Name of faculty: Science	**Department:** Environmental Science
Program: B.Sc.	**Type:** Theory + Practical
Subject: DSC-7 Environmental Biotechnology	**Semester:** 4
Credit: 04 + 02	**Total learning hours:** 60

Course description:

The course includes study of various biotechnological techniques necessary in environment conservation and maintenance. This course deals with the aspects of fuel management and organic fuel applications, remediation technologies etc.

Student learning outcome:

On completion of course students will be able to:

- Understand the Molecular and recombinant biotechnological techniques.
- Learn different bioremediation methods.
- Know biofuel production technologies and applications.
- Understand the bioleaching methods, and variety of alternative options in place of non degradable polluting materials.

Unit-1: Introduction and Scope of Environmental Biotechnology: (6h)

1.1 Definition, introduction and scope of environmental biotechnology
1.2 Need and issues of environmental biotechnology
1.3 Challenges of environmental biotechnology
1.4 Abatement of pollution and Environmental clean-up technologies

Unit-2: Introduction and tools for genetic engineering: (6h)

2.1 DNA modifying enzymes: Nuclease, Alkaline Phosphatase, DNA Polymerase, Reverse Transcriptase, Polynucleotide Kinase, Methylase and DNA ligase
2.2 Methods of Gene cloning and Gene transformation
2.3 Linkers, adaptors, homopolymer tailing, Site directed mutagenesis
2.4 PCR: Process, Methodology and Types, Reverse Transcriptase PCR, Real Time PCR

Unit-3: Different types of gene cloning vectors:(12h)

3.1 Cloning vectors: Types and Properties, Essential components of gene cloning vectors, Selectable and screenable markers
3.2 Plasmids, Bacteriophages, M13 mp vectors, PUC19 and Bluescript vectors
3.3 Insertion and Replacement Vectors, TA cloning vectors, YACs and BACs
3.4 Expression vectors, plant based vectors, Ti and Ri plasmids as vectors

Unit-4: Gene library and Genome Editing techniques: (12h)

4.1 Isolation ofmRNA and total RNA, reverse transcriptase and cDNA synthesis
4.2 Introduction to miRNA and siRNA
4.3 Gene knock in and Gene knockout
4.4 Genome Editing: CRISPER-CAS, TALENs, ZFNs
4.5 Applications of genetic engineering techniques in environmental biotechnology

Unit-5: Biomass and Bioenergy: (6h)

5.1 Biomass as a source of energy: Composition and types of biomass
5.2 Biomass conversion: Thermo-chemical conversion, Bioconversion
5.3 Bioenergy- Petroleum plants, Bioethanol

5.4 Gaseous fuels - Biogas, Biohydrogen and Microbial Fuel cells

Unit-6: Bioremediation technologies: (6h)
6.1 Bioremediation: Introduction and Types
6.2 Bioaugmentation and Biofiltration
6.3 Bioremediation of hydrocarbons
6.4 Bioremediation of industrial wastes
6.5 Bioremediation of recalcitrant and xenobiotic compounds

Unit-7: Phytoremediation and rhizoremediation technologies(6h)
7.1 Phytoremediation - Introduction, Types and Mechanisms
7.2 Advantages, Disadvantages and Applications of phytoremediation
7.3 Rhizoremediation - Introduction, Types and Mechanisms
7.4 Concept of Phytoextraction and rhizofiltration

Unit-8: Applications of Environmental Biotechnology and sustainable technologies: (6h)
8.1 Bioleaching: Types, Processes and Examples
8.2 Bioplastics, Bioscrubbers, Biopesticides and Biofertilizers
8.3 Environmental Nanotechnology- Principles and Environmental applications
8.4 Biosensors: Types, Working and Applications

References:

- Fulekar, M. H. (2007) Environmental Biotechnology, CRC Press.
- Thakur, I. S. (2011) Environmental Biotechnology, I. K. International Pub. House Pvt. Ltd.
- Maier, R. M. (2009) Environmental Microbiology, Academic Press.

Practicals:

1. Isolation of symbotic, nonsymbiotic and anaerobic nitrogen fixing bacteria from rhizosphere
2. Isolation of genomic DNA from bacterial, yeast and plant samples
3. Isolation of plasmid DNA
4. Study of biosorption of heavy metal by fungal biomass
5. Synthesis of AgNPs by using sodium citrate
6. Isolation and enrichment of Uric Acid Utilizing Bacteria
7. Study of seed viability and seed germination assay in presence of environmental pollutants.

