinecourses.nptel.ac.in/noc21_cy15/preview
- https://ocw.mit.edu/high-school/biology/exam-prep/cells/subcellular-organization/cytoskeleton/
- http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S001174BS/P001859/M030475/ET/1526877295P11_M14_ET.pdf
- https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=2rAs1Puvga4LW93zMe83aA==

Semester-III
Paper-II (Theory + Practical)
Course Title: Chemical science II

Course objective: Students would get basics of stereochemistry, isomerism, chemistry of organic compounds and that of various analgesics and other drugs.

Credits: 4+2		**Compulsory**
Max. Marks: 100+25 (Practical)		Min. Passing Marks:……
Total Number of Lectures = 60		
Units	**Content (Theory)**	**Number of Lectures**
1	• Basic stereochemistry: Geometrical isomerism, E, Z, nomenclature enantiomerism, distereoisomerism, D, L configuration, and absolute configuration (R, S nomenclature), conformational analysis, and IUPAC nomenclature. • Concepts of thermodynamics in chemical reaction.	**12**

2	• Reaction mechanism: type of organic reactions, reaction intermediates, S_{N1}, S_{N2}, E_1 and E_2 reactions, hemolytic and heterolytic fission, nucleophile, electrophiles, mechanism of Aldol condensation, Cannizaro reaction, Friedal craft reaction, Beckmann reagent, Dield-Alder reaction, Hoffmann-reaction, electrophilic substitution reactions, orientation effect.	**12**
3	• Aliphatic and aromatic organic compounds: general method of preparation, properties, chemical reaction and application of both aliphatic and aromatic hydrocarbon, aldehydes, ketones, alcohols, ether, thioether, amines, amids, anhydrides, and carboxylic acids, phenols, organic chemistry of Sulphur compounds, chloramin-t, saccharin etc	**12**
4	• Heterocyclic aromatic compounds: pyridine, pyrol, quinoline, isoquinoline structure properties synthesis and applications. • Basic concepts about bioactive natural product viz, alkaloids, terpenoids, steroids.	**12**
5	• Basic concept about analgesics, antipyretics, preparation and uses of asperin, paracetamol, sulphadrug viz sulphanilamide, sulphaquanidine and sulphapyridine.	**12**

Books Recommended:

- Lee, J.D., "Concise, Inorganic Chemistry", Oxford University Press, 2008, India, 5th edition.
- Puri, B.R., Sharma, L.R., and Kalia, K.C., "Principles of Inorganic Chemistry", Vishal Publishing Co., India, 2020, 33rd edition.
- Mukerji, S.M., "Reaction mechanism in Organic Chemistry", Laxmi Publications, 2007, 3rd edition.
- Singh, Jagdamba and Yadav, L.D.S., "Undergraduate Organic Chemistry" Pragati Prakashan, India, 2011, Vol 1.
- Loudon, G. Marc, "Organic Chemistry", Oxford University Press, 2008, 4th edition.
- Atkins P.W., "Atkin's Physical Chemistry: International", Oxford University Press, 2018, 11th edition.
- Ball D.W., "Physical Chemistry", Cengage India Private Limited, 2017, 2nd edition.
- Puri, B.R., Pathania, M.S. and Sharma, L.R., "Principles of Physical Chemistry", Vishal Publishing, India, 2020, 47th edition.
- Madan, R.L., "Chemistry for Degree Students, B. Sc. First Year", S. Chand Publishing, New Delhi, India, 2011, 3rd edition.
- Madan, R.D., Malik, U.M. and Tuli, G.D., "Selected topics in Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2010.
- Chandra, S., "Comprehensive Inorganic Chemistry" New Age International Publishers, India, 2018, 1st edition.
- Prakash, S., Tuli, G.D., Basu, S.K. and Madan, R.D., "Advanced Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2000, Vol 1.
- Finar, I.L., "Organic Chemistry", Pearson Education India, 2002, 6th edition.

- Eliel, E.L. and Wilen, S.H., "Stereochemistry of Organic Compounds", Willey, 1994,1st edition.
- Boyd, Morrison and Bhattacharjee, "Organic Chemistry", Pearson Education India, 2010, 7th edition.

Suggested online links:

- https://onlinecourses.nptel.ac.in/noc19_cy25/preview
- https://onlinecourses.swayam2.ac.in/nce19_sc15/preview
- https://nptel.ac.in/content/storage2/courses/104103022/download/module6.pdf
- https://www.openlearning.com/courses/introduction-to-physical-chemistry/?cl=1
- https://www.careers360.com/university/indian-institute-of-technology-bombay/chemistry-of-main-group-elements-certification-course
- https://onlinecourses.swayam2.ac.in/cec20_lb01/preview
- https://nptel.ac.in/courses/104/103/104103071/

Semester-III
Paper-II (Practical)
Course Title: **Chemical science II**

Total Number of Hrs = 60		
Units	**Content (Theory)**	**Number of Hrs**
1	Preparation of organic compound, Nitration, Bromination, Acetylation etc.	**15**
2	Preparation of Inorganic compound.	**15**
3	Paper, Thin layer and column chromatography of sugars, Amino acid, phenols etc.	**15**
4	Qualitative analysis of inorganic mixture containing not more than six ionic species. (excluding insoluble substances)	**15**

Semester-III
Paper-III (Theory + Practical)
Course Title: FUNDAMENTAL BIOCHEMISTRY

Course objective: Theoretical and practical knowledge of various topics, including, macromolecules, enzymes, hormones, vitamins and metabolic pathways.

Credits: 4+2		**Compulsory**
Max. Marks: 100+25 (Practical)		Min. Passing Marks:……
Total Number of Lectures = 60		
Units	**Content (Theory)**	**Number of Lectures**
1	• Bio molecules-Their functions and biological significance • Thermodynamics of biochemical reactions, Energy rich biomolecules (ATP, NADP & Other phosphorylated compounds). • Carbohydrates: chemical structure, classification & properties, Importance in biological systems. Amino acids & peptides – classification, properties & structure; primary, secondary, tertiary & Quaternary structure of proteins. • Lipids: Structure, classification, properties & functions.	**15**
2	• Enzymes: classification, characteristics, factors affecting enzyme activity. Enzyme kinetics, Km, Enzyme inhibition. Coenzymes, isoenzymes & multienzyme complexes Apoenzyme, Allosteric enzymes.	**8**
3	• Nucleic acids: Base composition, nucleosides, nucleotides & polynucleotide structure. Forms and types of nucleic acids, Primary and secondary structure of nucleic acids	**7**
4	• Hormones: Structure, chemical classification, Mode of action at molecular level, functions in brief & regulation. • Vitamins: Structure & Functions.	**7**
5	• Coordinated control of Metabolism: Glycolysis, citric acid cycle, pentose phosphate pathway, Glycogen breakdown & synthesis, control of glycogen metabolism, Electron transport & Oxidative phosphorylation, Fatty acid oxidation & Fatty acid biosynthesis, Nitrogen fixation in plants & microorganisms, inborn errors of metabolism, glucogenic & Ketogenic amino acids, Urea cycle, Catabolism of Purine & pyrimidine nucleotides.	**15**
6	• Cell-cell interaction; cell adhesion to matrix, cell locomotion (muscle contraction, cell beading). • Membrane trans post	**8**

Books Recommended:

- Nelson DL. Cox MM. (2017) Lehninger Principles of Biochemistry (7th ed.). W H Freeman

New York.
- Voet, D., & Voet, J. G. (2016). Biochemistry (5th ed.). Hoboken, NJ: J. Wiley & Sons.
- Rodwell VW. Bender D. Botham KM. Kennelly PJ Weil PA.(2018). Harper's Illustrated Biochemistry. (31st edition) McGraw-Hill Education
- Berg, JM Tymoczko, JL. Gatto, GJ., Stryer, L. (2015). Biochemistry. (8th ed.) W H Freeman and Company New York.
- Hofmann A. Clokie S. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology. (2018) (8th edition) Cambridge University Press
- Boyer RF. (2012) Biochemistry laboratory: modern theory and techniques (2nd Edition). Pearson Education, Inc
- Jain JL. Jain S. Jain N. (2005). Fundamentals of Biochemistry. (6th edition). S Chand and
- Company Ltd.
- Satyanarayana U. Chakrapani U. (2013). Biochemistry (4th edition). Elsevier and Books and Allied (P) Ltd

