INDEX
Department of Microbiology
Semester- III

B.Sc. (Hons.) Microbiology

DISCIPLINE SPECIFIC CORE COURSE – 7: BASIC CONCEPTS OF CELL BIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSC301: BASIC CONCEPTS OF CELL BIOLOGY	4	3	0	1	Class XII pass with Biology/ Biotechnology/ Biochemistry	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of this course is to introduce the students to the essentials of eukaryotic cell biology. The students will gain knowledge about the physical and chemical architecture of cells as well as structural and functional details of different cell organelles.
- To familiarize the students with cell cycle events, and mechanisms of cell communication and cell death. They will be educated about the hallmarks, etiology and diagnosis of cancers. They will be introduced to the cutting-edge science of stem cell technology, their production and various applications

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to describe the structure of the cell wall and cell membrane, membrane transport mechanisms, cell-matrix and cell-cell interactions, and the importance of the cytoskeleton.
- Student will be able to describe the organization and functioning of various cell organelles and gain insights into the internal organization of the nucleus.
- Student will be able to discuss the mechanisms of protein sorting, intracellular trafficking, and protein export.

- Student will be able to analyse the structure of the plant and animal cell by microscopic observation and the ultrastructure of cell organelles by electron microscopy.
- Student will be able to demonstrate the fractionation of cell components by ultracentrifugation and describe cell sorting by flow cytometry.

SYLLABUS OF DSC-7

UNIT – I (12 hours)

Cell envelope and cell interactions: Structure and composition of bacterial, fungal and plant cell walls. Composition of plasma membrane: phospholipid bilayer, membrane proteins, glycocalyx. Membrane transport mechanisms: passive diffusion, facilitated diffusion (carrier proteins and channel proteins), active transport (Na+-K+ ATPase, ABC transporters). Components of extracellular matrix: polysaccharides, structural proteins, adhesion proteins. Cell-matrix interactions: cell surface receptors, focal adhesions, hemi- desmosomes. Cell-cell interactions: adhesion junctions, tight junctions, gap junctions, plasmodesmata

UNIT – II (6 hours)

Cytoskeleton: structural organization of actin filaments, microtubule structure and dynamics, structure of centriole, cilia, flagella. Microtubule motor proteins: kinesins and dyneins.

UNIT – III (12 hours)

Structures and functions of nucleus and other cell organelles: Structure and function of nucleus and its components (nuclear envelope, nuclear lamina, nuclear pore complex). Internal organization of nucleus: heterochromatin, euchromatin, nucleolus. Structure and function of cell organelles: mitochondrion, chloroplast, ribosome, peroxisome, lysosome

UNIT – IV (15 hours)

Protein sorting and membrane trafficking: Structure of endoplasmic reticulum (smooth and rough, ER transmembrane proteins). Targeting and translocation of proteins across the endoplasmic reticulum, protein processing, folding and assembly. Brief overview of the role of endoplasmic reticulum in synthesis of lipids and assembly of phospholipid bilayers. Structure and organization of golgi apparatus. Protein glycosylation, protein sorting, and exocytosis. Signal sequences in transmembrane transport: nuclear localization signal, endoplasmic reticulum signal sequence

Practical component

UNIT 1: (20 hours)

Cell and cell organelles: Use of light microscopy and electron microscopy in studying cells. Study of the structure and function of a plant cell and an animal cell through microscopy. Analysis of the ultrastructure of cell organelles through electron micrographs: nucleus, plasma membrane, mitochondrion, chloroplast, ribosome, endoplasmic reticulum, golgi bodies, lysosome, centriole

Unit 2: (10 hours)

Cell fractionation and sorting: Principle and working of cell fractionation by density gradient centrifugation using virtual lab. Principle and working of cell sorting by flow cytometry using virtual lab. Analysis of cell cycle stages using flow cytometry.

Essential/recommended readings

Theory:

1. Molecular Cell Biology by H. Lodish, A. Berk, C. Kaiser, M. Krieger, A. Bretscher, H.Ploegh, A. Amon and K.C. Martin. 9th edition. W.H. Freeman, UK. 2021.
2. Essential Cell Biology by B. Alberts, K. Hopkin, A.D. Johnson, D. Morgan, and M. Raff. 5th edition. W.W. Norton & Co, USA. 2019.
3. Karp's Cell and Molecular Biology by G. Karp, J. Iwasa and W. Marshall. 9th edition. Wiley, USA. 2019.
4. The Cell: A Molecular Approach by G.M. Cooper. 8th edition. Sinauer Associates, UK. 2018.
5. Cell Biology by T.D. Pollard, W.C. Earnshaw, J. Lippincott-Schwartz and G.T. Johnson. 3rd edition. Elsevier, USA. 2016.
6. Becker's World of the Cell by J. Hardin and G. Bertoni. 9th Edition. Pearson, USA. 2015.
7. Cell and Molecular Biology by E.D.P. De Robertis. 8th edition. Lippincott, Williams and Wilkins, USA. 2006.

Practicals:

1. A Cell Biology Manual by J. Francis. Kendall/Hunt Publishing Co, USA. 2022.
2. Practical Laboratory Manual- Cell Biology by A. Gupta, B.K. Sati. Lambert Academic Publishing, USA. 2019.
3. Cell Biology Practical Manual by R. Gupta, S. Makhija and R. Toteja. Prestige Publishers, India. 2018.
4. Laboratory Manual of Cell Biology by R. Majumdar, R. Sisodia. Prestige Publishers, India. 2018.
5. Essential Cell Biology Vol 1: Cell Structure- A Practical Approach by J. Davey and M.Lord. Oxford University Press, UK. 2003.
6. Essential Cell Biology Vol 2: Cell Function- A Practical Approach by J. Davey and M. Lord. Oxford University Press, UK. 2003.

Suggestive readings

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE –8:
MICROBIAL PHYSIOLOGY AND METABOLISM- I

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSC302: **MICROBIAL PHYSIOLOGY AND METABOLISM- I**	**4**	**3**	**0**	**1**	**Class XII pass with Biology/ Biotechnology/ Biochemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to enable students to understand the underlying mechanisms governing various physiological and metabolic features of prokaryotes. These include transport mechanisms for the uptake of nutrients, bacterial growth, and the diversity of prokaryotes due to (i) adaptations to the different habitats in which they grow and (ii) metabolic pathways for energy production and carbon and nitrogen assimilation.
- The course will build the strong foundation needed by the students for further studies in the advanced fields of microbiology including metabolic engineering.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to discuss the diverse nutritional categories of bacteria/archaea and mechanisms of transport of nutrients across membranes of microbes.
- Student will be able to describe the physiology of bacterial growth, calculation of generation time and specific growth rate, and the effects of physicochemical factors on microbial growth.
- Student will be able to describe the metabolic pathways used by bacteria for energy generation and conservation during growth on glucose and other carbon sources under aerobic and anaerobic conditions.
- Student will be able to discuss energy production processes in microbes.

- Student will be able to analyse growth kinetics of bacteria, and evaluate the impact of external factors on bacterial growth kinetics.

SYLLABUS OF DSC-8

UNIT – I (10 hours)

Nutritional diversity amongst bacteria and mechanisms of nutrients transport: Classification of bacteria based on carbon, electron and energy sources. Nutrient transport across membrane: passive transport (diffusion- simple and facilitated), active transport (primary and secondary with suitable examples, concept of uniport, symport, antiport) and group translocation. Electrogenic and electroneutral transport. Transport of iron in bacteria through concerted action of primary and secondary active transport.

UNIT – II (12 hours)

Microbial growth patterns, kinetics and physiological adaptations: Batch, continuous, diauxic and synchronous growth. Bacterial growth kinetics: growth curve, generation time and specific growth rate. Physiological adaptations by microbes for growth under different environmental conditions: effect of temperature, pH, oxygen concentration, solute and water activity.

UNIT – III (12 hours)

Chemoheterotrophic metabolism under aerobic conditions: Concept of metabolism and energy production. Glucose degradation/catabolism by microbes via: glycolysis, Entner-Doudoroff (ED) pathway, Pentose phosphate pathway (PPP). The pyruvate dehydrogenase reaction, Krebs Cycle, anaplerotic reactions, Glyoxylate cycle. Utilization of fructose, lactose and pentose

UNIT – IV (11 hours)

Electron transport and energy production: Redox potentials of the electron carriers, organization of electron carriers in mitochondria, coupling sites, mechanisms of proton translocation, chemiosmotic hypothesis, oxidative phosphorylation and ATP generation, uncouplers and inhibitors of respiratory chain, comparison of mitochondrial and bacterial electron transport, branched respiratory chain in E. coli under high and low levels of O_2.

Practical component

UNIT 1: (20 hours)

Microbial growth: Study of various methods of measurement of microbial growth. Collection of data and plotting of bacterial growth curve of E. coli using turbidometric method (using optical density as the indirect method of measurement of bacterial growth). Understanding bacterial growth kinetics by calculation of generation time and specific growth rate of bacteria from the graph. Study of radial growth of *Aspergillus niger* using point inoculation method

Unit 2: (10 hours)

Effect of environmental factors on microbial growth: Study of the effect of physicochemical factors like temperature and pH variations on the growth of *E.coli*. Understanding the physiological importance of catalase and oxidase in protecting bacteria from the harmful effects of oxidizing environment: detection and assay of their activity in bacteria.

Essential/recommended readings

Theory:

1. Lehninger Principles of Biochemistry by D.L. Nelson and M.M. Cox. 8th edition. W.H. Freeman Fundamentals of Bacterial Physiology and Metabolism by Rani Gupta and Namita Gupta. Springer Nature Singapore Pvt. Ltd., Singapore. 2021.
2. Lehninger Principles of Biochemistry by D.L. Nelson and M.M. Cox. 8th edition. W.H. Freeman and Company, UK. 2021.
3. Brock Biology of Microorganisms by M.T. Madigan,J. Aiyer,D. Buckley,W.Sattley and D. Stahl.16th edition. Pearson, USA. 2021.
4. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGrawHill Higher Education, USA. 2019.
5. Microbial Biochemistry by G.N. Cohen. 2nd edition. Springer, Germany. 2014.
6. The Physiology and Biochemistry of Prokaryotes by D. White, J. Drummond and C. Fuqua. 4th edition. Oxford University Press, UK. 2011.
7. Microbial Physiology by S.R. Reddy and S.M. Reddy. Scientific Publishers India. 2007.
8. Microbial Physiology by A.G. Moat, J.W. Foster and M.P. Spector. 4th edition. John Wiley& Sons, USA. 2002.

Practicals:

1. Essentials of Practical Microbiology by A. Sastry and S. Bhat. 2nd edition. Jaypee Brothers Medical Publishers, India. 2021.
2. Microbiology: A Laboratory Manual by J. Cappuccino and C.T. Welsh. 12th edition. Pearson Education, USA. 2020.
3. Laboratory Experiments in Microbiology by T. Johnson and C. Case. 12th Edition. Pearson Education, USA. 2019.
4. Microbiology Practical Manual edited by A. Jain, J. Agarwal, V. Venkatesh. Elsevier, India. 2018.
5. Applied Microbial Physiology: A Practical Approach by P. M. Rhodes and P. F. Stanbury. IRC Press. 1997.

Suggestive readings

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 9: ENVIRONMENTAL MICROBIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSC303: ENVIRONMENTAL MICROBIOLOGY	**4**	**3**	**0**	**1**	**Class XII pass with Biology/ Biotechnology/ Biochemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this paper is to provide students with in-depth knowledge of diverse microbial populations/ communities present in different habitats in the ecosystem.
- Students will become aware of the inter-microbial, microbe-plant and microbe-animal interactions and their benefits. The students will also learn about the management of solid and liquid waste and different strategies for microbial remediation of environment pollutants.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to discuss natural habitats of diverse microbial populations and give an overview of the concept of metagenomics.
- Student will be able to analyse various positive and negative interactions amongst microbes and also between microbes and plants / animals.
- Student will be able to explain the importance of microorganisms in mineral cycling within an ecosystem, and their effects on the environment.
- Student will be able to discuss various methods involved in sewage treatment, how we can make water safe for drinking, and various methods for testing water potability.
- Student will be able to evaluate different waste management strategies using microorganisms.