Name of Faculty: Science	**Department**: Biotechnology
Program: B.Sc. Biotechnology	**Type:** Theory + Practical
Subject: DSC-8 Microbial Physiology and Metabolism	**Semester:**04
Credit: 04 + 02	**Total learning hours:** 60
Course description: The objectives of this course are to provide students with the theory and practical experience Physiology and Metabolism aspect of Microorganisms which facilitate investigation of molecular biology and evolution-related concepts.	
Student learning outcome: At the end of the course, students will be able to: ● Understand basics of microbial growth and cell cycle, modes of microbial reproduction. ● Know the role and effect of various factors- environmental, physical and chemical on growth of microorganisms and also learn ways and means of cultivating microorganisms in in vitro conditions. ● Explain methods and techniques for controlling microbial growth. ● Learn about the response of microorganisms towards various stresses to sustain and survive during exposure to these stresses. ● At the end of the course, the student has an understanding on the metabolism and mechanism of various biomolecules. ● The student through this course will be able to explain the principle of energy yielding and consuming reactions, various anabolic and catabolic pathways, transport systems and the mechanisms of energy conservation in microbial metabolism.	

UNIT-1: Microbial Growth: **(9 hrs)**

1.1. Reproductive Strategies in Bacteria and Archaea
1.2. Bacterial Cell Cycle and its Regulation
1.3. Bacterial Cell division (Gram Positive Bacillus and Gram Negative Rods)
1.4. Growth Curve Studies
1.5. Bacterial Differentiation (Bacillus Endospore formation)

UNIT-2: Microbial Nutrition **(8 hrs)**

2.1 Effect of Environmental Factors on Growth of Microorganisms
2.2 Microorganisms in Natural Environments
2.3 Cultivation of Microorganisms in Laboratory
2.4 Measurement of Microbial Population

UNIT-3: Control of Microorganisms **(7 hrs)**

3.1. Principles of Microbial Control
3.2. Pattern of Microbial Death
3.3. Mechanical Methods for Microbial Control
3.4. Physical Methods for Microbial Control
3.5. Chemical Methods for Microbial Control

UNIT-4: Response to stress: **(7 hrs)**

4.1. Osmotic Stress
4.2. Oxidative Stress
4.3. Thermal Stress
4.4. pH Stress and Acid Tolerance
4.5. Nutrient Stress and Starvation

UNIT-5 Carbohydrate Metabolism **(9 hrs)**

5.1 Concept of Metabolism and Bioenergetics
5.2 Aerobic (PP Pathway) & Anaerobic Glycolysis (Sequence of Reactions, Regulation)
5.3 ED Pathway
5.4 Pyruvate Metabolism, Citric acid Cycle & its Regulation
5.5 Glycogenesis, Glycogenolysis (Sequence of Reactions & Regulation)

UNIT-6 Lipid Metabolism **(8 hrs)**

6.1 Outline of Lipid Synthesis
6.2 Catabolism of Fatty acid: Beta oxidation
6.3 Oxidation of Unsaturated Fatty Acids
6.4 Oxidation of Odd Chain Fatty Acids, Cholesterol & Ketone Bodies.

Unit-7Amino acid Metabolism **(7hrs)**

7.1 Essential & Non Essential Amino Acids, Brief Outline of Amino Acid Synthesis
7.2 Catabolism of Amino acids, Transamination
7.3 Metabolic Breakdown of Individual Amino Acids – Glucogenic & Ketogenic Amino Acids, Amino Acids As Biosynthetic Precursors

Unit-8 Nucleotide Metabolism **(5 hrs)**

8.1 Biosynthesis of Purine & Pyrimidine (*De novo* & Salvage Pathway);
8.2 Degradation of Purine & Pyrimidine

References and Textbooks: (With Author, Edition, Publishers, ISBN)

- John P. Harley, Donald A. Klein, Microbiology- Lansing Prescott, 10th Edition, Mcgraw Hill Publication. ISBN-13-978-1259281594
- Albert Moat, John Foster, Micheal Spector, Microbial Physiology, 4th Edition, A John Wiley & Sons, Inc., Publication ISBN 0-471-39483-1
- Stryer, L., "Biochemistry", 4th Edition, W.H. Freeman & Co., 2000.
- Murray, R.K., etal "Harper's Biochemistry", 23rd Edition, Prentice Hall International, 1993.
- Voet D and Voet JG. 2011. Biochemistry. 4th Ed. John Wiley and Sons, Inc. NY, USA

Practicals:

1. To culture bacteria in solid and liquid media.
2. To study bacterial growth curve.
3. Study of Biochemical test for characterization of Bacteria.