Suggested online links:

- https://ocw.mit.edu/courses/find-by-topic/#cat=healthandmedicine&subcat=spectroscopy
- https://nptel.ac.in/courses/104/105/104105076/
- https://nptel.ac.in/courses/102/106/102106087/
- https://ocw.mit.edu/courses/chemistry/5-07sc-biological-chemistry-i-fall-2013/module-i/session-4/
- https://www.youtube.com/channel/UCtiCUwgrWOPPz-qOu-QGRDg
- https://ocw.mit.edu/courses/biology/7-016-introductory-biology-fall-2018/lecturevideos/lecture-4-enzymes-and-metabolism/
- https://ocw.mit.edu/courses/chemistry/5-07sc-biological-chemistry-i-fall-2013/module-i/session-3/
- https://onlinecourses.swayam2.ac.in/cec20_bt12/preview

Semester-III
Paper-III (Practical)
Course Title: **FUNDAMENTAL BIOCHEMISTRY**

Total Number of Hrs = 60		
Units	**Content (Theory)**	**Number of Hrs**
1	Estimation of Carbohydrates	**8**
2	Estimation of Proteins	**8**
3	Separation of Amino acids by Paper Chromatography	**12**
4	Thin layer Chromatography	**8**
5	Gel Electrophoresis	**8**
6	Assay of enzyme activity and Enzyme kinetics	**8**
7	Saponification of Fats	**8**

Semester-IV
Paper-I (Theory + Practical)
Course Title: BASIC GENETIC ENGINEERING

- **Course Objectives:** Students will obtain knowledge of various topics as per the syllabus including hands on training on different rDNA techniques, Restriction digestion, gel-electrophoresis, plasmid isolation etc. They would also learn basic tools of bioinformatics.

Credits: 4+2		**Compulsory**
Max. Marks: 100+25 (Practical)		Min. Passing Marks:……
Total Number of Lectures = 60		
Units	**Content (Theory)**	**Number of Lectures**
1	• Scope & History of Genetic Engineering • Isolation & Purification of genomic & plasmid DNA from Bacteria, Plant & Animal cells. • Vectors: Nomenclature, properties, plasmids, cosmids, phages, yeast vector, plant & animal vectors, cassette vectors. • Restriction enzymes & other enzymes required in recombinant DNA technology.	**15**
2	• Introduction to techniques in Molecular Biology: Gene synthesis, cDNA synthesis & cloning, Gene sequencing (Maxma Gilbert method & Sanger's method), PCR (its forms & application). Northern, Southern & Western blotting. In situ hybridization, dot blots cDNA library construction & screening. • Genomic library construction & screening • Linkers, adaptors, Blunt end ligation, Homopolymer tailing	**15**
3	• Basic principle & introduction of antisense & ribozyme technology, post transcriptional gene silencing (RNAi technology), Gene therapy, Introduction to microarray technology	**10**
4	• Cloning & expression of foreign genes in Prokaryotes (E. coli) & Eukaryotes (*e.g.* yeast). Application of recombinant DNA technology.	**10**
5	Bioinformatics: History and scope, concepts of CD-ROM, e- mail, web sites, internet networking, database, collection & retrieval data of gene bank. Tools for sequence alignment (FASTA, BLAST, PSI-BLAST), primer designing, phylogenetic analysis, database searching for similar sequences.	**10**

Books Recommended:

- Brown, T. A. (2006). Gene Cloning and DNA Analysis: an Introduction. Oxford: Blackwell

Pub.
- Primrose, S. B., & Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics. Malden, MA: Blackwell Pub.
- Slater, A., Scott, N. W., & Fowler, M. R. (2003). Plant Biotechnology: The Genetic Manipulation of Plants. Oxford: Oxford University Press.
- Slater, A., Scott, N. W., & Fowler, M. R. (2008). Plant Biotechnology: an Introduction to Genetic Engineering. Oxford: Oxford University Press

Suggested online links:

- https://onlinecourses.nptel.ac.in/noc19_bt15/preview
- https://nptel.ac.in/courses/102/103/102103013/
- https://www.classcentral.com/course/swayam-genetic-engineering-theory-and-application-14090
- https://onlinecourses.swayam2.ac.in/cec19_bt02/preview
- https://ocw.mit.edu/courses/biology/7-01sc-fundamentals-of-biology-fall-2011/recombinant-dna/
- https://ocw.mit.edu/courses/biology/7-16-experimental-molecular-biology-biotechnology-ii-spring-2005/

Semester-IV
Paper-I (Practical)
Course Title: **BASIC GENETIC ENGINEERING**

Total Number of Hrs = 60		
Units	**Content (Theory)**	**Number of Hrs**
1	Isolation of Plasmid DNA	**20**
2	Restriction digestion with EcoRI' HindIII or any other restriction enzyme available	**20**
3	Agarose gel electrophoresis of Restricted and Unrestricted DNA fragments.	**20**

Semester-IV
Paper-II (Theory + Practical)
Course Title: FUNDAMENTAL OF COMPUTERS

Course Objective: Students will learn fundamentals of computers: languages, networking, general use software, operating systems etc. They would also get an idea of internet and its application particularly in biological research.

Credits: 4+2		**Compulsory**
Max. Marks: 100+25 (Practical)		Min. Passing Marks:……
Total Number of Lectures = 60		
Units	**Content (Theory)**	**Number of Lectures**
1	• History of development of computers, Generation of computers, Basic components of a computer, Input & Output devices, Classification of computers. • Concept of computer languages- Introduction to basic, FORTRAN, C & C^{++}	**20**
2	• Computer Networking: Concepts, various configurations of a computer Network. • Basic concepts of LAN, WAN & MAN	**10**
3	• Microsoft office: MS-Word MS-Excel MS-Power Point MS-Acces	**10**
4	• Computer software- Operating system • Introduction to DOS and Windows • Introduction to scandisk, Defragmentation and Antivirus software. • Prevention & & cure of computer viruses and worms.	**10**
5	• Binary representation of data • Algorithm and flow charts • Internet & its applications.	**10**

Books Recommended:

- Yashwant Kanitkar; Let us C: BPB publications 2017
- Hayes, J. P. Computer architecture and Organization; 3rd Edition MGH
- Goyal A. Computer Fundamentals; Pearson

Suggested online links:

- https://onlinecourses.swayam2.ac.in/cec21_cs04/preview

- https://nptel.ac.in/courses/106/104/106104128/
- https://nptel.ac.in/courses/106/105/106105214/
- https://nptel.ac.in/courses/106/105/106105163/
- https://nptel.ac.in/content/storage2/courses/106106156/Assignment-1.pdf

Semester-IV Paper-II (Practical)

Course Title: **FUNDAMENTAL OF COMPUTERS**

Total Number of Hrs = 60		
Units	**Content (Theory)**	**Number of Hrs**
1	Introduction to C^{++}	**20**
2	Introduction to Array	**10**
3	For loop and while loop	**10**
4	IF Statement	**10**
5	Basic, Networking.	**10**

Semester-IV
Paper-III (Theory)
Course Title: ELEMENTARY PHYSICS FOR BIOLOGISTS

Course Objective: Biophysics, biochemistry and many other disciplines of biotechnology use various equipment that work on different principles of physics. This course introduces the students to various domains of physics including, mechanics, heat and thermodynamics, electricity, optics and radioactivity etc.