- Student will be able to describe various methods of microbial remediation for treating pollutants present in our environment. Student will be able to determine the importance of quality control in the food industry and describe various indices being used to measure quality and safety in the food industry.

SYLLABUS OF DSC-9

UNIT – I (11 hours)

Natural habitats and their microbial communities: Concepts of habitat, niche. Autochthonous, allochthonous, zymogenous microorganisms. Colonization and succession. Lithosphere: Soil profile, soil characteristics: physical and chemical, soil microbial community. Hydrosphere: Freshwater habitat: stratification and microbial composition of lake. Marine habitat: stratification and microbial composition of ocean. Atmosphere: atmosphere as microbial habitat, dispersal of microorganisms/spores, bioaerosols, methods of air sampling (filtration and deposition). Extreme habitats with reference to temperature, hydrostatic pressure, salinity and low nutrient levels. Concept of metagenomics, use of metagenomics to profile microbial communities in natural habitats.

UNIT – II (9 hours)

Interactions of microbial populations: Microbe-microbe interactions. Positive interactions: mutualism, protocooperation, commensalism. Negative interactions: antagonism, competition, predation, parasitism. Microbe-plant interactions. Symbiotic association: microbes associated with roots and aerial plant surfaces, leguminous roots-rhizobium symbiosis, Anabaena-Azolla symbiosis, mycorrhizal and actinorhizal associations. Microbe- animal interactions. Microflora in ruminant gut, nematophagous fungi and symbiotic luminescent bacteria.

UNIT – III (9 hours)

Mineral cycling by microbes and their effects on the environment : Importance of biogeochemical cycles. Carbon cycle: microbial degradation of cellulose, lignin and chitin, Nitrogen cycle: nitrogen fixation, ammonification, nitrification, denitrification and nitrate reduction. Phosphorus cycle: solubilisation and immobilization. Sulphur cycle: oxidative and reductive sulphur transformation, metal corrosion, acid mining drainage, nitrate pollution

UNIT – IV (9 hours)

Wastewater treatment and water potability: Sources and composition of liquid waste. Sewage strength: BOD and COD. Primary, secondary (aerobic: trickling filter, activated sludge process; anaerobic: septic tank, anaerobic sludge digestor) and tertiary sewage treatment. Treatment and safety of drinking (potable) water, Methods to detect potability of water samples: standard qualitative procedure - presumptive test/MPN test, confirmed and completed tests for fecal coliforms; membrane filter technique and

Presence/Absence tests for coliforms, Indicator microorganisms.

UNIT – V (7 hours)

Disposal of solid waste by microbes and microbial remediation of environment: Sources and types of solid waste. Methods of solid waste disposal: sanitary landfills, composting (static piles, aerated piles and continuous feed reactors). Concepts of xenobiotics, recalcitrant compounds and bioremediation. Biodegradation of pesticides (DDT and Propanil), oil spills, e-waste and plastics.

Practical component

UNIT 1: (15 hours)

Soil microflora:

Study of the presence of microbial activity in soil by qualitative detection of enzyme activity: dehydrogenase, amylase, urease. Microbial interactions: Isolation and quantitation of bacteria from rhizosphere and root-free soil to determine the rhizosphere effect. Isolation of symbiotic and non-symbiotic nitrogen fixers: *Rhizobium* and *Azotobacter* or *Azospirillum*.

Unit 2: (15 hours)

Mineral cycling and waste management by microbial remediation: Demonstration of phosphate solubilization by plate isolation method. Student group project: Preparation of Winogradsky column mini aquatic ecosystem. Assessment of the microbiological quality of water by standard qualitative procedures. Determination of BOD of wastewater sample by Dissolved Oxygen Electrode method/ Winkler's method. **Student group project**: Sewage surveillance in the fight against COVID19.

Essential/recommended readings

Theory:

1. Brock Biology of Microorganisms by M.T. Madigan,J. Aiyer,D. Buckley,W.Sattley and D. Stahl.16th edition. Pearson, USA. 2021.
2. Microbial bioremediation by P. Rajendran and P. Gunasekaran. 1st edition, MJP Publishers, India. 2019.
3. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGrawHill Higher Education, USA. 2019.
4. Environmental microbiology by K.V. Ramesh. MJP Publisher. 2019.
5. Soil Microbiology by N.S. Subba Rao. 5th edition. Medtech, India. 2017.
6. Wastewater Microbiology by D.H. Bergey. Medtech, India. 2014.
7. Environmental Biotechnology by M. Jain. 1st Edition. Alpha Science International Ltd. 2014.
8. Environmental Microbiology edited by I.L. Pepper, C.P. Gerba, T.J. Gentry. 3rd edition.Academic Press, USA. 2014.
9. Microbial ecology by L.L. Barton and D.E. Northrup. 1st Edition. John Wiley & Sons. 2011.

10. Environmental Microbiology of Aquatic and Waste Systems by N. Okafor. Springer, USA.2011.
11. Environmental Biotechnology: Basic Concepts and Applications by I.S. Thakur. 2nd Edition. I K International Publishing House Pvt. Ltd. 2011.
12. Advances in Applied Bioremediation edited by A. Singh, R.C. Kuhad and O. P. Ward.Springer-Verlag, Germany. 2009.
13. Microbial Ecology: Fundamentals and Applications by R.M. Atlas, R. Bartha. 4th edition.Benjamin Cummings, USA. 2000.
14. Principles of Microbiology by R. M. Atlas. 2nd edition. W.M.T. Brown Publishers, USA.1997.

Practicals:

1. Benson's Microbiological Applications, Laboratory Manual in General Microbiology by A. Brown and H. Smith. 15th edition. McGraw-Hill Education, USA. 2022.
2. Microbiology: A Laboratory Manual by J. Cappuccino and C.T. Welsh. 12th edition. Pearson Education, USA. 2020.
3. Experiments in Microbiology, Plant Pathology and Biotechnology by K. R. Aneja. 5th edition. New Age International Publishers, India. 2017.
4. Manual of Environmental Microbiology by C. J., Hurst, R. L., Crawford, J. L., Garland and D. A. Lipson. American Society for Microbiology Press. USA. 2007.
5. Microbial Ecology: Fundamentals and Applications by R.M. Atlas and R. Bartha. 4th edition. Benjamin Cummings, USA. 2000.
6. Methods in Applied Soil Microbiology and Biochemistry by K. Alef and P. Nannipieri. Ist edition. Academic Press, USA. 1995.

Suggestive readings

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 1:
EUKARYOTIC MICROBES: BIOLOGY AND BIOTECHNOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE1: **EUKARYOTIC MICROBES: BIOLOGY AND BIOTECHNOLOGY**	**4**	**2**	**0**	**2**	**Class XII pass with Biology/ Biotechnology/ Biochemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of the course is to make students familiar with eukaryotic microorganisms namely algae, protozoa and fungi. They will become aware of their characteristics and applications in various fields such as industry, food, environment and medical science.
- They will understand how eukaryotic microbes can be used to develop eco-friendly and sustainable solutions to problems we are encountering in various fields.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to explain the characteristics of major algal types, the applications of micro and macro algae in different fields, and algae mass cultivation methods.
- Student will be able to describe different types of protozoa and their salient features, the significance of protozoa in medical, environmental and other fields.
- Student will be able to explain the characteristics of different types of fungi, their benefits and harmful effects, the biology and commercial importance of mushrooms.
- Student will be able to demonstrate the isolation and identification of green algae from pond water, the extraction and analysis of chlorophyll pigment. They will be able to discuss the thallus organization of different types of algae and the taxonomic position of Euglena.

- Student will be able to identify different types of protozoa and explain their major characteristics, the life cycles of some protozoa which cause diseases transmitted through insects or by contaminated food and water.
- Student will be able to describe different types of fungi and will be able to identify them based on their macroscopic and microscopic characteristics. They will be able to demonstrate fungal techniques, the difference between edible and poisonous mushrooms, steps of mushroom cultivation through visit to mushroom cultivation centre.

Theory component

Unit 1: (10 hours)

Algae structure, ecology and significance: General characteristics and brief account of habitat and thallus organization of major algal types: Chlorophyta, Bacillariophyta, Dinoflagellates, Xanthophyta, Phaeophyta and Rhodophyta. Applications of algae in wastewater treatment, biofuel and bioenergy products, pharmaceutical industries and food and feed sectors with reference to *Chlorella, Euglena, Dunaliella, Porphyra, Gracilaria,* diatoms*, Sargassum* and *Laminaria.* Mass cultivation of algae in open and closed photobioreactors.

Unit 2: (10 hours)

Protozoa structure, ecology and significance: An overview of habitat, cell structure, locomotion, and nutrition of different protozoa: *Entamoeba, Plasmodium, Giardia, Tetrahymena, Trypanosoma and Leishmania*. Disease causing protozoa: list of diseases, causative agent, mode of transmission, preventive measures currently in use (if any). Significance of protozoa in food web and water purification. Marine protozoa as source of filtering agents, chalk, abrasive and building material. Role of protozoa in symbiosis therapy and drug discovery. Role of *Tetrahymena* as model organism.

Unit 3: (10 hours)

Fungal structure, ecology and significance: An overview of habitat, thallus structure, nutrition and positive and negative importance (ecological, industrial, and medical) of different fungi: *Neocallimastix, Saccharomyces, Penicillium, Neurospora, Agaricus* and *Armillaria.* Detailed account of biology and commercial importance of Mushrooms: History, classification and distribution, life cycle, cultivation, nutrient and medicinal values; Edible and poisonous mushrooms.

Practical component

Unit 1: (24 hours)

Isolation, identification and pigment analysis of algae: Study of the following algae by temporary mounts/permanent slides/photographs (at least one alga to be studied by making temporary mounts): *Chlorella, Porphyra, Gracilaria,* diatoms*, Sargassum, Dunaliella, Caulerpa, Ulva.* Comparison of the vegetative thallus organization. Isolation of green algae from pond water and their identification by making temporary mounts. Recording of macroscopic and microscopic characterteristics of isolated algae. Extraction of pigment (chlorophyll) from algae and its analysis using chromatography or spectrophotometry. Study of the structure of *Euglena* cell highlighting its algal and protozoa characteristics discussion of its 'taxonomic enigma' status.

Unit 2: (16 hours)

Identification of protozoa and their importance: Study of different protozoa (*Entamoeba, Plasmodium, Giardia, Tetrahymena, Trypanosoma and Leishmania***)** with the help of permanent slides / photographs. Comparison of their structure and important characteristics. Study of the different stages of disease cycles of arthropod-borne protozoal diseases (*Plasmodium, Trypanosoma* and *Leishmania*) with the help of pictorial aids. **Student research study project**: Transmission, symptoms, prevention and cure of these diseases. Study of food and water-borne diseases caused by protozoa (*Entamoeba* and *Giardia*) in reference to life cycle, transmission, symptoms, prevention and cure. Comparison of the disease cycles of *Entamoeba* and *Giardia*.

Unit 3: (20 hours)

Identification of fungi and their importance: Study of fungi by temporary mounts/ permanent slides/photographs (at least one fungus to be studied by making temporary mounts): *Neocallimastix, Saccharomyces, Penicillium, Neurospora, Agaricus* and *Armillaria.* Observation of macroscopic and microscopic identifying characteristics. Preparation of spore suspension of fungus (*Aspergillus niger*) and counting of spores / ml using hemocytometer. Study of edible and poisonous mushrooms with the help of samples/photographs. Visit to mushroom cultivation center to learn various steps involved in mushroom cultivation.

Suggested Reading:

1. Brock Biology of Microorganisms by M.T. Madigan,J. Aiyer,D. Buckley,W.Sattley and D. Stahl.16th edition. Pearson, USA. 2021.
2. A Textbook on Mushroom Cultivation: Theory and Practice by A. Aggarwal, Y. P. Sharma, and E.Jangra.1st edition. Newrays Publishing House, India. 2021.
3. Prescott's Microbiology by J.M.Willey, K.Sandman and D. Wood. 11th edition. McGraw Hill Higher Education, USA. 2019.