REFERENCE:

Experimental Microbiology by Rakesh Patel
Vol:1 & 2

Name of faculty: Science	**Department:** Biotechnology
Program: B.Sc. Biotechnology	**Type:** Theory + Practical
Subject: SEC-2 Genetics	**Semester:** 4
Credit: 04 + 02	**Total learning hours:** 60

Course description:

This paper deals with the basics of genetics- i.e how all the important functions at different levels viz. Molecular, cellular, organism levels are controlled and governed by different genes. Since the advent of molecular studies the intriguing fact that, how everything works in coordination and regulated manner, has been the subject of study. This is to an extent covered in this paper so as to cater the knowledge to students about DNA being transferred hereditary, what factors influence this inheritance in different populations, what makes an individual somewhat different from others in their characteristics, how the studies related to such phenomena can be brought about, which anomalies in genes of an individual may lead to disorders .

Student learning outcome:

On completion of course students will be able to:

- Describe the pattern of inheritance observed based on various principles and postulates of inheritance.
- Understand the basis of different phenotypic characters as expressed by populations and individual persons.
- Apply the principles of inheritance to biological systems for experimental analysis.
- Justify, relate and apply the methods and tools to study variations at chromosomal/gene levels and corresponding disorders/traits.

Unit-1 Introduction to Genetics: (7 h)

1.1. Definition of Genetics.
1.2. History of Genetics (Charles Darwin to Mendel till modern day genetics)
1.3. Classical and Modern genetics
1.4. Sub-disciplines of Genetics
1.5. Nucleic Acid as Genetic material: Deciphering the Puzzle (Griffiths Experiment, Avery's Transformation Experiment, Hershey and Chase's Experiment, RNA as viral genetic material)

Unit-2 Mendelian Genetics (Transmission Genetics): (7 h)

2.1 Mendel's Experimental Design
2.2 Monohybrid Cross and Mendel's Postulates
2.3 Dihybrid Cross and Mendel's Postulates
2.4 Mendelian Genetics in Humans

Unit-3 Extensions of Mendelian genetics: (7 h)

3.1 Incomplete or Partial Dominance
3.2 Codominance
3.3 Multiple Alleles and Inheritance in Population (ABO Blood Groups and A and B Antigens, Bombay Phenotype, White Locus in Drosophila)
3.4 Epistasis

Unit-4 Organization of DNA in Chromosomes: (6 h)

4.1 Viral Chromosomes
4.2 Prokaryotic Chromosomes
4.3 Eukaryotic Chromosomes (Structure of Chromatin, Euchromatin and Heterochromatin, Centromeric and Telomeric DNA, Structure of Eukaryotic Chromosomes)

Unit-5 Chromosomal Variations and Cytogenetics: (6 h)

5.1 Types of Chromosomal Mutations (Variations in Chromosome Structure-Polytene Chromosomes etc., Variations in Chromosome Number)
5.2 Genetic Disorders Prevalent in India
5.3 Pedigree Analysis (Sex Linked Inheritance-Queen Victoria)
5.4 Banding Techniques and Karyotyping

Unit-6 Chromosomal Basis of Inheritance: (10 h)

6.1 Chromosome Theory of Inheritance (Sex Chromosomes, Sex Linkage, Non-Disjunciton of X-Chromosome)
6.2 Sex Chromosomes and Sex Determination (Klinefelter and Turner Syndromes- in Relation to Y Chromosome Determining Maleness in Humans, Sexual Differentiation in Humans)
6.3 Dosage Compensation of X-linked Genes in Mammals (Barr Body, Lyon Hypothesis)

Unit-7 Population and Behavioural Genetics: (9 h)

7.1. Genetic Structure of Populations (Genotype, Alleles Frequencies)
7.2. Hardy-Weinberg Law
7.3. Natural Selection (Wallace Darwin Concept) and Evolutionary Variation in Alleles (Migration- Altering Allele Frequencies, Genetic Drift- Founder Effect, Inbreeding)
7.4. Genetics of Behaviour (Behaviour First Approach- Geotaxis in Drosophila, Gene First Approach- Learning Memory in Drosophila, Human Behavioural Genetics- Schizophrenia)

Unit-8 Quantitative Genetics: (8 h)

8.1. Quantitative Genetics: Studying Genetic Variations Quantitatively
8.2. Traits, Variations and Inheritance
8.3. Statistical Analysis (Samples and Populations, Mean, Variance and SD, Correlation, Regression, ANOVA)
8.4. Heritability and QTL

References:

- Klug, W. S. and Cummings, M. R. (2007) *Concepts of Genetics*, 7th Edition, Pearson Education. ISBN 13: 978-0-321-79578-6
- Rusell, P. J, (2010) *i*Genetics, 3rd edition, Pearson Education ISBN-9789332571624

- Griffiths, A. F., Wessler, S. R., Carroll, S. B. And Doebley J (2012) *Introduction to Genetic Analysis*, 10th Edition, W. H. Freeman and Company, New York. ISBN-978-1429229432
- Tamarin, R. H (2002), 7th edition, Principles of Genetics, Tata McGraw Hill Inc., New York (Indian Reprint), ISBN-9780070486676

Practicals:

1. To study Polytene chromosomes from Drosophila Salivary glands.
2. To prepare Metaphase plates from onion root tips and to analyse human chromosomes through Karyotyping and report abnormalities. Or To perform Pedigree analysis (students have to select any trait of their own family and report after pedigree analysis).
3. Population Genetics:
    a. To study and analyse Hardy –Weinberg Principle through blood groups study in population.