Credits: 6	**Compulsory**	
Max. Marks: 100	Min. Passing Marks:……	
Total Number of Lectures = 90		
Units	**Content (Theory)**	**Number of Lectures**

1	Basic conservation laws of mechanics, Momentum, Angular momentum, Torque, central force Inertial and non-initial frames of references, Fictitious force, Galilean and Lorentz transformations, Work and Energy conservation of energy. Rotation of Rigid bodies, Moments of inertia of various bodies, Surface tension, viscosity, elasticity,	**15**
2	Temperature and heat, heat capacity and specific heat, heat capacity of ideal gases, conductivity of heat. Zeroth, First and second laws of thermodynamics, entropy and heat engine, Brief ideal of thermodynamic relationships.	**15**
3	Coulomb's law, Gauss's law of electrostatics and its application magnetic field: Dia Para and Ferromagnetism, Faraday's law of induction, self and mutual inductance's, Brief idea of A.C. circuit, power factor, impedance and power dissipation etc.	**15**
4	Elementary ideas about interference, Diffraction of light, transmission diffraction and polarization and its different forms, Brewster's and Malus law, Polaroids and retardation plates, Optical activity.	**15**
5	Photoelectric effect, Compton scattering and pair production, X-rays, their production and uses, Wave particle duality, de Broglie waves, Bohr atomic modal, laser, solar cell and micro-waves, Uncertainty principle and its application. Radioactivity, Decay law, half-life, average life of radioactive material, Alpha, beta and gamma decay	**15**
6	Galvanometer, ammeter, voltmeter, pH meter, Lux meter, Spectrometer, LCR meter.	**15**

Books Recommended:

- Halliday, D. Resnick R. et al, Funadamentals of Physics; John Wiley and sons, NIC
- Zemansky M.M., Dittman et al. Heat and Thermodynamics; Mc Graw Hills 8th Ed.
- Subrahmaniyam N. & et Al.; A Text Book Of Optics; Schand; 23rd Rev. Edn. 2006 edition
- C. L. Arora (1999); Heat and Thermodynamics; S. Chand Limited
- S R Manohara & Shubha A (2018); Electricity, Magnetism and Electromagnetic Theory; S. Chand Publishing

Suggested online links:

- https://nptel.ac.in/courses/115/106/115106122/
- https://onlinecourses.nptel.ac.in/noc20_ph08/preview
- https://nptel.ac.in/courses/112/108/112108148/
- https://nptel.ac.in/courses/112/105/112105220/
- https://nptel.ac.in/noc/courses/noc18/SEM2/noc18-ph09/
- https://onlinecourses.swayam2.ac.in/nce19_sc08/preview
- https://onlinecourses.swayam2.ac.in/nce19_sc07/preview
- https://onlinecourses.nptel.ac.in/noc20_ce27/preview

Year	Semester	Course Code	Paper Title	Theory/Practical	Credits
DEGREE IN BACHELOR OF SCIENCE (Biotechnology)					
3	V	UBT13-(T/P)	Basics of Immunology	Theory + Practical	4+2
		UBT14-T	Introductory Animal Biotechnology	Theory	6
		UBT15-T	Environmental Biotechnology	Theory	6
		UBT16-(T/P)	Biology of Animals	Theory + Practical	4+2
	VI	UBT17-(T/P)	Introductory Plant Biotechnology	Theory + Practical	4+2
		UBT18-(T/P)	Bio Analytical Techniques	Theory + Practical	4+2
		UBT19-T	Microbial Genetics	Theory	6
		UBT20-T	Medical Biotechnology	Theory	6
				Total	48

Semester-V
Paper-I (Theory + Practical)
Course Title: BIOLOGY OF ANIMALS

Course Objective: This course will introduce students to Classification and nomenclature of animals, evolution, adaptation and animal physiology etc. This would help them in applying biotechnological principles to animal model systems.

Credits: 4+2		**Compulsory**
Max. Marks: 100+25 (Practical)		Min. Passing Marks:……
Total Number of Lectures = 60		
Units	**Content (Theory)**	**Number of Lectures**
1	• Basic concept of classification for the five kingdom approach, Linnaean hierarchy. • Principles of nomenclature, International code of zoological nomenclature. • Outline classification of Non-chordates and chordates including general characters and examples of major living groups.	**12**

2	• Organic evolution- Evidences. • Theory of evolution- Lamarckism & Neo- Lamarckism; Darwinism & Neo-Darwinism; Modern synthetic theory of evolution. • Population genetics- Hardy-Weinberg law.	**12**
3	• Digestion: Digestion & absorption of carbohydrates, proteins and lipids, role of enzymes and hormones, Respiratory pigments. • Respiration:, Respiratory pigments, Transport of oxygen and carbon dioxide; Control of breathing. • Circulation: Composition and function of blood & lymph, Heart beat & cardiac cycle. • Structure of muscles and mechanism of muscle contraction.	**12**
4	• Nervous system: CNS, PNS, Autonammic system, nerve impulse. • Excretion: Composition of Urine & its formation in mammals • Endocrines: A brief idea of structure and functions of Hypothalamus, Pituitary, Thyroid, Parathyroid, Adrenal, Pancreas, Testis & ovary.	**12**
5	• Aquatic adaptations of fish- Morphological, Anatomical and physiological. A brief idea of fish culture. • Outline of Sericulture, Apiculture & insects pest management.	**12**

Books Recommended:

- Shipley, A. E., & MacBride, E. W. (2014). *Zoology: An elementary text-book*. Cambridge, England: Cambridge University Press.
- Miller, S. A., Harley, J. P., & Molles, M. C. (2012). *Zoology* (9th ed.). Maidenhead, England: McGraw Hill Higher Education.
- Hill, R., Wyse, G. A., & Anderson, M. (2016). *Animal Physiology* (4th ed.). Sunderland, MA: Sinauer Associates.
- R. Jurd; Instant Notes Animal Biology; Bios Scientific Publishers

Suggested online links:

- https://nptel.ac.in/courses/102/104/102104058/
- https://www.digimat.in/nptel/courses/medical/anatomy/AN11.html
- https://nptel.ac.in/courses/102/104/102104042/
- https://ocw.mit.edu/courses/biology/7-016-introductory-biology-fall-2018
- https://www.digimat.in/nptel/courses/medical/anatomy/AN11.html
- https://onlinecourses.swayam2.ac.in/cec20_bt19/preview
- https://onlinecourses.nptel.ac.in/noc21_bt46/preview
- https://ocw.mit.edu/courses/brain-and-cognitive-sciences/9-04-sensory-systems-fall-2013

Semester-V
Paper-I (Practical)
Course Title: **BIOLOGY OF ANIMALS**

Total Number of Hrs = 60		
Units	**Content (Theory)**	**Number of Hrs**
1	Dissection of cranial nerves of scoliodon.	**15**
2	Dissection of nervous system of prawn.	**15**
3	Study of museum specimens; slides of chordates and non-chordates.	**15**
4	Dehydration procedure.	**15**

Semester-V
Paper-II (Theory + Practical)
Course Title: BASICS OF IMMUNOLOGY

Course Objective: Students will learn various organs, cells and responses of Immune system. They would also learn responses generated by Lymphocytes, Antigen-Antibody interactions, various immunological techniques and immune disorders.

Credits: 4+2	**Compulsory**	
Max. Marks: 100+25 (Practical)	Min. Passing Marks:……	
Total Number of Lectures = 60		
Units	**Content (Theory)**	**Number of Lectures**
1	• Generation of Immune system organs and cells • Body defense mechanisms against infection- Innate & acquired.	**12**
2	• Body defence mechanisms against infection- Innate & acquired. • Active & Passive immunity, primary & secondary Immune response.	**12**
3	• Important attributes of antigens epitops, heptans & Carriers, Antibody structure, Immunoglobulin classes & antibody diversity.	**12**
4	• Antigen & Antibody interaction in vivo & vitro. Agglutination & Precipitation reaction, Hemoagglutination, Immunofluorescence, ELISA, RIA etc.	**12**

5	• General idea about MHC in mouse, HLA system in humans, significance of MHC molecules & basic idea of complement system. • Monoclonal antibodies & their applications. • Immune disorders- Autoimmune diseases (Rheumatoid arthritis, Hashimoto's thyroiditis, & immunodeficiency (AIDS & SCID).	**12**

Books Recommended:

- Paul W E. (2012). Fundamental Immunology. New York: Raven Press.
- Punt J, Stranford S, Jones P., Owen JA, (2018). Kuby Immunology.(8th edition) New York: W.H. Freeman.
- Hay FC, Westwood OMR.(2008). Practical Immunology.(4th Edition). Wiley
- Delves P J, Martin SJ, Burton DR, and Roitt IM. (2017). Roitt's Essential Immunology.(13th edition). Wiley- Blackwell.
- Murphy K, and Weaver C, (2016). Janeway's Immunobiology. (9th edition) New York: Garland Science.
- Abbas AK, Lichtman AHH, Pillai S (2017) Cellular and Molecular Immunology (9th edition)
- Mohanty SK, Leela KS (2014) Textbook of Immunology. (2nd Edition). Jaypee Brothers Medical Publishers Pvt Ltd.
- Paul W E. (2012). Fundamental Immunology. New York: Raven Press.
- Parham, P. (2005). The Immune System. New York: Garland Science. Blackwell.