4. Paniker's Textbook of Medical Parasitology by C.K. J. Paniker and S. Ghosh.8th edition. Jaypee Brothers Medical Publishers, India. 2018.

5. Laboratory Manual for Algae and Fungi by B.K.Chetri.1st edition.Lulu.com publisher.2018.

6. Textbook of Algae by O.P.Sharma. Tata McGraw Hill Publishing Co. Ltd, India. 2017.

7. Algae Biotechnology: Products and Processes by F.Bux, and Y. Chisti (Eds.) 1st edition. Springer International Publishing, USA. 2016.

8. Algae: Anatomy, Biochemistry, and Biotechnology by L. Barsanti and P.Gualtieri. 2nd edition.CRC Press, Taylor and Francis group,USA. 2014.

9. Introductory Mycology by C.J. Alexopoulos, C.W. Mims and M. Blackwell. 4th edition. John Wiley and Sons, New York. 2012 (reprint).

10. Manual of Soil Fungi by J.C. Gilman. 1st edition. Biotech Books, India. 2012 (Reprint).

11. Introduction to Fungi by J. Webster and R.W.S. Weber. 3rd edition. Cambridge University Press. USA. 2007.

12. The Fungi by G.Sumbali. 2nd edition. Narosa Publishing India House, India. 2005.

13. Protozoa by R.L. Kotpal. 12th edition. Rastogi Publication, India. 2006.

14. Manual of Phycology by G.M.Smith.1st edition. Scientific Publishers Journals, India.1994

DISCIPLINE SPECIFIC ELECTIVE COURSE – 2:
Applications of Statistics in Biology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE7: Applications of Statistics in Biology	4	2	0	2	Class XII pass with Biology/ Biotechnology/ Biochemistry	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to enable the students to understand the basic concepts of statistics and how statistics helps in analysing biological data by using simple examples. Students will learn to handle biological data using statistical tools and to draw appropriate conclusions from the analysis.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to explain the collection and analysis of data through descriptive statistics, measures of skewness and kurtosis, Discrete and Continuous Random variable; with emphasis on examples from biological sciences.
- Student will be able to describe correlation and regression, various Discrete and Continuous Distributions namely Binomial, Poisson, Exponential and Normal distribution.
- Student will be able to explain different statistical methods, principles of statistical analysis of biological data, sampling parameters.
- Student will be able to describe large sample test based on normal distribution, and small sample test based on t-test and F test

Contents:

Theory: **30 hours**

Unit 1: (10 hours)

Data collection and handling: Collection, Classification, Tabulation and Graphical representation of Data. Measure of central tendency and dispersion. Correlation and Regression analysis: Relation between two variables, curve fitting, two regression lines, Karl Pearson's coefficient of correlation.

Unit 2: (10 hours)

Probability, variables and types of distribution: Probability theory and concept of Random Variable (discrete and continuous), Standard distributions: Exponential distribution, Binomial distribution, Poisson distribution, Normal distributions.

Unit 3: (10 hours)

p-value and sample tests: Sampling Distributions, Testing of Hypothesis, Level of Significance and Degree of Freedom; Interpretation and significance of p-value. Large Sample Test based on Normal Distribution, small sample test based on t-test and F test.

Practicals: **60 hours**

Unit 1: (20 hours)

Handling of data, dispersion, Karl Pearson coefficient, and regression analysis using Excel: Handling of data using measures of central tendency; handling of data using measures of dispersion; finding Karl Pearson correlation coefficient and interpretation of result; Spearman rank correlation with and without ties; how to obtain regression lines.

Unit 2: (20 hours)

Distributions (Practical Using Excel): Fitting of binomial distributions for n and p = q = ½ given; fitting of Poisson distributions for given value of lambda; application problems based on binomial distribution; application problems based on Poisson distribution; problems based on area property of normal distribution; finding the ordinate for a given area for normal distribution; application based problems using normal distribution

Unit 3: (20 hours)

Sample tests and their applications (Practical Using Excel): Problems based on Large Sample Tests and interpretation of result; estimators of population mean when Population is large; Tests of hypotheses for the parameters of a normal distribution- Single Mean; Tests of hypotheses for the parameters of a normal distribution - Difference of Means; application of t-test- single mean, difference of means and Paired t-test; application of F- test and interpretation of result on given data set.

Suggested reading:

1. Introduction to the Theory of Statistics by A.M. Mood, F.A. Graybill and D. C. Boes. 3rd edition (Reprint). Tata McGraw-Hill, India. 2017.
2. An Introduction to Medical Statistics by M. Bland. 4th edition. Oxford University Press USA, 2015.
3. An Introduction to Biostatistics by N. Gurumani. 2nd edition. MJP publishers, India. 2014.
4. An introduction to Biostatistics and Research Methods by PSS Sunder Rao and J. Richard. 5th edition. PHI learning, India. 2012.
5. Fundamentals of Statistics (Vol. I & II) by A. M. Goon, M. K. Gupta and B. Dasgupta. 8th edition. The World Press, India. 2008.
6. Mathematical Statistics with Applications by I. Miller and M. Miller. 7th edition, Pearson Education, Asia. 2006.
7. Biostatistics: A Foundation for Analysis in the Health Sciences by Daniel, Wayne W. John Wiley, UK. 2005.
8. Fundamentals of Biostatistics by Irfan A Khan. Ukaaz Publications, India. 1994.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 3:
MICROBIAL QUALITY CONTROL IN FOOD AND PHARMACEUTICAL INDUSTRIES

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
MICROB-DSE12: MICROBIAL QUALITY CONTROL IN FOOD AND PHARMACEUTICAL INDUSTRIES	**4**	**2**	**0**	**2**	**Class XII pass with Biology/ Biotechnology / Biochemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is for students to develop an understanding of the concept and implementation of microbial quality control in the food and pharmaceutical industries.
- Students will gain insights into how the final products obtained for human and animal consumption are consistent, certified as safe for human consumption, and compliant with microbial standards.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to describe the parameters and techniques of Good Laboratory and Microbiological practices, sources of contamination, microbial monitoring of the environment and the concept of clean areas in the industry.
- Student will be able to explain the techniques of collecting and processing food, water and pharmaceutical samples for bioburden testing, various microscopic, culturing, biochemical, molecular and immunological testing techniques used for assessing the presence of microbes/pathogens as well as the toxic microbial products.

- Student will be able to describe Total Quality Management (TQM) system and Standard Operating Procedures (SOP) for fulfilling the requirements of Quality Control (QC) are created, various microbiological standards and certifications by accrediting bodies for food and pharmaceutical industries.
- Student will be able to demonstrate the techniques for checking milk quality by performing rapid and standard laboratory tests, method of testing of microbiological quality of water samples (Most Probable Number).
- Student will be able to describe how the food sample is processed for the detection of microorganisms, various differential and selective media to detect and identify different microorganisms present in a food sample.
- Student will be able to demonstrate sterility testing of various food and pharmaceutical products under different conditions.
- Student will be able to develop HACCP flow charts for different products, the application of various standards in quality regulation in food and pharma products with the help of case studies.

Contents:

Theory: **30 hours**

Unit 1. (8 hours)

Microbiological safe practices for food and pharmaceutical industry: Laboratory practices for safety and quality (GLP and GMLP). Concept of Biosafety cabinets. Biosafety levels (BSL-I to BSL-IV): designs, specifications and uses. Concept of Clean Area and its classification. Microbial monitoring of controlled environments (bioburden). Sources of contamination in food and pharmaceutical industries. Steps to avoid contamination. Food Safety, Sanitation Standard Operating Procedure (SSOP) and Personal Hygiene**.**

Unit 2: (14 hours)

Monitoring and analysis of microbiological quality of food and pharmaceutical samples: Types of products in food and pharmaceutical industries. Bioburden testing for food, beverages and medical devices. Collection and processing of samples for microbiological monitoring. Detection of microorganisms by microscopic method (fluorescence-based Direct Microscopic Count). Detection of microorganisms by cultural methods: enrichment technique, standard plate count, the concept of differential and selective media for detection of pathogens (XLD agar, Salmonella-Shigella agar, Mannitol salt agar, EMB agar, McConkey agar). Microbiological examination of non-sterile pharmaceutical products,

concept of microbial limits, sterility testing (its objectives and significance). Molecular, biochemical and immunological methods for detection of microorganisms and their products (Nucleic acid probes, PCR, biosensors, Limulus lysate test, pyrogen testing). Significance of rapid detection methods (Clot on Boiling Test, dye reduction test by Resazurin) in food industry.

Unit 3: (8 hours)

Microbial quality standards and management: Introduction and importance of quality standards. Concepts and approaches of Total Quality Management (TQM), Quality Management System, ISO 9001:2000, Quality Assurance and Quality Control. Development of Standard Operating Procedures. Hazard analysis of critical control point (HACCP): principles, applications and limitations. Concept of Codex Alimentarius and Codex Standards. Role of accredited certification bodies (BIS, Agmark, FSSAI, ISO) in maintaining product quality.

Practicals: 60 hours

Unit 1: (20 hours)

Testing of quality of milk and water samples: Checking the effectiveness of pasteurization of milk: Alkaline phosphatase test. Detection of microbiological quality of milk sample through Triphenyltetrazolium chloride (TTC) test, Clot on boil (COB) test and dye reduction test (Resazurin). Determination of microbiological quality of water sample by MPN method.

Unit 2: (30 hours)

Microbiological quality of food and pharmaceutical products: Sample processing for detection of microorganisms in food (one solid: Bread/idli batter/cheese/ biscuits/ pizza base/salad/cake etc. and one liquid:juice/ butter milk/ energy drink etc. sample/s.) Detection and Identification of microorganisms present in processed food samples through different types of media (XLD agar/Salmonella-Shigella agar, Mannitol salt agar, EMB agar, McConkey agar). Sterility testing of food (canned food/tetrapak drink) and pharmaceutical products (eye drops/injection ampoule) for aerobic microbes using cultural methods. Demonstration to test the presence of anaerobic microbes by virtual lab/video .Principle and concept of Limulus lysate (LAL) test for detecting the presence of endotoxin in consumable products by virtual lab/video.

Unit 3: (10 hours)

Quality regulation of food and pharmaceutical products: Study of HACCP of milk/dairy product with the help of flow chart. **Student group project**:

applications of various standards (BIS, Agmark, FSSAI, ISO) in quality regulation in food and pharma products: case studies involving at least one food and one pharma product.

Suggested Reading:

1. Analytical Food Microbiology: A Laboratory Manual by A.E. Yousef, J.G. Waite-Cusic and J.J. Perry. 2nd edition. Wiley Publishers, UK. 2022.

2. Essentials of Pharmaceutical Microbiology by A. Kar, 2nd edition. New Age International. India. 2020.

3. Food Safety and Quality Control by P. Mathur. 1st edition. The Orient Blackswan, India. 2018.

4. Pharmaceutical Biotechnology: Fundamentals and Applications by J.A.D. Crommelin, R. D. Sindelar, and B. Meibohm.(Eds.) 4th edition. Springer, Germany. 2016.

5. Manuals of methods of analysis of foods and water by Food Safety and Standards Authority of India, Ministry of health and family welfare, Government of India, 2016.
   https://old.fssai.gov.in/Portals/0/Pdf/Draft_Manuals/WATER.pdf
   https://old.fssai.gov.in/Portals/0/Pdf/Manual_Fruits_Veg_25_05_2016.pdf

6. Pharmaceutical Microbiology: Essentials for quality assurance and quality control by T. Sandle. 1st edition. Woodhead Publishing. UK. 2015.

7. Fundamentals of Food Microbiology by Bibek Ray and A. Bhunia. 5th edition. CRC Press UK. 2013.

8. Pharmaceutical Biotechnology: Concepts and Applications by G. Walsh. 1st edition. John Wiley & Sons Ltd. USA. 2011.

9. Modern Food Microbiology by J.M. Jay, M.J. Loessner and D.A. Golden. 7th edition. CBS Publishers and Distributors, India. 2006.

10. Handbook of Microbiological Quality control in Pharmaceutical and Medical Devices. R.M Baird, N.A Hodges, and S.P Denyer (Eds) 2nd edition. Taylor and Francis Inc., USA. 2005.