Name of faculty: Science	**Department:** Allied
Program: B.Sc.	**Type:** Theory
Subject: DSE-4 Nanoscience and Nanotechnology	**Semester:** 4
Credit: 02	**Total learning hours:** 30

Course description: Nanoscience is the study of structures and molecules on the scale of nanometers and the technology which utilizes it in practical applications is called nanotechnology. Today, engineers and researchers are finding a wide variety of methods to deliberately make nanoscale materials to take the advantages of their enhanced properties such as higher strength, lighter weight, high chemical reactivity, etc. also the nanotechnology offers more advances in disease treatments, in imaging and diagnostics equipment, in energy efficient products such as fuel and solar cells, etc. so in order to move towards the advanced materials and devices, students should have the knowledge of nanoscience.

Student learning outcome: After learning the course,students should be able :

- To understand the difference between bulk and nanoscale materials.
- To understand the basics of nanoscale science.
- To understand the synthesizing technique and difficulties to synthesize the nanomaterials so they can get interested in the search for new composition techniques of nanomaterials.
- To understand the various applications of nanoscience and nanotechnology.

Unit-1: Fundamentals of Nanoscience and Nanotechnology (3 Hrs)

1. Introduction to the world of Nanoscience.
2. Nano and Nature: Nanoscopic colors, Bioluminescence, Tribiology.
3. Introduction to hydrophilic and hydrophobic materials.
4. Timeline of Nanotechnology in different centuries.

Unit-2: Nanoscale Science (The big world of Nano scale) (4 Hrs)

1. Interconversion of Units.
2. Introduction to surface area to volume ratio and aspect ratio.
3. Difference between surface area to volume ratio of bulk materials and nano materials (sphere, rods, cubes).
4. Difference in aspect ratio of bulk wire and nanowire.
5. Nanomaterial and wavelength of light.

Unit-3: Classification of Nano structured materials (4 Hrs)

1. Small things can make a big difference.
2. Classification of nanostructured materials (3D, 2D, 1D, 0D).

3. Relationship between dimension and shape of nanomaterials (Quantum dots, Quantum wires, carbon nanotubes, Fullerenes).
4. Effect of size on electronic and optical properties.

Unit-4: Fundamental of atomic structure and Bonding (3 Hrs)

1. Bohr's atomic structure.
2. Bohr's atomic radii, comparative size of nanomaterials and atomic size, electronic configuration.
3. Types of energy levels.
4. Bonding and electronic structures of solids.

Unit-5: Concept of solid state physics and crystal structure (4 Hrs)

1. Introduction.
2. Planes in the crystals and crystallographic directions.
3. Types of crystal structures.
4. Reciprocal lattice.

Unit-6: Synthesis techniques (4 Hrs)

1. Introduction
2. Top-Down fabrication methods(concepts with examples only)
3. Bottom-Up fabrication methods(concepts with examples only)
4. Chemical,Biological and Self-assembly methods of synthesis

Unit-7: Properties of Nano materials (4 Hrs)

1. Introduction
2. Mechanical & Optical properties
3. Electrical & Magnetic properties
4. Structural and Thermal properties

Unit-8: Applications and Future perspective of Nanoscience and Nanotechnology. (4 Hrs)

1. Introduction
2. Cosmetics & Domestic appliances
3. Nanobiotechnology and Medical fields
4. Environmental development
5. Food and Agriculture

Reference Books:-

- Nanoscience and Nanotechnology Fundanentals to Frontiers-M.S. Ramachandra Rao, Shubra Singh.

- Nanotechnology Principles and practicals-S.K. Kulkarni.
- Bio-nanotechnology: concepts and applications- Madhuri Sharon ,Maheshwar Sharon.
- Introduction to nanoscience and nanotechnology, CRC Press, Tylor and Francis Group, Boca Raton, G.L. Hornyak,H.F. Tibbals, J. Dutta , J. Moore.
- A textbook of Nanoscience and Nanotechnology- B.S. Murty.
- Environmental Nanotechnology-M. H. Fulekar, Bhawana Pathak,Taylor & Francis, CRC Press (2018).
- A textbook of Nanoscience and Nanotechnology -Tata McGraw Hill Education Private Limited.