Suggested online links:

- https://onlinecourses.swayam2.ac.in/cec20_bt05/preview
- https://www.classcentral.com/course/swayam-immunology-14117
- http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000035ZO/P001308/M020592/ET/1519021131M14DiversityofimmunoglobulinQuad1.pdf
- https://ocw.mit.edu/courses/find-by-topic/#cat=healthandmedicine&subcat=immunology
- https://nptel.ac.in/courses/102/103/102103038/
- http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000035ZO/P001308/M020597/ET/1498640388PrinciplesandapplicationsSPRQuad1.pdf
- https://nptel.ac.in/courses/102/105/102105083/ https://nptel.ac.in/courses/102/103/102103015/
- https://nptel.ac.in/content/storage2/courses/102103013/pdf/mod7.pdf

Semester-V
Paper-II (Practical)
Course Title: **BASICS OF IMMUNOLOGY**

Total Number of Hrs = 60		
Units	**Content (Theory)**	**Number of Hrs**
1	Demonstration of immunization techniques and bleeding of experimental animals.	**15**
2	Separation of serum.	**15**

3	Antibody and Antigen interaction- Agglutination, Precipitation, Ochterlony double diffusion	**15**
4	ELISA	**15**

Semester-V Paper-III (Theory)

Course Title: INTRODUCTORY ANIMAL BIOTECHNOLOGY

Course Objective: Students will learn theoretical and practical aspects of animal cell culture & its applications, vaccine technology, immunodiagnostics, embryo technology, animal transgenesis and gene therapy etc.

Credits: 6	**Compulsory**	
Max. Marks: 100	Min. Passing Marks:……	
Total Number of Lectures = 90		
Units	**Content (Theory)**	**Number of Lectures**
1	**Animal Cell Culture:** • History and development of cell culture • Layout and basic requirements for cell culture laboratory • Sterilization and preparation for cell culture • Culture media – Natural and synthetic; Importance of serum in cell culture • Growth factors- EGF, ECF, PDGE, IL –2, NGF & erythropoietin	**18**
2	**Application of Animal Cell Culture:** • Types of animal cell culture • Concept of transformation and neoplastic cells • Development of primary culture (chicken embryo fibroblast) • Commonly used cell lines- their organization and characteristics (Vero, BHK-21, MDBK, HeLa etc.) • Subculture and cryopreservation • Application of animal cell culture technology	**18**
3	**Immunodiagnostics and Vaccine Technology** • Introduction to immunodiagnostics • Monoclonal antibodies • Introduction to vaccines • Types of vaccines • Killed V/s Attenuated vaccines • Modern generation vaccines	**18**

4	**Embryo Biotechnology and Animal Cloning** • Embryo Biotechnology: Introduction to embryo transfer technology • Brief Introduction to developmental Biology: oocyte, sperm, fertilization, embryogenesis • Methodology: Selection of donor; superovulation; selection of recipient; synchronization of estrous; embryo transfer; cryopreservation • Animal Cloning: Introduction to animal cloning • Importance and scope of animal cloning	**18**
5	**Fermentation Technology and Animal Transgenesis** • Introduction to fermentation Technology • Bioreactors for large scale production of animal cells • Production of hormones and special secondary metabolites- insulin, growth hormone and interferon • A brief introduction to animal transgenesis. • Various methods of animal transgenesis. • Gene Therapy: Introduction; Types of gene therapy, Applications. Socio ethical issues	**18**

Books Recommended:

- Animal Cell Culture Techniques. Ed. Martin Clynes, springer.
- Animal Cell Culture - Practical Approach, Ed. John R.W. Masters, OXFORD.
- Culturing of animal cells by Ian Freshney, 6th edition
- Pörtner, R. (2007). Animal Cell Biotechnology: Methods and Protocols. Totowa, NJ: Humana Press
- Singh B. Gautam SK (2013). Textbook of animal biotechnology. The Energy and Resources Institute, TERI
- Gupta PK (2018) Animal Biotechnology. Rastogi Publications
- Animal Cell Culture Methods In: Methods in Cell Biology, Vol. 57, Ed. Jenni P Mather and David Barnes, Academic Press.
- Biotechnology: Expanding Horizons by BD Singh, 3rd Edition, Kalyani Publishers.

Suggested online links:

- https://www.nptel.ac.in/content/storage2/courses/102103012/pdf/mod6.pdf
- https://nptel.ac.in/courses/102/104/102104042/
- https://nptel.ac.in/content/storage2/courses/102103038/download/module2.pdf
- https://www.nptel.ac.in/noc/courses/noc20/SEM1/noc20-me04/
- https://ocw.mit.edu/courses/find-by-topic/#cat=science&subcat=biology&spec=stemcells
- https://ocw.mit.edu/courses/materials-science-and-engineering/3-051j-materials-forbiomedical-
- applications-spring-2006/lecture-notes/lecture13.pdf
- https://ocw.mit.edu/courses/biological-engineering/20-109-laboratory-fundamentals-inbiological-engineering-fall-2007/lecture-notes/
- https://ocw.mit.edu/courses/health-sciences-and-technology/hst-535-principles-andpractice-of-tissue-engineering-fall-2004/

Semester-V
Paper-IV (Theory)
Course Title: ENVIRONMENTAL BIOTECHNOLOGY

Course objective: Theoretical knowledge of various topics as per the syllabus including ecosystem, conservation of biodiversity and resources, conventional and alternative fuels, and waste management. They will also study of role of biotechnological techniques in environment protection.

Credits: 6	**Compulsory**	
Max. Marks: 100	Min. Passing Marks:……	
Total Number of Lectures = 90		
Units	**Content (Theory)**	**Number of Lectures**
1	• Basic concept of Ecosystem- types, structure and functions. • Renewable and non- renewable resources • Conservation of Biodiversity, in situ, ex situ, Gene bank. • An idea of biosensors, biopolymers, bio plastic and biochips.	**18**
2	• Wastewater management- Treatment of municipal waste and industrial effluents. • Solid waste and soil pollution management- Management of non-hazardous solid waste and medical solid waste. • Management of hazardous waste • Air pollution and its control • Reclamation of wasteland	**18**
3	• Conventional fuels (Firewood, coal, gas, animal oils) and their environmental impact. • Modern fuels- Methanogenic bacteria & biogas, microbial hydrogen production, solar energy. • Plant based petroleum industry • Biopesticides- Bacterial & Fungal • Biofertilizers- Nitrogen fixers, PSB, Mycorrhiza & VAM; vermicomposting.	**18**
4	• Bioabsorption of metals- microorganisms and metal absorption; bacterial metal resistance; mechanism of bioabsorption; Phytoremediation • Bioremediation- microorganisms in bioremediation; bioremediation technologies. • Biorecovery of petroleum- MEOR	**18**

5	• Concept of biosafety in relation to: • Organism pathogenicity • Biological active biotechnology product • Release of GMOs to the environment • Genetic modification and food uses • Biosafety and recombinant DNA guidelines • Concept of GMP(Good manufacturing practices) & GLP (Good Laboratory practices)	**18**

Books Recommended:

- Ritmann R and McCarty P L (2000). Environmental Biotechnology: Principle & Applications. 2nd Ed., McGraw Hill Science.
- Thakur IS. (2011) Environmental Biotechnology basic concepts and applications. I.K. International Publishing House Pvt. Limited
- Srinivas TR (2008). Environmental Biotechnology. New Age International Pvt. Ltd.
- Evans GM and J. C. Furlong (2003). Environmental Biotechnology: Theory and Applications. Wiley Publishers.
- Scragg A., (2005) Environmental Biotechnology. Pearson Education Limited.
- Chapman JL Ecology: Principal & Application. Cambridge Univ. Press.
- Odum E and Barret G. (2004) Fundamentals of Ecology. Nataraj Publication.