11. Hugo and Russell's Pharmaceutical Microbiology by S.P. Denyer, N.A. Hodges and S.P. Gorman. 7th edition. Blackwell Science. 2004.

12. Microbiological Analysis of Food and Water: Guidelines for Quality Assurance by N.F. Lightfoot and E.A. Maier. 1st edition. Elsevier Science. 1998.

13. Quality control in the Pharmaceutical Industry by M.S. Cooper (Ed). Vol.2. Academic Press,USA.1974.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 4: BIOTECHNIQUES AND INSTRUMENTATION

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
MICROB-DSE2: BIOTECHNIQUES AND INSTRUMENTATION	**4**	**2**	**0**	**2**	**Class XII pass with Biology/ Biotechnology / Biochemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this paper is to develop a strong understanding of the principles and applications of some basic and advanced techniques frequently used in sciences dealing with biological systems. This will allow the students to relate the concepts of the various areas being taught to them with the working and applicability of the instruments and techniques involved.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Will have learnt about the main components, working principles, and applications of different types of microscopes. The student will also be familiarized with the preparation of samples and staining for microscopy.
- Will have gained knowledge of basic concepts, applications, merits and limitations of various bio separation techniques like chromatography, electrophoresis and centrifugation.
- Will be acquainted with the principles and applications of some analytical techniques like X-ray diffraction and UV-visible spectrophotometry. Will have been introduced to the concepts of advanced techniques like circular dichroism, NMR spectroscopy and mass spectrometry.
- Will be able to use the microscope to determine the size of microbial cells applying the technique of micrometry. Will also be able to separate

biomolecules using planar (paper chromatography/ TLC) and column chromatography.

- Will have gained hands-on experience of separation of mixtures using gel electrophoresis techniques (PAGE/Agarose) and laboratory centrifuges. Will have gained knowledge of working of density gradient centrifugation with the help of virtual lab / videos.
- Will be able to determine the λmax for an unknown sample and be able to calculate its extinction coefficient using a spectrophotometer. Will get familiar with the technique of autoradiography and NMR spectroscopy with the help of virtual lab / videos.

Theory: **30 hours**

Unit 1: (10 hours)

Principles and applications of microscopy: Concept of resolving power and magnification. Principles, working, and applications of : Bright-field and dark-field microscopy, phase contrast microscopy, fluorescence microscopy, confocal microscopy, electron microscopy (scanning electron microscopy, transmission electron microscopy, and cryo- electron microscopy).

Unit 2: (12 hours)

Principles and applications of separation techniques: Partition chromatography: thin layer chromatography. Column chromatography: gel filtration, ion-exchange, affinity and HPLC. Differential and density gradient centrifugation, ultracentrifugation. Agarose gel electrophoresis. Polyacrylamide gel electrophoresis.

Unit 3: (8 hours)

Principles and applications of other analytical techniques: UV-Visual spectrophotometry (Beer and Lambert Law), X-ray diffraction, circular dichroism, nuclear magnetic resonance (NMR) spectroscopy, mass spectrometry.

Practicals: **60 hours**

Unit 1: (24 hours)

Micrometry and chromatography: Principle of micrometry. Determination of the sizes of different microbial cells by micrometry. Separation of complex mixtures of biomolecules by paper chromatography/ Thin Layer Chromatography. Group project: Packing and running column chromatography. Determination of molecular weight of a protein using gel filtration chromatography.

Unit 2: (20 hours)

Electrophoresis and centrifugation: Separation of DNA by agarose gel electrophoresis. Separation of proteins by SDS-PAGE. Separation of components of a given mixture using a laboratory scale centrifuge using various rotors. Understanding density gradient centrifugation with the help of virtual lab.

Unit 3: (16 hours)

Imaging and advanced analytical techniques: Using spectrophotometer to determine λ_{max} for an unknown sample and calculation of extinction coefficient. Principle and working of autoradiography. Demonstration of autoradiography using virtual lab / video. Understanding NMR spectroscopy with the help of virtual lab / video.

Suggested Reading:

1. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology edited by A. Hofmann and S. Clokie. 8th edition. Cambridge University Press, UK. 2018.
2. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGraw Hill Higher Education, USA. 2019.
3. The Cell: A Molecular Approach by G.M. Cooper. 8th edition. Sinauer Associates, UK. 2018.
4. Lehninger Principles of Biochemistry by D.L. Nelson and M.M. Cox. 7th edition. W.H. Freeman and Company, UK. 2017.
5. Biophysical Chemistry by D. Klostermeier and M.G. Rudolph. 1st edition. CRC press, UK. 2017.
6. Principles of Instrumental Analysis by D.A. Skoog, F.J. Holler and S.R. Crouch. 7th edition. Cengage Learning, USA. 2017.
7. Techniques and Methods in Biology. K. L. Ghatak. PHI Learning Private Limited, India. 2011.
8. Lab Manual in Biochemistry, Immunology and Biotechnology by A. Nigam and A. Ayyagari. Tata McGraw Hill, India. 2007.
9. Physical Biochemistry- Application to Biochemistry and Molecular Biology by D. Freifelder. 2nd edition. W.H. Freemen and Company, USA. 1982.
10. Systems Biology: A textbook by E. Klipp et al. 2nd edition. Wiley-VCH. 2016

DISCIPLINE SPECIFIC ELECTIVE COURSE – 5: PLANT-PATHOGEN INTERACTIONS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE8: PLANT-PATHOGEN INTERACTIONS	4	2	0	2	Class XII pass with Biology/ Biotechnology/ Biochemistry	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to provide the students with an overview of the interactions of pathogenic microbes with their host plants, and how these interactions lead to plant disease. The students will become aware of the biochemical basis of plant- pathogen interactions, the production of virulence factors by pathogens, and thei defence mechanisms induced in plants in response to infection.
- They will learn about the genetic basis of disease resistance. They will be able to identify plant pathogens from the symptoms and microscopic study of infected plant specimens.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to explain the important terms related to plant diseases, the scientific contributions of prominent plant pathologists, how microbes attack plants using enzymes, toxins, growth regulators etc., thereby affecting their physiological processes.
- Student will be able to explain describe how plants defend themselves upon attack by pathogens with help of Case studies of some important plant diseases.
- Student will be able to describe the genetics of plant disease and resistance, and developing disease-resistant transgenic plants.

- Student will be able to identify plant pathogens by observing symptoms of diseased plants, cutting sections/ preparing whole mounts of diseased plant material, and observing microscopically.
- Student will be able to explain the etiology, symptoms and control measures of specific bacterial, phytoplasma, virus and viroid diseases with the help of photographs of diseased plants, common disease symptoms observed in locally grown plants during a field visit.
- Student will be able to explain the concept of Koch's postulates using pathogen-infected plant material.

Contents:

Theory: **30 hours**

Unit 1: (5 hours)

Introduction to plant pathology: Concepts and history: Concept of disease and pathogenesis. Causal organisms and symptoms associated with common plant diseases: rust, smut, blight, chlorosis, necrosis, gall, mosaic and wilt. Contributions of the following plant pathologists: E. J. Butler, Anton DeBary, Alexis Millardet, E. Smith, T. O. Diener, E. C. Stakman, J. E. Vanderplank, B. B. Mundkur, J. F. Dastur.

Unit 2: (19 hours)

Physiochemical basis of host-pathogen interactions: Virulence factors of pathogens - Enzymes: pectinases, cellulases. Toxins: host-specific (HV, T-toxin) and non-specific (tabtoxin, tentoxin). Growth regulators: auxin, gibberellin. Virulence factors in viruses: replicase, coat protein, silencing suppressors. Host physiological processes affected by pathogens - photosynthesis, respiration, cell membrane permeability, translocation of water and nutrients, plant growth and reproduction. Defense mechanisms in plants - Inducible structural defenses (histological: cork layer, abscission layer, tyloses,gums), inducible biochemical defenses (hypersensitive response (HR), systemic acquired resistance (SAR), phytoalexins, pathogenesis-related (PR) proteins). Study of some important diseases (etiology, epidemiology, symptoms and control measures): bacterial (crown gall), fungal (black stem rust of wheat), viral (Tobacco mosaic virus, Banana bunchy top).

Unit 3: (6 hours)

Genetics of plant disease resistance: Gene for gene hypothesis: concept of resistance (R) gene and avirulence (avr) gene, the gene for gene hypothesis. Types of plant resistance: true resistance– horizontal and vertical, apparent resistance-disease escape, disease tolerance. Genetic engineering for disease

resistance in plants: with plant-derived genes and pathogen-derived genes.

Practicals: **Duration: 60 hours**

Unit 1: (24 hours)

Identification of plant pathogens examining infections microscopically: Principle and working method of lactophenol cotton blue staining. Preparation of whole mount of plant material, followed by staining with lactophenol cotton blue and microscopic observation for identification of the pathogen. Cutting fine transverse sections of infected plant material, staining with lactophenol cotton blue and observing the slide microscopically for identification of the pathogen. Any four from: *Albugo/ Puccinia/ Ustilago/ Phytophthora/ Fusarium/ Peronospora.*

Unit 2: (24 hours)

Study of plant diseases: Study of the etiology, symptoms and control measures of the following diseases. Bacterial: angular leaf spot of cotton, citrus canker. Phytoplasma: aster yellow, citrus stubborn. Viral: rice tungro disease, papaya ring spot, leaf curl of tomato. Viroid: potato spindle tuber, coconut cadang cadang disease. Field visit to a local park/college garden, to study common plant disease symptoms in plants. Recording observations in files with photographs of the diseased plants. **Study research study project**: History, etiology, symptoms, control measures, and economic impact if any, of any four rare plant diseases.

Unit 3: (12 hours)

Demonstration of Koch's postulates using a fruit/ vegetable infected with a plant pathogen: Observation of symptoms, isolation of pathogen by inoculation on potato dextrose agar plates, microscopic identification of the pathogen. Reinoculating it on a healthy fruit/vegetable to observe for similar symptoms, followed by reisolating it and observing microscopically in order to prove Koch's postulates.

Suggested Reading:

1. Fundamental of Plant Pathology Practical Manual by S. Singh, A. Kumar, A.K. Mishra. 1st edition. Deepika Book Agency, India. 2021.

2. Practical lab manual for Microbiology and Plant pathology by Huma Naaz, Hadi Husain Khan, Chandan Kumar Singh. 1st edition. AkiNik Publications, India. 2018.

3. Plant Diseases by R.S. Singh. 10th edition. MedTech, India. 2017.

4. Introduction to Principles of Plant Pathology by R.S. Singh. 5th edition. MedTech, India.2017.

5. Plant Pathology by R.S. Mehrotra and A. Aggarwal. 3rd edition. Tata McGraw-Hill Education, India. 2017.

6. Diseases of Crop Plants in India by G. Rangaswami and A. Mahadevan. 4th edition. Prentice Hall, India. 2005.

7. Plant Pathology by G. N. Agrios. 5th edition. Elsevier Academic Press, USA. 2005.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 6:
BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE9: BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS	**4**	**2**	**0**	**2**	**Class XII pass with Biology/ Biotechnology/ Biochemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of the course is to introduce students to the fundamental aspects of biosafety and Intellectual Property Rights (IPR) to enable them to understand concerns related to safety from biological hazards and to gain an overview of the biosafety regulatory framework.
- They will be introduced to the importance of protecting intellectual property and become familiar with all aspects of the IPR Acts. Through case studies in law and scientific research students will understand the applications of the legal concepts in the space of scientists, scientific discoveries and innovations.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to describe how national and international biosafety regulations are formulated and implemented at the level of research institutes and laboratories locally, so as to safeguard the handlers as well as the environment from potential pathogens.
- Student will be able to describe the role of an IBSC in the biosafety regulatory framework and how to file an application seeking approval of a research proposal involving an LMO.

- Student will be able to explain the guidelines and precautions that need to be followed during the handling of radioisotopes, the concepts of Intellectual Property Rights, how they are protected through patents.
- Student will be able to demonstrate how to file a patent application. Student will be able to explain some International Agreements, Treaties and Acts governing protection of IPR.
- Student will be able to discuss the basic concepts of protection of IP through Copyright, Trademarks, Geographical indications, Industrial designs, Traditional Knowledge and New Plant Varieties along with specific biotechnological cases.