Suggested online links:

- https://nptel.ac.in/courses/127/106/127106004/
- https://nptel.ac.in/courses/102/105/102105088/
- https://onlinecourses.swayam2.ac.in/ugc19_bt18/preview
- https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-34-waste-containmentand-remediation-technology-spring-2004/lecture-notes/
- https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-018j-ecology-i-theearth-system-fall-2009/
- https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-018j-ecology-i-theearth-system-fall-2009/lecture-notes/MIT1_018JF09_Lec07.pdf
- https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-89-environmentalmicrobiology-fall-2004/

Semester-VI
Paper-I (Theory + Practical)
Course Title: INTRODUCTORY PLANT BIOTECHNOLOGY

Course objective: The course introduces students to basics of plant biotechnology: Media preparation and sterilization, cryopreservation, growth hormones, in-vitro micropropagation of plant tissue, anther, pollens etc. Marker assisted selection, genetic fidelity markers, plant transgenesis etc would also be taught.

Credits: 4+2	**Compulsory**
Max. Marks: 100+25 (Practical)	Min. Passing Marks:……

Total Number of Lectures = 60		
Units	**Content (Theory)**	**Number of Lectures**
1	• Introduction and history of plant tissue culture • Applications • Selection & sterilization of explant • Media used for sterlization & culture • Growth regulators	**12**
2	• Cytopreservation • Synthetic seeds and its application • Micropropogation • Somatic Embryogenesis & organogenesis • Protoplast culture & fusion	**12**
3	• Anther and Ovary culture • Di haploids and their applications • In Vitro pollination & fertilization • Their applications in plant breeding	**12**
4	• DNA Markers • Types of markers • Applications of DNA markers in plant science • Diversity analysis, mapping and tagging, evolutionary studies and marker assisted selection.	**12**
5	• Plant transformation & methods: Agrobacterium-mediated, biolistic, transfection etc. successful examples of transgenic plants, advantage of transgenic plants. • Recent developments in transformation methods.	**12**

Recommended Books:

- Razdan, M. K. (2003). Introduction to Plant Tissue Culture. Enfield, NH: Science
- Chawla, H. S. (2000). Introduction to Plant Biotechnology. Enfield, NH: Science.
- Smith R. (2012). Plant Tissue Culture (3rd Edition) Academic Press.
- Slater, A., Scott, N. W., & Fowler, M. R. (2008). Plant Biotechnology: an Introduction to Genetic Engineering. Oxford: Oxford University Press.

Suggested online links:

- https://nptel.ac.in/courses/102/103/102103016/
- https://www.bhu.ac.in/science/biotechnology/syllabi/M.Sc%20(BioTechnology)%20including%20SWAYAM.pdf
- https://onlinecourses.swayam2.ac.in/cec19_bt01/preview
- https://onlinecourses.swayam2.ac.in/cec21_bt02/preview
- https://onlinecourses.swayam2.ac.in/cec21_bt03/preview
- https://nptel.ac.in/content/storage2/courses/102103013/pdf/mod6.pdf

Semester-VI
Paper-I (Practical)
Course Title: **INTRODUCTORY PLANT BIOTECHNOLOGY**

Total Number of Hrs = 60		
Units	**Content (Theory)**	**Number of Hrs**
1	Plant tissue culture, Media preparation	**10**
2	Ex plant selection and sterilization	**10**
3	Callus culture	**10**
4	Callus splitting and Regeneration	**10**
5	Rooting and Shooting of callus using Auxins and Cytokinins	**10**
6	Hardening of the tissue culture generated plantlets	**10**

Semester-VI
Paper-II (Theory + Practical)
Course Title: Bio-analytical Techniques

Course objective: Students will learn principle and applications of Microscopy, chromatography, centrifugation, electrophoresis, blotting techniques, spectroscopy and autoradiography etc

Credits: 4+2	**Compulsory**
Max. Marks: 100+25 (Practical)	-Min. Passing Marks:……

Total Number of Lectures = 60

Units	**Content (Theory)**	**Number of Lectures**
1	• Balances (Electrical & Electronics) • Microscopy- (Compound, Phase contrast, Electron- TEM & SEM), Fluorescence microscopy • pH meter	**12**
2	• Chromatography: Paper chromatography, Thin layer chromatography, Column chromatography, Gas chromatography	**12**
3	• Colorimetry and Spectrophotometry (UV-VIS): Lambert Beer's law, Concept of IR, NMR and mass spectrometry, Radio-immune assay; ELISA; Western blotting	**12**
4	• Centrifugation: Zonal, Density gradient, Differential centrifugation; Tracer techniques & Autoradiography	**12**
5	• Electrophoresis: PAGE, Agarose gel Electrophoresis • Autoclave**,** Laminar air flow	**12**

Books Recommended:

- Berg, JM Tymoczko, JL. Gatto, GJ., Stryer, L. (2015). **Biochemistry.** (8th ed.) W H Freeman and Company New York.
- Nelson DL. Cox MM. (2017) **Lehninger Principles of Biochemistry** (7th ed.). W H Freeman New York.
- Voet, D., & Voet, J. G. (2016). **Biochemistry** (5th ed.). Hoboken, NJ: J. Wiley & Sons.
- Rodwell VW. Bender D. Botham KM. Kennelly PJ Weil PA.(2018). **Harper's Illustrated Biochemistry**.(31st edition) McGraw-Hill Education
- Hofmann A. Clokie S. **Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology**. (2018) (8th edition) Cambridge University Press
- Boyer RF. (2012) **Biochemistry laboratory : modern theory and techniques**(2nd Edition). Pearson Education, Inc

Suggested online links:

- https://ocw.mit.edu/courses/find-by-topic/#cat=healthandmedicine&subcat=spectroscopy
- https://nptel.ac.in/content/storage2/courses/102103044/pdf/mod5.pdf
- https://nptel.ac.in/courses/102/103/102103044/
- https://nptel.ac.in/content/storage2/courses/103105060/Sde_pdf/Module-7.pdf

- https://nptel.ac.in/content/storage2/courses/102103047/PDF/mod3.pdf
- https://nptel.ac.in/courses/102/101/102101049/
- https://nptel.ac.in/content/storage2/courses/104103069/module6/lec1/1.html

Semester-VI
Paper-II (Practical)
Course Title: **Bio Analytical Techniques**

Total Number of Hrs = 60		
Units	**Content (Theory)**	**Number of Hrs**
1	Gravimetric estimation of barium, zinc, iron, copper, sulphate and Chromium	**30**
2	Organic Mixture: Separation of two component organic mixtures (water soluble), systemic analysis of each component.	**30**

Semester-VI
Paper-III (Theory)
Course Title: Microbial Genetics

Course objective: In this course students will get introduced to prokaryotic genome organization, genetic exchange and its mechanisms, gene mapping, gene regulation in prokaryotes and bacteriophage genetics etc.

Credits: 6	**Compulsory**
Max. Marks: 100	Min. Passing Marks:……

Total Number of Lectures = 90		
Units	**Content (Theory)**	**Number of Lectures**
1	**Prokaryotic Genomes** Physical organization of bacterial genomes (Structure of the bacterial nucleoid, Replication and partitioning of the bacterial genome and Genome of Archaea).	**15**
2	**Mechanism of genetic exchange** : Plasmid and bacterial sex, Types of plasmids (F Plasmid: a Conjugate plasmid', Mobilization of Non-conjugative plasmid, R plasmid, Col plasmid Copy number and incompatibility), Episomes. Transposable elements (Insertion sequence and transposons,	**15**
3	**Integrons and Antibiotic** Resistance cassettes, Multiple Antibiotic Resistant bacteria, Mu–virus); Bacterial Genetics (Mutant phenotype, DNA mediated Transformation; Conjugation (Cointegrate Formation and Hfr Cells, Time–of–Entry Mapping, F' Plasmid); Transduction (Generalized transduction, Specialized Transduction)- gene mapping	**15**

4	**Molecular Mechanism of gene regulation in prokaryotes** Transcriptional regulation in prokaryotes (inducible and repressible system, positive regulation and negative regulation); Operon concept – lac, trp, Ara operons.	**15**
5	**Bacteriophages:** Stages in the Lytic Life Cycle of a typical phage, Properties of a phage infected bacterial culture, Specificity in phage infection, E. coli PhageT4, *E. coli* Phage T7, *E. coli* phage lambda, Immunity to infection, Prophage integration, Induction of prophage, Induction & Prophage excision, Repressor, Structure of the operator and binding of the repressor and the Cro product, Decision between the lytic and lysogenic Cycles, Transducing phages, *E. coli* phage phiX174, filamentous DNA phages, Single stranded RNA phages, The lysogenic Cycle.	**15**
6	**Bacteriophage Genetics** Benzer's fine structure of gene in bacteriophage T4: Plaque Formation and Phage Mutants, Genetic recombination in the lytic cycle, (concept of recon, muton, cistron).	**15**

Books Recommended:

- Cronan J. and Freifelder D., Microbial Genetics; Second Edition
- Khalifa AE; Fundamentals of Microbial Genetics; Lamber Academic Pub.
- Sundara R.S. Microbial Genetics; Amol Publications Pvt Ltd
- Modern Microbial Genetics, Second Edition; Editor(s): Uldis N. Streips, Ronald E. Yasbin; Wiley-Liss, Inc.

Suggested online links:

- https://nptel.ac.in/content/storage2/courses/102103013/pdf/mod7.pdf
- https://nptel.ac.in/content/storage2/courses/102103013/module1/lec1/5.html
- https://ocw.mit.edu/courses/biology/7-03-genetics-fall-2004/lecture-notes/
- https://nptel.ac.in/content/storage2/courses/102103013/pdf/mod1.pdf

Semester-VI
Paper-IV (Theory)
Course Title: Medical Biotechnology

Course objective: The course will help the students to develop understanding in the field of medical biotechnology. They will be taught basics and applications of gene therapy, gene delivery methods, xenotransplantation and drug-delivery etc.

Credits: 6	**Compulsory**
Max. Marks: 100	Min. Passing Marks:……
Total Number of Hrs = 90	

Units	Content (Theory)	Number of Lectures
1	**Gene therapy** Background, types of gene therapy (ex vivo & in vivo), choosing targets for gene therapy, vectors in gene therapy, retroviruses, adenoviruses, adeno-associated viruses, types of gene delivery, Weismann barrier (soma-to-germ line barrier), epigenetic inheritance, problems & ethics.	**20**
2	**Gene Delivery methods** Viral delivery (through Retroviral vectors, through Adenoviral vectors), Non-viral delivery, Antibody engineering	**15**
3	**Vaccines** & **Synthetic therapy** Vaccine vectors, nucleic acid vaccines, immune-enhancing technology. Synthetic DNAs, therapeutic Ribozymes, synthetic drugs.	**20**
4	**Xenotransplantation** Terminology, technology behind it, organ donors, social & ethical issues.	**15**
5	**Cell Adhesion-based therapy** and **Drug delivery** Integrin's, inflammation, cancer & metastasis. Conventional & new approaches to drug delivery.	**20**

Books Recommended:

- Blick BR, Delovitch TL et al. Medical Biotechnology (2ndEdition). ASM Press
- Nallari P., Rao V. Medical Biotechnology. Oxford Higher Education
- Glick BR & Patten CL (Ed); Medical Biotechnology: Principles and Applications of Recombinant DNA; ASM Press

Suggested online links:

- http://www.ocw.titech.ac.jp/index.php?module=General&action=T0300&GakubuCD=2&GakkaCD=321503&KeiCD=15&course=3&KougiCD=202103160&Nendo=2021&lang=EN&vid=03
- https://ocw.mit.edu/courses/find-by-topic/#cat=healthandmedicine
- https://ocw.mit.edu/courses/biology/7-349-stem-cells-a-cure-or-disease-spring-2011/
- https://ocw.mit.edu/courses/health-sciences-and-technology/hst-151-principles-of-pharmacology-spring-2005/
- https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-bt24/

Elective Courses For B.Sc. Biotechnology

Course Title: Evolution & Introduction to Developmental Biology

Maximum Marks: 100

Credits: 6

Course objective: Students will learn concepts of classical and modern theories of evolution, Paleontology, developmental biology, molecular embryology, metamorphosis and organogenesis etc.

Unit	Topic	No. of Lectures
I	• Historical development of the concept of evolution. • Theories of organic evolution: Lamarckism (Neo-Lamarckism); Darwinism (Neo- Darwinism); Modern synthetic theory. • Evidence in favor of evolution: Comparative anatomy, Comparative Embryology, Paleontology, Biochemistry & Genetics	20
II	• Paleontology: Fossils & fossilization. Dating of fossils. Significance of fossil record. • Geological distribution of animals, period of evolution and extinction of major groups Evolution of Horse	15
III	• Basic concepts in developmental biology. • Modern concept of embryology on the basis of molecular analysis. Gametogenesis: Events in spermatogenesis. Morphology of mature mammalian spermatozoon. Events in Oogenesis. • Fertilization: Steps in fertilization; Mechanism of fertilization; Molecular events. Elementary idea of parthenogenesis.	20
IV	• Types of eggs and cleavage. Role of yolk during cleavage. • Products of cleavage (Morula and Blastula). • Comparison of gastrulation in sea urchin, frog, chick and mammal up to the formation of three germ layers. • Fate of germ layers. Extra Embryonic Foetal Membrane (Chick).	15
V	• Elementary concept of primary organizer; Induction; nature and its mechanism of Action. Totipotency. Teratogenesis. • Different developmental stages in insect (Drosophila); Metamorphosis in Frog. Development of chick embryo up to 72 hours. • Organogenesis of vertebrate eye. Neurogenesis & Notogenesis	20

Recommended Books:

- Grant: Biology of Development System. Holt, Reinehart & Wilson, 1978.
- Gilbert, Developmental Biology. 3rd ed. Sinauer, 1991.
- Berril: Developmental Biology, McGraw-Hill. Indian ed. 1974.
- Instant Notes Developmental Biology R. M. Twyman 2003.
- Modern Text Book of Zoology Vertebrates. R. L. Kotpal 2009

Suggested online links:

- https://nptel.ac.in/courses/103/101/103101127/
- https://youtu.be/iccPlDk21D0
- https://nptel.ac.in/courses/102/106/102106084/
- https://onlinecourses.swayam2.ac.in/cec20_bt06/preview
- https://onlinecourses.nptel.ac.in/noc22_ee56/preview

Course Title: **Industrial and Environmental Biotechnology**		
Credits: 4+2		
Max. Marks 100+25 (Practical)		
Course objective: Students will learn Screening of metabolites, strain development procedure, Fermentation and bioreactor technology, production of industrially important primary and secondary metabolites. In environmental biotechnology they will build concepts in bioremediation, pollutants and their hazards, sewage treatment, bioleaching etc. They will also be introduced to IPR, bioethics and entrepreneurship etc.		
Unit	**Topic**	**No. of Lectures**
I	**Introduction of Industrial microbiology and Bioprocess technology:** • History-Introduction, scope and relation with other sciences. • Screening for new metabolites: primary and secondary products. • Strain development through selection, mutations and recombination, and other recent methods	7
II	**Bioprocess technology:** • Introduction to bioprocess technology. • Design and working of a typical bioreactor • Range of bioprocess technology and its chronological development. • Basic principle components of fermentation technology. Types of microbial culture and its growth kinetics– Batch, Fed-batch and Continuous culture.	9
III	**Production of alcohols, antibiotic and enzymes:** • Production of alcohols (Ethanol) and organic acids (citric and acetic). • Production of biologically active compounds: antibiotics (penicillin) and enzymes (amylase, protease). • Production of microbial food and single cell proteins • Bioreactor for immobilized cells/enzyme system • Biosensors and their applications	9
IV	**Environment and pollution:** • Physico-chemical and biological characteristics of environment. • Water, soil and air as a component of environment. • Pollutants: Nature, origin, source, monitoring and their impacts. • Air, Water and Noise pollution • Conventional fuels and their environmental impact	8

V	**Bioremediation:** • Bioremediation of soil & water contaminated with oil spills, heavy metals and detergents. • Degradation of lignin and cellulose using microbes. Phyto-remediation. • Degradation of pesticides and other toxic chemicals by micro-organisms- degradation aromatic and chlorinates hydrocarbons and petroleum products.	8
VI	**Sewage treatment and biofertilizers:** • Treatment of municipal waste and Industrial effluents. • Bio-fertilizers: Role of symbiotic and asymbiotic nitrogen fixing bacteria in the enrichment of soil. • Algal and fungal biofertilizers (VAM)	7
VIII	**Bioleaching and genetically modified organisms:** • Enrichment of ores by microorganisms (Gold, Copper and Uranium). • Environmental significance of genetically modified microbes, plants and animals.	6
VIII	**Bioethics, IPR, Entrepreneurship:** • Importance of Bioethics, IPR and entrepreneurship • Introduction to Intellectual Property Rights (IPR)- World Intellectual properties, Indian Intellectual properties • Entrepreneurship in India	6