Contents:

Theory: **30 hours**

Unit 1: (12 hours)

Biosafety: Biosafety levels and risk groups. Role of Institutional Biosafety Committees (IBSC). GMOs/LMOs: Concerns and Challenges. GRAS microorganisms. Risk Analysis, and Assessment for Environmental release of GMOs, Cartagena Protocol. AERB/RSD/RES guidelines for using radioisotopes in laboratories and precautions to be taken.

Unit 2: (12 hours)

Intellectual Property Rights and its types: Introduction and need for intellectual property rights (IPR). Patents: Types of inventions protected by a patent. Prior art search, patent applications and its types, patenting process. Patent infringement, Rights and Duties of patent owner. Patent Publications. Trade secrets and know-how agreements. Budapest Treaty on international recognition of the deposit of microorganisms. Patenting life: legal protection of biotechnological inventions-World Intellectual Property Rights Organization (WIPO) TRIPS, compulsory licensing, Patent Co-operation Treaty (PCT)

Unit 3: (6 hours)

Copyrights, Trademarks, Geographical indications, Industrial designs and New Plant Varieties and Traditional knowledge: Concepts, need, coverage and duration. Commercializing Biotechnology Invention. Case studies of Biotechnology.

Practicals: **60 hours**

Unit 1: (24 hours)

Biosafety levels and guidelines: Study of the layout and design of BSL-1, BSL-2, BSL-3 and BSL-4 laboratories and precautions to be followed according to the level of containment. Filing applications for approval from the Institutional Biosafety Committee (IBSC). **Student group project**: the emergence of biotechnology as the most important tool used to combat the Covid19 pandemic, biosafety protocols in handling Sars-CoV2.

Unit 2: (16 hours)

Genetically Modified Organism: Designing a suitable strategy to protect a genetically modified organism. Case study of the release of GMO Bt Cotton. Status of Bt brinjal and GM mustard in India.

Unit 3: (20 hours)

Patent applications and related case studies: The procedure for filing a patent application. Case study of patenting of basmati rice (GI). Case study of turmeric/ neem (traditional knowledge). **Student group project**: Preparation of patent application

Suggested Reading:

1. Intellectual Property Rights in India by P. Saidaiah and K. Ravinder Reddy. International Books and Periodical Supply Service, India. 2020.
2. The Blessing and Curse of Biotechnology: A Primer on Biosafety and Biosecurity, article by R. Langer and S. Sharma. https://carnegieendowment.org/2020/11/20/blessing-and-curse-of-biotechnology- primer-on-biosafety-and-biosecurity-p. 2020.
3. Intellectual Property Rights at a Glance by P. Singh and R.Singh. Daya Publishing House, New Delhi. 2018.
4. Biological Safety: Principles and Practices by D.P. Wooley and K.B. Byers. 5th edition. ASM Press, USA. 2017.
5. Fundamentals of Intellectual Property Rights: For Students, Industrialist and Patent Lawyers by B. Ramakrishna and H.S. Anil Kumar. 1st edition. Notion Press, India. 2017.
6. Biotechnology and Intellectual Property Rights: Legal and Social Implications by K. K Singh. Springer, India. 2015.

7. IPR, Biosafety and Bioethics by D. Goel and S. Parashar. 1st edition. Pearson Education, India. 2013.

8. Law Relating to Patents, Trade Marks, Copyright, Designs and Geographical Indications by. B.L.Wadehra. Universal Law Publishing, India. 2004

9. Encyclopedia of Ethical, Legal and Policy issues in Biotechnology edited by T. M Murrayand M.J. Mehlman. John Wiley and Sons, UK. 2000.

10. http://shodhganga.inflibnet.ac.in/bitstream/10603/205165/7/chapter%20iii.pdf

11. https://dbtindia.gov.in/regulations-guidelines/regulations/biosafety-programme

DISCIPLINE SPECIFIC ELECTIVE COURSE – 7:
APPLICATIONS OF MICROBES IN BIOREMEDIATION AND PETROLEUM INDUSTRY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE10: APPLICATIONS OF MICROBES IN BIOREMEDIATION AND PETROLEUM INDUSTRY	4	2	0	2	Class XII pass with Biology/ Biotechnology/ Biochemistry	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this paper is to provide students with a comprehensive understanding of the process of bioremediation, its strategies, and the role played by microorganism in dealing with environmental pollutants of concern.
- This course highlights the applications of microbes in Microbial Enhanced Oil Recovery (MEOR), clean-up of oil spills, and the detoxification of heavy-metal contaminated environment. Students will acquire hands-on training in the above-mentioned areas.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to explain the concepts of microbial bioremediation, its strategies and its applications, the microbiology of oil fields,Microbial Enhanced Oil Recovery (MEOR) and role of microbes in cleaning up of oil-spills.
- Student will be able to describe the use of biosensors in detection of heavy metals, explain heavy metal tolerance in microorganisms and the application of microbes in the detoxification of such contaminated sites.
- Student will be able to demonstrate the practical skills to isolate hydrocarbon-degrading microorganisms and assess their degradation potential.

- Student will be able to demonstrate how to detect and screen biosurfactant-producing microorganisms in the laboratory.
- Student will be able to demonstrate the isolation of heavy metal tolerant microorganisms, and discuss with case-studies on Microbial Enhanced Oil Recovery.

Contents:

Theory: **30 hours**

Unit 1: (12 hours)

Microbes and Bioremediation: Concept of bioremediation. Abiotic and biotic factors affecting bioremediation by microorganisms. *In-situ* bioremediation strategies: Biosparging, Bioventing, Bioslurping, Biostimulation, Bioaugmentation, and Bioattenuation. *Ex-situ* bioremediation techniques: Bioreactor, Biopiling, Landfarming, composting and Biofilters. Use of genetic engineered microorganisms (GEMs). Advantages, disadvantages and applications of bioremediation.

Unit 2: (12 hours)

Bioremediation of oil spills and microbial enhanced oil recovery: Microbiology of oil fields: introduction to oil fields, formation of oil reservoirs, oil production, indigenous microbial communities in oil fields. Hazards of petroleum hydrocarbon contamination. Microbial degradation of petroleum hydrocarbons (aliphatic, alicyclic, aromatic). Abiotic and biotic factors affecting the degradation of petroleum hydrocarbons. Strategies used to clean up oil spills using microorganisms. Applications of microbial consortia and oil-eating superbugs in bioremediation. Enhanced oil recovery (EOR) versus Microbial Enhanced Oil Recovery (MEOR) Microorganisms and microbial products used in MEOR (biomass, bio-surfactants, biopolymers, solvents, acids, and gases). Technologies used in *ex-situ and in - situ* MEOR applications.

Unit 3: (6 hours)

Heavy metal remediation by microbes: Sources and hazards of heavy metal pollution (As, Cu, Pb, Cd, Hg). Metal-microbes interaction and heavy metal tolerance by microorganisms. Applications of microbes in biosorption and detoxification of environment contaminated with heavy metal(s). Use of biosensors in detection of heavy metal contamination.

Practicals: **60 hours**

Unit 1: (20 hours)

Isolation and detection of hydrocarbon-degrading microorganisms: Sample collection from an oil - contamination site, enrichment, isolation on a suitable minimal medium containing petroleum hydrocarbon, identification of isolates by suitable staining and microscopic observation. Detection of hydrocarbon degradation by the isolates using the redox dye Dichlorophenol-indophenol (DCPIP)**.**

Unit 2: (20 hours)

Detection and screening of bio-surfactant producing microorganisms: Detection of biosurfactant production by hydrocarbon-degrading microorganisms using oil spread method. Screening and selection of the biosurfactant-producing microbes by the following hydrophobicity tests: (1) Drop-collapse method using positive control (Tween-80) and negative control (distilled water) (2) Toluene test (spectrophotometric measurement) and (3) by hydrophobic interaction column chromatography (using Octyl-Sepharose resin).

Unit 3: (20 hours)

Isolation of heavy metal-tolerant microorganisms and case-studies: Sample collection from potential heavy metal-contamination sites (soil/sewage/water bodies/mines), isolation on minimal medium with increasing concentrations of the heavy metal, identification of isolate by suitable staining and microscopic observation. Screening of the isolates for their metal tolerance in broth cultures containing heavy metals. Case studies on *ex-situ* and *in-situ* Microbial Enhanced Oil Recovery by discussions and with the help of visual aids.

Suggested Reading:

1. Brock Biology of Microorganisms by M. T. Madigan, K.S. Bender, D.H. Buckley, W.M. Sattele and D. A. Stahl 16th edition. Pearson, USA. 2021.
2. Microbiology: A Lab Manual by J. G. Cappuccino and C. T. Welson. 12th edition. Pearson. 2020.
3. Waste Water Microbiology by D. H. Bergey. 2nd edition. MedTech, India. 2019.
4. Practical Environmental Bioremediation: The Field Guide by R. B. King, J. K. Sheldon and G.M. Long. 2nd edition. CRC Press, USA. 2019.
5. Prescott's Microbiology by J.M. Willey, K. Sandman and D. Wood. 11th edition. McGraw Hill Higher Education. USA. 2019
6. Soil Microbiology by N. S. Subba Rao. 5th edition. MedTech, India. 2017

7. Environmental Microbiology by I. L. Pepper, C. P. Gerba and T.J. Gentry. (Ed). 3rd edition. Academic Press, USA. 2014.
8. Environmental Microbiology of Aquatic and Waste Systems by N. Okafor. Springer, USA. 2011.
9. Advances in Applied Bioremediation by A. Singh, R. C. Kuhad and O. P. Ward. Springer- Verlag, Germany. 2009.
10. Environmental Microbiology: A Laboratory Manual by I. L. Pepper and C. P. Gerba 2nd edition. Elsevier Academic Press, USA. 2004.
11. Microbial Ecology: Fundamentals and Applications by R. M. Atlas and R. Bartha. 4th edition. Benjamin Cummings, USA. 2000.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 8: SCIENTIFIC WRITING AND COMMUNICATION

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE16: SCIENTIFIC WRITING AND COMMUNICATION	**4**	**2**	**0**	**2**	**Class XII pass with Biology/ Biotechnology/ Biochemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to familiarize the students with the basic principles of science writing and communication. Students will become aware of databases and tools for effective writing and will be empowered to take up careers as research analysts, technical writers, editors of journals and books etc. They will gain insights into the process of scientific publication. They will learn to effectively communicate science to the masses.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to demonstrate how to carry out a literature search, and explain various types of scientific writings, structure of scientific manuscript and study design.
- Student will be able to describe various types of journals, the concept of impact factors, steps in publication, and software to detect plagiarism.
- Student will be able to discuss the process of writing grant, and how to communicate effectively on scientific issues
- Student will be able to describe the process of writing research/review articles, the process of presenting scientific data through poster or oral presentation.

Contents:

Theory: **30 hours**

Unit 1: (10 hours)

Scientific literature and study design: Understanding research writing. Conducting literature search, scientific literature databases and gap analysis. Types of contemporary science writing (original research article, review, systematic review, meta-analysis, commentary, and opinion). Structure/outline of a research article. Survey study, questionnaire design, using common statistical tools/software for data analysis and presentation in research articles.

Unit 2: (13 hours)

Publication process: Identifying relevant journals through online tools. Impact factor, H-index, citations, Science Citation Index. Steps of the publication process: preparation of manuscript, textual and graphical abstracts, use of multimedia in scientific writing, editing and proofreading, referencing styles, authorship, ethical requirements in science publication, plagiarism detection tools (URKUND/Turnitin), peer review process, predatory publishers andjournals, open access publication.

Unit 3: (7 hours)

Generating funding for research and elements of communication: Introduction to national (DBT, SERB) and international funding agencies (NIH, Welcome Trust). Basics of grant- writing, and structuring a research proposal for extramural funding.

Practicals: **60 hours**

Unit 1: (15 hours)

Communicating scientific issues to the public: Drafting popular articles (newspaper/ magazines). Multimedia tools for effective writing and communication (creating stories using photos, illustrations, audio, video, animation). Publishing blogs.