Suggested Reading

1. Glazier AN and Nikaido H (2007).Microbial Biotechnology – Fundamental & Applied Microbiology – Second Edition. Cambridge University Press.
2. Casida LE (2019) Industrial Microbiology. Second Edition,New Age International Publisher.
3. Stanbury P F and Whitaker, A. (2010). Principles of Fermentation Technology. Oxford: Pergamon Press
4. Shuler M L and Kargi F. (2002). Bioprocess Engineering: Basic Concepts. Upper Saddle River, NJ: Prentice Hall.
5. Crueger W and Crueger A (2002) Cruegers Biotechnology: A Textbook of Industrial Microbiology. Third Edition, Panima Publishing Corp., New Delhi.
6. Blanch H W and Clark D S. (1997). Biochemical Engineering. New York: M. Dekker.
7. Bailey J E and Ollis D F. (1986). Biochemical Engineering Fundamentals. New York: McGraw-Hill.
8. Richard HB, Julian ED, Arnold LD. (2010) Manual of Industrial Microbiology and Biotechnology, 3rd Edition
9. Thakur IS. (2011)Environmental Biotechnology basic concepts and applications. I. K. International Publishing House Pvt. Limited
10. Evans GM and J. C. Furlong (2003). Environmental Biotechnology: Theory and Applications. Wiley Publishers.
11. Ritmann R and McCarty P L (2000). Environmental Biotechnology: Principle & Applications. 2nd Ed., McGraw Hill Science.
12. Scragg A., (2005) Environmental Biotechnology. Pearson Education Limited.
13. Srinivas TR (2008). Environmental Biotechnology.New Age International Pvt. Ltd.
14. Chapman JL .Ecology: Principal & Application.Cambridge Univ. Press.
15. Odum E and Barret G. (2004) Fundamentals of Ecology. Nataraj Publication

Course Title: Industrial and Environmental Biotechnology (Practical)		
Total Number of Hrs=60		
	Topic	**No. of hrs.**
	1. Calculation of bacterial growth curve. 2. Calculation thermal death point (TDP) of a microbial sample. 3. Production and analysis of ethanol. 4. Production and analysis of amylase. 5. Production and analysis of lactic acid. 6. Isolation of industrially important microorganism from natural resource. 7. Calculation of Total Dissolved Solids (TDS) of water sample. 8. Calculation of BOD of water sample. 9. Calculation of COD of water sample. 10. Bacterial Examination of Water by MPN Method.	60

Course name: Food Biotechnology		
Credits: 6		
Max. marks=100		
Course objective: Students will understand the concepts of food biotechnology and would be able to relate the role of biotechnology in the food industry. They will get concepts regarding, food components, preservation, fermentation, spoilage and microbes involved in fermentation and spoilage.		
Unit	**Topic**	**No. of Lectures**
I	**Introduction to Food Biotechnology** • Historical Background of Food technology • Traditional fermented foods (meat, fish, bread, sauerkraut, soy bean, coffee, cocoa, tea) • Importance, global trends, codex guidelines, nutritional labelling in India, FSSAI guidelines • Improvements through Biotechnology (e.g. Golden Rice, Potato, Flavr Savr Tomato etc.)	**10**
II	**Enzymes in Food Industry:** • Carbohydrases • Proteasase • Lipases • Modification of food using enzymes: • Role of endogenous enzymes in food quality, • Enzymes use as processing aid and ingredients	**12**
III	**Food Fermentations:** • Common fermented foods - Cheese, Butter, Yoghurt, fermented/condensed milk and kefir. • Alcoholic beverages (Beer, Wine, Whisky), • Sauerkraut, Pickles, Soy products, Tea, coffee etc.	**12**
IV	**Food preservation:** • Food adulteration and prevailing food standards in India. • Source of microorganisms in milk and their types. • Microbiological examination of milk (standard plate count, direct microscopic count, reductase and phosphatase test). • Dehydration and pasteurization of milk.	**10**
V	**Value addition products:** • Value addition products like High Fructose Syrup, Invert Sugars etc. SCPs (e.g. Spirulina, Yeast etc.) as food supplements, • Edible fungus: Mushrooms. Potential of Probiotics. • Flavor enhancers: Nucleosides, nucleotides and related compounds. Organic acids (Citric acid, Acetic acid) and their uses in foods/food products.	**12**

VI	**Vitamins and Minerals:** • Importance of Vitamins and their supplementation in foods and feedstock. • Food preservation and storage. Food Processing • Important minerals and their function in body and deficiency conditions • Requirements, allowances, enrichment, restorations, fortifications, losses of minerals, optimization and retention of minerals;	**12**
VII	**Growth of microorganisms in food:** • Intrinsic and extrinsic factors. • Food Spoilage (microbial and non-microbial) Control mechanisms of food spoilage: Physical and Chemical. • Microbial spoilage of food and factors affecting them: Spoilage of various kinds of foods: fish. meat, poultry, sea foods, bread and dairy products). • Food adulteration and prevailing food standards in India. • Indicator Microorganisms: As an indicator of good quality	**10**
VIII	**Food and water borne diseases:** • Gastroenteritis, Diarrhoea, Shigellosis, Salmonellosis, Typhoid, Cholera, Polio, Hepatitis, Dental Infections, etc. • Food borne intoxications: Staphylococcal, Bacillus, Clostridium etc. • Detection of food-borne pathogens.	**12**

Suggested Books

- Ray B and Bhunia A. 2008. Fundamental Food Microbiology, 4th Ed., CRC press, Taylor and Francis Group, USA.
- Martin RA and Maurice OM. 2008. Food Microbiology, 3rd Ed., The Royal Society of Chemistry, Cambridge, UK.
- James M J. 2000. Modern Food Microbiology, 6th Ed. Aspen Publishers, Inc., Gaithersburg, Maryland, USA.
- Frazier WC, and Westhoff DC. Food Microbiology. Fourth edition, MacGraw Hills publication
- Lopez GFG, Canaas G, Nathan EV. Food Sciences and Food biotechnology.
- Adams AR, and Moss MO. *Food Microbiology*. Third edition, Royal Society of Chemistry publishing.
- Hohn T and Leisinger KM. Biotechnology of Food Crops in Developing Countries.
- Doyle MP, Beuchat LR and Montville TJ. Food Microbiology Fundamentals and Frontiers. ASM Press.
- Schwartzberg HG, RaoMA. (Eds.) Biotechnology and Food Process Engineering.

Course Title: **Food Microbiology**		
Credits: 4+2		
Max. marks=100+25 (Practical)		
Course Objective: The course will deliver the students about the basic concepts of food & nutrition, microbial spoilage of foods, food examination, preservation, fermentation and sanitization etc.		
Unit	**Topics**	**Total No. of Lectures/ Hours (60)**
I	**Introduction to food & nutrition**. History, Development and Scope of food microbiology; Concept of food and nutrients; Physiochemical properties of food; Importance and types of microorganisms in food (bacteria, mold and yeast); Food as a substrate for microorganism- Intrinsic and extrinsic factors that affect growth and survival of microbes in food, natural flora and source of contamination of foods in general.	**8**
II	**Microbial spoilage of various foods** Principal; Spoilage of vegetables, fruits, meats, eggs, milk and butter, bread, canned foods.	**6**
III	**Microbial examination of food** DMC, viable count, examination of faecal Streptococci. Food quality monitoring, Biosensors and Immunoassays.	**6**
IV	**Food Preservation** Basic Principles, Methods (heating, freezing, dehydration, chemical preservatives, radiation). Modern technologies in food preservation, Packaging material.	**8**
V	**Fermented foods:** Fermented dairy products (cheese, butter, yoghurt), Kefir; Other Fermented foods- Soya sauce, Saurkraut, Dosa, Tempeh; Probiotics: health benefits, types of microorganisms used, probiotic foods available in market.	**8**
VI	**Food borne diseases (Causative agents, foods involved, symptoms and preventive measures)** Food intoxication- Staphylococcus aureus, Clostridium botulinum and Mycotoxins; Food infections- E.coli, Salmonellosis, Bacillus cereus, Sheigellosis, Listeria.	**8**
VII	**Microorganisms and milk** Physical and chemical properties of milk; Milk as a substrate for microorganisms; Microbiological analysis of milk – Rapid Platform test, standard plate count, MBRTtest, alkaline phosphatase enzyme test, DMC; Method of preservation of milk and milk product, pasteurization sterilization and dehydration.	**8**
VIII	**Food sanitization and control** HACCP, Indices of food sanitary quality and sanitisers; Microbiological quality standard of food.	**8**

Recommended Books:

- Adams & Moss, Food Microbiology, Published by Royal Society of Chemistry, Cambridge, U.K.
- R.S. Mehrotra – Plant Pathology, Tata Mc-Graw Hill
- Frazier & Westhoff., Food Microbiology Tata Mc-Graw Hill (2014)
- Varnam A.H. & Evans M G – Food borne pathogens. Wolfe Publishing House, London
- B.D. Singh (2015) Biotechnology, Kalyani Publisher
- Prajapati (2007) Fundamentals of Dairy microbiology, Indian Council of Agricultural Research, New Delhi
- Andrew Proctor (2011) Alternatives to conventional food processing. RSCPublisher
- Arun K. Bhunia & Bibek Ray, Fundamental Food Microbiology, 5th Ed., CRC Press

Suggested links:

- https://onlinecourses.swayam2.ac.in/cec19_ag03/preview
- http://www.vlab.co.in

Course Title: Food Microbiology (Practicals)		
Total No. of Hrs: 60		
S. No.	**Topics**	**Total No. of Hours (60)**
1	Study of Bioreactor & its essential parts	**4**
2	Necessity & procedure of writing SOPs for instruments used in large scale production	**6**
3	Isolation and microscopic observation of industrially important microorganism	**8**
4	Isolation and characterization of microorganism used in Dairy industry	**8**
5	Isolation and characterization of Yeast used in Bakery/distillery/winery	**8**
6	Isolation & identification of important microorganism of food microbiology	**8**
7	Bacteriological analysis of food products	**8**
8	Determination of the quality of milk by MBRT	**2**
9	Bacterial examination of milk – Alcohol test	**4**
10	Preservation methods	**4**

Course Title: Elementary Industrial Microbiology

Credits: 6

Max. marks=100

Course Objective: This course introduces students to various aspects of industrial microbiology, including, Microbial isolation techniques, GRAS microbes, fermentation, downstream processing etc. It also provides idea of production of antibiotics, alcohol, vitamins, amino acids, biofuels and biofertilizers etc.

Unit	Topics	Total No. of Lectures/ Hours (90)
I	History & Multidisciplinary nature of Industrial microbiology. A typical Bio process: Introduction, advantages & limitations. Patents and intellectual property rights.	12
II	Taxonomic diversity of industrially useful bacteria & fungi. Important characteristics of microbes used in Industrial Microbiology, Isolation techniques. Concept & examples of microorganisms classified as Generally Regarded as Safe (GRAS).	12
III	Exploitation of microorganism and their products, Screening, Strain development strategies, Immobilization methods.	12
IV	Fermentation: Media, Raw material, Antifoaming agents, Buffers. Equipments, Fermenter design. Types of fermentation – Single, Batch, Continuous.	10
V	Down-stream processing steps: Detection and assay of the product, Recovery (intercellular and extracellular product). Purification (solvent extraction & chromatography)	12
VI	Production of Alcohol (industrial alcohol, wine, beer, whiskey), Organic acid (Citric acid), Antibiotic (Penicillin)	10
VII	Production of Vitamin (B12), Enzyme (Amylase), Amino acid (Glutamic acid), Hormones (Insulin), Vaccine (Hepatitis B).	10
VIII	Biofuel (Methane), Production of Biofertilizers & Biopesticides, Biotransformation of steroids.	12

Recommended Books:

- Industrial Microbiology (2000) by AH Patel, Macmillan Publishers India
- Biology of Industrial microorganism (1981) by Arnold L. Domain, Bejamin/ cummings Pub. Co.
- Industrial Microbiology by Prescott & Dunns, AVI Publishing Company Inc.
- Industrial Microbiology by Casida LE, New age International (P) Ltd.

Suggested links:

- http://foodhaccp.com/foodsafetymicro/onlineindex.html
- http://www.cpe.rutgers.ed/courses/current/If0401wa.html

Course Title: **Molecular Cancer Biology**		
Credits: 6		
Max. marks=100		
Course Objective: This course focuses on introducing the students with various types of cancers, biology and biochemistry of cancer, signaling in cancer, mechanism of carcinogenesis, Therapeutic modulations against cancer etc.		
Unit	**Topics**	**Total No. of Lectures/ Hours (90)**
I	Introduction, growth characteristics of cancers cells; Morphological and ultrastructural properties of cancer cells. Differences between benign and malignant tumors. Types of growth: hyperplasia, dysplasia, anaplasia and neoplasia. Nomenclature of neoplasms. Epidemiology of cancer	**10**
II	Cancer biology and biochemistry- Aberrant metabolism during cancer development; Paraneoplastic syndromes; cellular protooncogenes- oncogene activation. Growth factors-EGF, TNF- and TGF- and growth factor receptors. Signal transduction in cancer. Role of transcription factors, Tumor markers.	**20**
III	Radiation and chemical carcinogenesis- stages in chemical carcinogenesis- Initiation, promotion and progression. Free radicals, antioxidants in cancer; Viral carcinogenesis -DNA and RNA Viruses. Hormone mediated carcinogenesis in humans	**15**
IV	Cell Cycle Regulation-Tumor suppressor genes p53, p21, Rb, BRACA1 and BRACA2. Telomeres, Telomerase, and Immortality; cell- cell interactions, cell adhesion-invasion and metastasis - VEGF signaling, angiogenesis; Epigenetics-Role of DNA methylation in gene silencing- epigenetic silencing of tumor-suppressor genes; Apoptosis in cancer-Cell death by apoptosis, role of caspases; Death signaling pathways-mitochondrial and death receptor pathways.	**25**
V	Detection of Cancers, Prediction of aggressiveness of Cancer, Different forms of therapy, Chemotherapy, radiation Therapy, and Immunotherapy: advantages and limitations. Epigenetics of cancer, Identification of targets for drug development.	**20**

Recommended Books:

- The Molecular Biology of Cancer: S. Pelengaris, M. Khan. Blackwell Publication.
- Cancer Associated Viruses (2012), Erle S. Robertson (Editor); Springer Science & Business Media
- The Biological Basis of Cancer: R. G. McKinnell, et al 2nd Ed, Cambridge University Press, 2006.
- The Biology of Cancer: R. A. Weinberg. Garland Science. 2006.
- Virology a practical approach, Maly B.W.J. IRL Press, Oxford, 1987.
- Introduction to modern Virology, Dunmock N.J and Primrose.S.B., Blackwel Scientific Publications. Oxford, 1988.
- An Introduction to Cellular & Molecular Biology of Cancer, Oxford Medical publications, 1991
- Gene expression systems. Joseph M. Fernandez & James P. Hoeffler. Academic Press, 1999.
- Cancer Biology IV Ed Volume2 Raymond W Ruddon M.D.(2007)
- Cancer Biology (3rd_Edition) Roger J.B. et al (2006)
- Advances in Cancer Stem Cell Biology, Roberto Scatena, Alvaro Mordente & Bruno Giardina (Ed) Springer(2012).

Suggested links:

- https://nptel.ac.in/content/storage2/courses/104103068/pdf/M4.pdf
- https://onlinecourses.swayam2.ac.in/aic20_ge02/preview
- https://dth.ac.in/medical/courses/pathology/2/3/index.php
- https://ocw.mit.edu/courses/biology/7-016-introductory-biology-fall-2018/lecture-videos/lecture-25-cancer-1/
- https://ocw.mit.edu/courses/biology/7-342-cancer-biology-from-basic-research-to-the-clinic-fall-2004/