Unit 2: (30 hours)

Writing original research / review articles: Drafting abstracts. Hands-on training in the preparation of manuscript text: methods, results, discussion, and conclusion. Presenting data in tables and figures: use of Microsoft Excel. Hands-on training in the use of Mendeley to insert references / citations in an article. Writing a review article based on 10 research papers in 1000 words.

Unit 3: (15 hours)

Presentation of scientific data in conferences/seminars: Designing posters. Training in oral presentations: use of Microsoft Powerpoint. Presenting the research and main findings of recent scientific articles through Journal Club**.**

Suggested Reading:

1. Research Methodology and Scientific Writing by C.G. Thomas. 2nd edition. Springer. 2021.
2. Scientific writing and communication by A. Hoffman. 4th edition. Oxford University Press. 2019.
3. Effective writing and publishing scientific papers - Part I: how to get started by D. Kotz and J.W. Cals. 2013. J Clin Epidemiol. 66(4):397.
4. Effective writing and publishing scientific papers - Part II: title and abstract by D. Kotz and J.W. Cals. 2013. J Clin Epidemiol. 66(6):585.
5. Effective writing and publishing scientific papers - Part III: introduction by D. Kotz and J.W. Cals. 2013. J Clin Epidemiol. 66(7):702.
6. Effective writing and publishing scientific papers - Part IV: methods by D. Kotz and J.W. Cals. 2013. J Clin Epidemiol. 66(8):817.
7. Effective writing and publishing scientific papers - Part V: results by D. Kotz and J.W. Cals. 2013. J Clin Epidemiol. 66(9):945.
8. Effective writing and publishing scientific papers - Part VI: discussion by D. Kotz and J.W. Cals. 2013. J Clin Epidemiol. 66(10):1064.
9. Effective writing and publishing scientific papers - Part VII: tables and figures by D. Kotz and J.W. Cals. 2013. J Clin Epidemiol. 66(11):1197.
10. Effective writing and publishing scientific papers - Part VIII: references by D. Kotz and J.W. Cals. 2013. J Clin Epidemiol. 66(11):1198.
11. Effective writing and publishing scientific papers - Part IX: authorship by D. Kotz and J.W. Cals. 2013. J Clin Epidemiol. 66(12):1319.
12. Effective writing and publishing scientific papers - Part X: choice of journal by D. Kotz and J.W. Cals. 2014. J Clin Epidemiol. 67(1):3.
13. Effective writing and publishing scientific papers - Part XI: submitting a paper by D. Kotz and J.W. Cals. 2014. J Clin Epidemiol. 67(2):123.
14. Effective writing and publishing scientific papers - Part XII: responding to reviewers by D. Kotz and J.W. Cals. 2014. J Clin Epidemiol. 67(3):243.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 9: AGRICULTURAL MICROBIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE13: AGRICULTURAL MICROBIOLOGY	4	2	0	2	Class XII pass with Biology/ Biotechnology/ Biochemistry	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this paper is to enable students to develop a clear understanding of the importance of microbes in agriculture to enable them to find eco-friendly solutions to agricultural problems.
- Students will get an overview of soil characteristics and the role of microbes and plant-microbe interactions in soil fertility. Students will study about the production and application of different types of commercial biofertilizers, become familiar with microbial biocontrol agents, and gain knowledge of composting, and organic farming. They will gain insights into recent trends in agriculture including agrowaste management and transgenics

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to explain types of soil and its characteristics, important microorganisms involved in mineralization of essential nutrients present in the soil and their significance in agriculture, plant-microbe interactions including symbiotic and asymbiotic associations, the commercial production of biofertilizers and method of composting.

- Student will be able to describe eco-friendly ways to control agricultural pests and pathogens, the mode of action, mass production and field applications of various biocontrol agents.
- Student will be able to discuss the recent trends in agricultural microbiology with reference to agrowaste management, organic farming and transgenic plants.
- Student will be able to demonstrate the isolation and screening of various microbes important in soil fertility (PGPR, VAM), the isolation of microorganisms from commercially available biofertilizers.
- Student will be able to explain the different stages of nodule development in leguminous plant roots and will observe nodule-forming bacteria under the microscope, the antagonistic potential of Trichoderma spp. as biological control agent against other fungi.
- Student will be able to describe composting as one of the ways of agrowaste management, the role of thermophiles in composting and the different enzymes involved in biodegradation, steps of mass production of blue green algae and application of microbes in organic farming/biogas production.

Theory: **30 hours**

Unit 1: (14 hours)

Soil fertility and Biofertilizers: Physical and chemical characteristics of different types of soil. Macro and micronutrients in soil. Role of NPK and biogeochemical cycles in soil fertility. Scope of microbes as biofertilizers and their advantages over chemical fertilizers. Isolation, characteristics, mass production and field applications of biofertilizers- Symbiotic: *Rhizobium, Frankia, Acetobacter diazotrophicus*, *Anabaena,* Mycorrhizal associations with special emphasis on VAM/AM fungi. Asymbiotic**:** Nitrogen-fixing bacteria (*Azospirillum, Azotobacter*), Plant growth promoting rhizobacteria (PGPR). Composting: types, methods, applications.

Unit 2: (8 hours)

Biocontrol agents and Biopesticides: Importance, potential and types of biocontrol agents. Microbes used as biopesticides, their mode of action, and advantages over chemical pesticides. Mass production and field applications of *Bacillus thuringiensis*, *Baculoviruses, Beauveria bassiana*, *Metarhizium anisopliae* and *Trichoderma spp*.

Unit 3: (8 hours)

Recent trends in Agriculture Microbiology: Agrowaste management and its significance: Biofuel, Bioenergy, Animal Feed. Organic farming: types, methods and

advantages. Development of transgenic plants: *Agrobacterium*-mediated plant transformations with specific example of Bt cotton.

Practicals: **60 hours**

Unit 1: (28 hours)

Isolation of microbes important in soil fertility: Isolation and screening of plant growth promoting rhizobacteria (PGPR) from soil. Isolation of microbes from commercially available biofertilizers using solid media. Isolation of VAM spores from the soil sample using "Wet-sieving and decanting technique" for spores extraction and observing them under microscope. Study of VAM colonization using temporary slides/photographs.

Unit 2: (16 hours)

Study of microbe interactions in soil: Demonstration of stages of nodule formation in leguminous plant with the help of photographs. Slide preparation of crushed nodule to observe nodule forming bacteria. Study of antagonistic activity of *Trichoderma* sp. against different fungi (any 2) using dual culture plate technique. Test of antagonistic efficacy on potato dextrose agar: simultaneous inoculation of antagonist and test fungus at two extreme positions and recording of zone of inhibition after 5 days of incubation.

Unit 3: (16 hours)

Agrowaste management: Hands-on training in composting using a variety of plant/food waste. Isolation of thermophiles from compost and qualitative assay of any two enzymes (amylase/cellulase/xylanase) using compost sample. Visit to mass production facility of blue green algae/biogas plant/organic farm.

Suggested Reading:

1. Benson's Microbiological Applications, Laboratory Manual in General Microbiology by A. E. Brown and H. Smith.15th edition. McGraw-Hill Education, USA. 2022.

2. Biopesticides and Bioagents: Novel tools for pest management by M. A. Anwer. I st edition. Apple Academic Press, USA. 2021.

3. Bioprocess Technology by P. T. Kalaichelvan and I. A. Pandi. 1st edition. MJP Publishers, India. 2021 (reprint).

4. Microbiology: A Laboratory Manual by J. Cappuccino and C.T. Welsh. 12th edition. Pearson Education, USA. 2020.

5. Soil Microbiology by N.S. Subba Rao. 5th edition. Oxford & Ibh Publishing, USA. 2020.

6. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGraw Hill Higher Education, USA. 2019.

7. Biofertilizers in Agriculture and Forestry by N.S. Subba Rao. 4th edition. Medtech. India. 2019.

8. Advances in soil microbiology: recent trends and future prospects by T.K. Adhya, B. Lal, B. Mohapatra, D. Paul and S. Das. Volume 2. Springer, Singapore. 2018.

9. Experiments in Microbiology, Plant Pathology and Biotechnology by K. R. Aneja. 5th Edition. New Age International Publishers, India. 2017.

10. Development of Bioinsecticides by F. Saleem A.R. Shakooori. Lap Lambert Academic Publishing, European Union. 2012.

11. Advanced Environmental Biotechnology by S.K. Aggarwal. 1st edition. APH publication, India. 2005.

12. Biotechnology of Biofertilizers edited by S. Kannaiyan. 1st edition. Springer, Netherlands. 2002.

13. Bioinoculants for Sustainable Agriculture and Forestry by S.M. Reddy. 1st edition Scientific Publishers, India. 2002.

14. Microbial Ecology: Fundamentals and Applications by R.M. Atlas and R. Bartha. 4th edition. Benjamin Cummings, USA. 2000.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 10:
PRINCIPLES OF GENETICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE3: **PRINCIPLES OF GENETICS**	**4**	**2**	**0**	**2**	**Class XII pass with Biology/ Biotechnology/ Biochemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is for students to gain knowledge of the major concepts of genetics. Students will build a foundation for understanding the basic principles of inheritance and heredity starting from classical genetics, and will gain insights into chromosomal behaviour, rearrangements and their consequences.
- Students will also learn about complex multifactorial quantitative genetics and population genetics in relation to survival and evolution. Through this course the students will develop a better understanding of life processes, survival and maintenance.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to explain the laws of inheritance, linkage, crossing over and its application to gene mapping.
- Student will be able to describe the mechanisms for extranuclear inheritance, complex traits and population genetics principles, model organisms of genetic research.
- Student will be able to explain pedigree analysis, aberrations in chromosomal structure and number.
- Student will be able to demonstrate the techniques of karyotyping and chromosome banding, the giant chromosomes.

Theory: **30 hours**

Unit 1: (12 hours)

Introduction to basics of Genetics: History: A brief account of early genetic experiments: Mendel's work. Studying variation: phenotype and genotype. Single gene inheritance pattern: concept of alleles, allelic interactions, autosomal and X-linked inheritance. Concept of segregation, penetrance, expressivity. Test for allelism: complementation. Two- gene inheritance pattern: independent assortment versus linkage. Molecular basis of phenotypic variation and inheritance patterns. Introduction to genetic maps: three point test crosses.

Unit 2: (9 hours)

Extra-nuclear inheritance and epigenetics: Introduction and rules of extra-nuclear inheritance. Organelle heredity: chloroplast mutations in *Chlamydomonas* and *Mirabilis jalapa.* Maternal effect: shell coiling in *Limnaea peregra.* Infectious heredity: Kappa particles in *Paramecium.*

Unit 3: (9 hours)

Quantitative and Population Genetics: Polygenic inheritance, Johannsen pure-line theory, multiple factor hypothesis. Types of quantitative traits, heritability and its measurements. Genetic structure of populations, gene pool, genotype frequencies, allele frequencies. Hardy–Weinberg Law: Assumptions and Predictions.

Practicals: **60 hours**

Unit 1: (30 hours)

A review of model organisms for genetic analysis: **Student group research study**: Organisms for genetic research: *Escherichia coli, Saccharomyces cerevisiae, Neurospora crassa, Drosophila melanogaster, Caenorhabditis elegans, Arabidopsis thaliana, Tetrahymena thermophila*. Case studies highlighting one major biological finding from studies with each of these organisms. Understanding genetic analysis through problem solving: statistical analysis of given genetic data by Chi-Square Analysis.

Unit 2: (20 hours)

Studying inheritance in humans: Pedigree analysis: chromosomes and aberrations through karyotyping and chromosome banding techniques.

Unit 3: (10 hours)

Study of Giant Chromosomes: Polytene and Lampbrush chromosomes. Preparation of temporary mounts of salivary glands of *Chironomus* / *Drosophila* larvae, and their visualization by bright field microscopy. Study of lampbrush chromosomes through permanent mounts.

Suggested Reading:

1. Introduction to genetic analysis by A. Griffiths, J. Doebley, C. Peichel and D. Wassarman. 12th edition. Macmillan Learning. 2020.
2. Laboratory Manual for Principles of Genetics by W. Mhiret. Lap Lambert Academic Publishing. 2020.
3. Concepts of Genetics by W.S. Klug, M.R. Cummings, C. Spencer and M. Palladino. 12th edition. Pearson Education, USA. 2019.
4. Genetics: A Conceptual Approach By B. Pierce. 7th edition. W.H. Freeman and Co. 2019.
5. Genetics: Analysis of Genes and Genomes by D. Hartl and B. Cochrane. 9th edition. Jones and Bartlett Learning, USA. 2017.
6. Introducing Epigenetics : A graphic guide by C. Ennis. Icon Books Ltd, India. 2017.
7. iGenetics- A Molecular Approach by P.J. Russell. 3rd edition. Pearson Education India. 2016.
8. Principles of Genetics by D. Snustad and M. Simmons. 7th edition. Wiley and Sons, UK. 2015.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 11: MICROBIAL BIOTECHNOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE4: **MICROBIAL BIOTECHNOLOGY**	**4**	**2**	**0**	**2**	**Class XII pass with Biology/ Biotechnology/ Biochemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to give students an overview of the beneficial role of microbial biotechnology in the welfare of humankind. They will learn about harnessing the power of microorganisms to manufacture medicinal, industrial, and agricultural products.
- Students will be acquainted with the large-scale culturing of microorganisms to produce various metabolites at a commercial scale. Students will gain hands-on experience in screening samples for enzyme and pigment producers and dye degrading microorganisms. They will learn to immobilise enzymes and cells and use enzyme-based biosensors for analytical purposes.
- The students will get conversant with applications of bioremediation and the protection of intellectual property rights.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to describe the emerging biotechnology industries at the national and international level, use of microbe-based technologies and innovations for the benefit of mankind.
- Student will be able to explain the potential use of high-yielding microorganisms to commercially produce human therapeutics and industrial products, biosensors and steroid biotransformation.
- Student will be able to describe how microorganisms are utilized for the industrial production of biofertilizers and biopesticides, their potential use in environmental pollution management.

- Student will be able to demonstrate immobilization of biocatalysts (whole cells/enzymes) and explain how this technology can find applications in large-scale enzymatic reactions, bioremediation and designing of biosensor-based kits.
- Student will be able to explain the screening of environmental samples to isolate organisms with desired properties (enzyme production, pigment production, dye degradation).
- Student will be able to describe the research work involving GMOs and approvals required thereof and will appreciate the importance of protecting Intellectual Property Rights.

Theory: **30 hours**

Unit 1: (4 hours)

Microbial Biotechnology as an emerging Industry: Global Biotechnology industries and their products. Biotechnology trends in India with particular reference to our country's premier biotechnology institutes and industries and their products : Biocon, Serum Institute of India, Bharat Biotech and Hindustan Antibiotics Ltd. Innovations and Startups based on Microbial Biotechnology. Biotechnology in mass production of valuable products using microorganisms and advantages of using microorganisms (Laboratory, pilot and industrial- scale bioreactors).

Unit 2: (14 hours)

Microbial Biotechnology in the development of human therapeutics and industrial products: Prokaryotes and eukaryotes as expression hosts for heterologous proteins. Microbial production of therapeutic recombinant products: hormones (insulin, human growth hormone), thrombolytic agents (streptokinase and tPA) and vaccines (Hepatitis B and Covid-19 vaccines). Industrial bulk products: Production of microbial polysaccharides (xanthan gum and agar-agar), bioplastics (PHB), food-grade pigments/colorants (phycocyanin and Beta-carotene/lycopene), high fructose corn syrup. Development and functioning of enzyme- based biosensors (GOD and cholesterol oxidase). Microbial transformation of steroids**.**

Unit 3: (12 hours)

Role of Microbial Biotechnology in agriculture and environment management: Biofertilizers: liquid and carrier-based biofertilizers. Mass production of *Rhizobium, Acetobacter diazotrophicus, Azotobacter sp*. Commercial production of Biocontrol agents (*Bacillus thuringiensis* & *Trichoderma harzianum*). Development of transgenic crops with particular emphasis on insect resistance, viral resistance and nutritional quality enhancement (Bt-brinjal, Roundup-ready crops and golden rice). RNAi and its application in crop improvement. Edible vaccines, synthetic meat and Single Cell Protein (*Spirulina* & *Fusarium graminearum*), biodiesel production (algal biofuel). Microbial bioremediation of oil spills using genetically modified organisms (GMOs) and microbial consortia. Microorganisms in the removal of heavy metals from aqueous effluents and copper bioleaching.

Practicals: **60 hours**

Unit 1: (18 hours)

Immobilization of enzymes, cells and biosensors: Immobilization of yeast cells (*Saccharomyces cerevisiae*) by entrapment using calcium alginate beads/agarose/agar and determination of the invertase activity of the immobilized cells by carrying out an invertase assay. Immobilization of an enzyme (amylase/urease/invertase) using calcium alginate/ agarose/ agar and study of its long term storage stability using enzyme assays. Use of an enzyme-based biosensor (glucose oxidase/glucose-1-dehydrogenase based devices to monitor glucose uptake/consumption during a fermentation; cholesterol oxidase/beta- hydroxybutyrate dehydrogenase-based kits to monitor changes in levels of the substrate over a period of time).

Unit 2: (30 hours)

Screening for enzymes and pigment-producer / dye-degrading microorganisms, and expression of a cloned gene: Primary screening of soil samples to isolate microorganisms that produce hydrolytic enzymes (any one): amylase, protease, lipase, CM cellulase, xylanase. Isolation of pigment-producing microorganisms from the environment and laboratory-scale production of any pigment using the shake-flask technique OR Screening for dye-degrading (methylene blue/ methyl orange/ Rhodamine B, etc.) microorganisms from the environment using plate assays and study of the absorption spectra of any dye. Transformation and expression studies of a given plasmid (expressing Green Fluorescent Protein) in the BL21 strain of *E coli,* analysis of protein expression using SDS-PAGE.

Unit 3: (12 hours)

An orientation to the biosafety regulatory framework for Genetically Modified Organisms (GMOs) in India: An introduction to different methods of protecting Intellectual Property in India (Patents, Copyrights, Trademarks, Geographical Indications, Industrial Design and New Plant Varieties). Filing applications for approval of research proposals by the concerned regulatory bodies. Filing of a patent application to the regulator for the protection of a GMO. **Student group research project:** Case study of any microbial consortium available in India for environmental bioremediation.

Suggested Reading:

1. Industrial Microbiology by A.H. Patel. 2nd edition. Laxmi publication Pvt Ltd/Trinity Press. 2022.

2. Microbiology: A Laboratory Manual by J. Cappuccino and C.T. Welsh. 12th edition. Pearson Education, USA. 2020.

3. Industrial Microbiology by L.E. Casida. 2nd edition. New Age International Publisher. 2019.

4. Intellectual Property Rights in India. Pidigam Saidaiah and K. Ravinder Reddy. International Books and Periodical Supply Service. 2020.

5. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGrawHill Higher Education, USA. 2019.

6. Crueger's Biotechnology: A Textbook of Industrial Microbiology by W. Crueger, A. Crueger and K.R.Aneja. 3rd edition. Medtech Publisher, India. 2017.

7. Principles of Fermentation Technology by P.F. Stanbury, A.Whitaker and S.J. Hall. 3rd edition. Elsevier Science Ltd, Netherlands. 2016.

8. Benson's Microbiological Applications: Laboratory Manual in General Microbiology by A.E. Brown and H. Smith. 15th edition. Mc-Graw Hill Education, USA. 2022.

9. Manual of Industrial Microbiology and Biotechnology by R.H. Baltz, A.L.Domain, and J.E. Davies. 3rd edition. American Society for Microbiology. 2010.

10. Molecular Biotechnology by B.R. Glick, J.J. Pasternak and C.L. Patten. 4th edition, ASM Press, USA. 2009.

11. Microbial Biotechnology: Fundamentals of Applied Microbiology by A.N. Glazer and H. Nikaido. 2nd edition. W.H. Freeman and Company, UK. 2007.

12. Manual of Industrial Microbiology and Biotechnology by A.L. Demain, J.E. Davies and R.M. Atlas. 2nd edition. ASM Press, USA. 1999.

13. The DBT portal: https://dbtindia.gov.in/regulations-uidelines/regulations/biosafety- programme

14. Intellectual Property Rights: Chapter III on the INFLIBNET portal: http://shodhganga.inflibnet.ac.in/bitstream/10603/205165/7/chapter%20iii.pdf

DISCIPLINE SPECIFIC ELECTIVE COURSE – 12: RESEARCH METHODOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE15: RESEARCH METHODOLOGY	4	2	0	2	Class XII pass with Biology/ Biotechnology/ Biochemistry	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of the course is to give the students a broad understanding about research approaches and tools, and importantly, an ability to deploy them in their degree programme.
- This will impart skills for critical reading of research literature, various research methods, including theory of scientific research and qualitative and quantitative methods and for developing a research proposal. The course will outline all the fundamentals of carrying out research in an ethical manner.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to explain the basics of research and hypothesis formulation, the different approaches of doing research, acquiring data, and performing data analysis.
- Student will be able to describe the process of scientific writing and presenting of research data.
- Student will be able to demonstrate the process of effective literature search and writing a review.
- Student will be able to analyse datasets and present them through tables, charts and graphs.
- Student will be able to describe the process of writing proposals for research grants.

Contents:

Theory **30 hours**

Unit 1: (8 hours)

Foundation of research and research ethics: What is research, benefits of research. Selection of research topic. Effective literature search. Problem identification and hypothesis building. Qualities of a good hypothesis, hypothesis testing, null hypothesis and alternative hypothesis, logic and importance. Ethics in research: indices for scientific rigor, honesty and integrity, respect for intellectual property, responsible publication of data.

Unit 2: (14 hours)

Approaches to research and research methods: Basic and applied research, descriptive and analytical research, quantitative and qualitative research, experimental and non-experimental research. Good laboratory practices (GLP): Standard Operating Procedures, Biosafety, Radiation safety. Experimental Design. Concept of Experiment Controls. Concept of independent and dependent variables. Recording experimental protocol and data in lab notebooks, preparation for experiments. Field experiments: sampling, types of sampling studies, characteristics of a good sample, sampling frame, sample size, sampling error, scales of measurement, double blind studies. Data analysis and representation: Use of Excel for tables and charts, Common statistical tests (hypothesis of association, student t test) and introducing popular

statistical packages.

Unit 3: (8 hours)

Research Communication: Knowledge dissemination. Effective presentation in scientific conferences (Poster/oral). Structure of research paper. Structure of a thesis/dissertation. Software for scientific paper formatting (LaTeX/MS Office). Software for management of references (Mendeley/Endnote). Software for image processing. Choosing a journal for publication. Impact factor of journals. Ethical issues related to publishing, plagiarism, software for detection of plagiarism.

Practicals: **60 hours**

Unit 1: (20 hours)

Literature Search and Review: General Search Engines, Bibliographic Databases, Digital Libraries, Types of publications, literature search on a given topic and writing a review.

Unit 2: (20 hours)

Analysis and presentation of given dataset: Training in the use of Microsoft Excel for data presentations in tables, graphs and charts. Training in the use of Microsoft Powerpoint for presenting scientific findings at meetings/conferences. Writing an Abstract for paper/conference based on given data.

Unit 3: (20 hours)

Planning and writing a research proposal: General considerations, finding a research problem. Major Funding agencies in India. Mandate of the call for proposals. How to write a proposal. **Student group project**: writing a research proposal on a given topic

Suggested Reading:

1. Research Methodology for Natural Sciences by S. Banerjee. I.I.Sc. Press, India. 2022.
2. Research Methodology and Scientific Writing by C.G. Thomas. 2nd edition. Ane Books, India. 2019.
3. Scientific writing and communication by A. Hoffman. 4th edition. Oxford University Press. 2019.
4. Research Methodology: Methods and Techniques by C.R. Kothari. 4th edition. New Age International Publishers, India. 2019.
5. Testing treatments: Better research for better healthcare by I. Evans, H. Thornton, I. Chalmers and P. Glasziou. 2nd edition. Pinter & Martin Ltd, UK. 2013.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 13:
Applications of Informatics in Biology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE5: **Applications of Informatics in Biology**	**4**	**2**	**0**	**2**	**Class XII pass with Biology/ Biotechnology/ Biochemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this paper is to enable the students to develop a clear understanding of the various concepts and applications of bioinformatics, a field which encompasses diverse applied disciplines such as molecular biology, genomics, proteomics, transcriptomics and systems biology. Students will also learn applications of artificial intelligence in bioinformatics.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to explain the goals of bioinformatics and its applications, diverse types of biological databases, concept and significance of sequence alignment, phylogeny, types of phylogenetic trees.
- Student will be able to describe the diversity of viral, prokaryotic, eukaryotic genomes and their organization, proteomics along with the details of structure of proteins, protein structure prediction, and energy minimizations.
- Student will be able to explain the significance of artificial intelligence and machine learning in various biological applications, computer-aided drug discovery, epitope prediction and its significance in vaccine development and allergen prediction.
- Student will be able to demonstrate how to work with biological databases, similarity searches, sequence alignments and phylogenetic analysis.

- Student will be able to demonstrate working with databases and analysis, gene prediction and other features, and primer designing.
- Student will be able to demonstrate how to identifying secondary structural features of proteins, prediction of protein structure models from amino acid sequences, molecular docking and epitope prediction.

Contents:

Theory: **30 hours**

Unit 1: (10 hours)

Fundamentals of bioinformatics, sequence alignment and phylogeny: Aims and scope of bioinformatics. Concepts of genome, transcriptome, proteome, systems biology, metabolome, interactome and neural network. Biological databases and types. Sequence similarity and Sequence alignment (Local and Global Sequence alignment), pairwise and multiple sequence alignment. Phylogeny, rooted and unrooted trees.

Unit 2: (10 hours)

Genomics and Proteomics: Features of the viral, prokaryotic (*E. coli*) and eukaryotic (human) genomes. Gene Ontology, Hierarchy, and features of protein structure, Structural classes, motifs, folds and domains. Homology modelling of tertiary structure of protein, Molecular dynamic simulations and energy minimizations, Evaluation by Ramachandran plot.

Unit 3: (10 hours)

Artificial Intelligence in bioinformatics: Role of AI and machine learning in biology (proteomics, structural biology, disease management, drug discovery and genomics). Computer-aided drug discovery and design. Bioinformatics in epitope mapping for vaccine design and allergen prediction.

Practicals: **60 hours**

Unit 1: (24 hours)

Biological Databases, similarity search, sequence alignments and phylogenetic analysis: Study of bioinformatics databases, File formats: FASTA, GenBank. Sequence submission tools: NCBI, PDB. Sequence retrieval and similarity search using BLAST, Multiple sequence (DNA/Protein) alignment using CLUSTAL omega. Phylogenetic analysis using MEGA.

Unit 2: (16 hours)

Identification and analysis of genome features: Picking out a given gene from genomes using GENSCAN or other software (promoter region identification, repeats in the genome,

ORF prediction, Gene finding tools), Genome browsing using Ensemble/Genome Data Viewer (NCBI) for features of E. coli and Human Genome (Search a genomic assembly to display a region annotated with a particular gene), Design and analysis of PCR primers using PRIMER BLAST or any other tool.

Unit 3: (20 hours)

Protein structure prediction and evaluation, molecular docking, epitope prediction: Primary structure analysis. Secondary structure prediction using psi-pred. Molecular visualization using JMOL/PyMOL, protein structure model evaluation, virtual screening of drugs using AUTODOC-VINA/ any other software, Demonstration of IEDB (https://www.iedb.org) server for the prediction of HLA class I and II binding epitopes.

Suggested Reading:

1. Bioinformatics: Tools and Techniques edited by L. Baker. 1st edition. Callisto. 2018.
2. Applied Bioinformatics: An Introduction by P. Selzer, R. Marhöfer and O. Koch. 2nd edition. Springer, USA. 2018.
3. Bioinformatics Techniques for Drug Discovery: Applications for Complex Diseases by A. Kaushik, A. Kumar, S. Bharadwaj and R. Chaudhary. 1st edition. Springer International, UK. 2018.
4. Foundations of Computing by P. Sinha and P.K. Sinha. 6th edition. BPB Publications, India. 2017.
5. Basic Applied Bioinformatics by C. Mukhopadhyay, R. Choudhary and M.A. Iquebal. 1st edition. Wiley-Blackwell, USA. 2017.
6. Bioinformatics: Principles and Applications by Z. Ghosh and V. Mallick. 1st edition. Oxford University Press, India. 2015.
7. Introduction to Bioinformatics by M.Lesk. 4th edition. Oxford Publication, UK. 2014.
8. Bioinformatics: methods and applications, genomic, proteomics and drug discovery by S. Rastogi, N. Mendiratta and P. Rastogi. 4th edition. Prentice Hall India Publication. 2007.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 14: ADVANCES IN MICROBIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE6: ADVANCES IN MICROBIOLOGY	**4**	**2**	**0**	**2**	**Class XII pass with Biology/ Biotechnology/ Biochemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to educate students about the latest developments in the field of microbiology and apprise them of the cutting-edge technologies being used for research and development.
- They will learn the uses of omics approaches, meta-omics, systems biology, and synthetic biology. They will become familiar with the development and applications of CRISPR-Cas technology and will gain insights into the versatile field of microbial nanotechnology.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to discuss the host-microbe arms race, newer methods to combat challenges of antimicrobial resistance and biofilms, the use of meta-omics approaches in research, latest cutting-edge technology of CRISPR-Cas and its applications.
- Student will be able to explain the Systems and Synthetic Biology and their applications; the principles, techniques, and applications of the versatile field of nanobiotechnology.
- Student will be able to demonstrate soil metagenomics and PCR-based taxonomy analysis, and describe major metagenomics projects worldwide through case studies.
- Student will be able to demonstrate synthesis and testing of silver nanoparticles with antimicrobial properties from plant, fungal/bacterial

extracts; and explain about the analytical research tools to characterize the nanoparticles.

- Student will be able to describe Poliovirus synthesis, mRNA vaccine synthesis and Genome synthesis of mycoplasma through case studies.

Contents:

Theory: **30 hours**

Unit 1: (10 hours)

Host- microbe interactions and use of microbes in healthcare: Host-Microbe arms race, genome- pathogenicity islands, Type Three Secretion System (T3SS), Quorum Sensing, and Biofilm formation in bacteria. Viral zoonosis and pandemics. Gene for Gene hypothesis, hypersensitive response, plant resistance genes, and signal transduction mechanism. Addressing the challenges of Anti-Microbial Resistance (AMR) and biofilms by phages, and of cancer through oncolytic viruses.

Unit 2: (10 hours)

Modern molecular techniques in Microbiology: Meta-Omics technology (Metagenomics, Metatranscriptomics, Metaproteomics, and Metabolomics): Principles, techniques deployed, and applications. CRISPR-Cas technology- History, mechanism, applications (in Health, Agriculture and other Industries) and limitations of this technology.

Unit 3: (10 hours)

Systems biology, Synthetic biology, and Nanobiotechnological Approaches in Microbiology: Systems biology approach for holistic perspectives and better outcomes. Types of Biological Networks. Cell signaling and interaction networks. Synthetic biology: principles and applications. Concept, methodology, and applications of Microbial Nanotechnology in health, agriculture, and food industry. Applications of Viral and Viral-like Nanoparticles.

Practicals: **60 hours**

Unit 1: (20 hours)

Metagenomic technique to study soil microorganisms: Hands-on training in extraction of DNA from soil, and PCR amplification of metagenomic DNA using universal16S ribosomal gene primers. **Student group project:** Research and review on major metagenomic projects (Sargasso Sea Project, Viral Metagenomics and Human Microbiome Project)

Unit 2: (25 hours)

Synthesis and analysis of silver nanoparticles from plants extracts and microbes (fungi/bacteria). Hands-on training in synthesis of silver nanoparticles by any one method. Testing of antimicrobial properties of synthesized silver nanoparticles. Characterization of nanoparticles by UV-vis Spectroscopy, X-ray Diffraction (XRD), Scanning and Transmission Electron Microscopy (SEM and TEM) through virtual labs / videos. Visit to Sophisticated Instrumentation Facility of a research institution.

Unit 3: (15 hours)

Student research study project: Poliovirus Synthesis: a case study to understand how the poliovirus was synthesized in the laboratory. mRNA-Vaccine Synthesis: a case study of the steps involved in synthesis of mRNA vaccine and testing its efficacy. **Student group project**: Covid19 mRNA vaccines in the market in India and overseas. Genome synthesis of mycoplasma: a case study to develop a synthetic genome of mycoplasma.

Suggested Reading:

1. Brock Biology of Microorganisms by M.T. Madigan, and J.M. Martinko. 16th edition. Pearson., USA. 2021.
2. Microbiomes: Current Knowledge and unanswered Questions by E. Rosenberg. Springer Nature, Switzerland. 2021.
3. An Introduction to Systems Biology: Design, Principles of Biological Circuits by Uri Alon, 2nd edition. CRC Press. 2020.
4. Antimicrobial Resistance: Global Challenges and Future Interventions edited by Sabu Thomas. Springer. 2020.
5. Biological Synthesis of Nanoparticles and Their Applications, by L. Karthik, A. Vishnu Kirthi, S. Ranjan, V. M. Srinivasan. CRC Press, Taylor and Francis, USA. 2020
6. Genomic Engineering via CRISPR-Cas 9 system edited by Vijay Singh and Pawan K. Dhar. Academic Press. 2020
7. Microbial Nanotechnology edited by M. Rai and Golinsky P. CRC Press. 2020
8. Bacterial Pathogenesis: A Molecular Approach by B.A. Wilson, A.A. Salyers, D. D. Whitt, and M.E. Winkler. 4th edition. ASM Press, USA. 2019.
9. Implications of Quorum Sensing and Biofilm formation in Medicine, Agriculture and Food Industry by P. V. Bramhachari. Springer. 2019.
10. Nanotechnology in Food: Concepts, Applications, and Perspective by H.J. Malmiri. Springer. 2019.
11. Quorum Sensing: Molecular Mechanism and Biotechnological Applications by G. Tommonaro. Academic Press, USA. 2019.
12. Agricultural Nanobiotechnology: Modern Agriculture for a Sustainable Future by F. Lopez-Valdez and F. Fernandez-Luqueno. Springer. 2018.

13. Implications of Quorum Sensing System in Biofilm Formation and Virulence by Bramhachari. Springer. 2018.
14. Nanobiotechnology: Human Health and the Environment by A. Dhawan, S. Singh, A. Kumar, and R. Shanker (editors). CRC Press, USA. 2018.
15. Synthetic Biology: Omics Tools and their Applications by Shailza Singh. Springer. 2018
16. Viral Metagenomics: Methods and Protocol by V. Pantaleo and M. Chiumenti. Springer Protocols. Humana Press. 2018.
17. Virus Derived Nanoparticles for Advanced Technologies-Methods and Protocols by C. Wege and G. Lomonsoff. Humana Press, Springer, USA. 2018.
18. Microbial Biofilms: Omics Biology, Antimicrobials and Clinical Implications by C. J. Seneviratne. CRC Press. 2017.
19. Precision Medicine, CRISPR, and Genome Engineering: Moving from Association to Biology and Therapeutics by S. H. Tsang. Springer. 2017.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 15: MICROBIOME IN HEALTH AND DISEASE

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE14: MICROBIOME IN HEALTH AND DISEASE	**4**	**2**	**0**	**2**	**Class XII pass with Biology/ Biotechnology/ Biochemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to introduce the human microbiome to students and give them an understanding of its dynamics and function in maintaining homeostasis.
- Students will gain an understanding of the diversity of microbial communities present in various organs in humans. They will gain insights into our current understanding of the impact of microbiome alterations on host health and disease. Students will become aware of techniques used to analyze large omics data sets in investigating microbial communities colonizing humans.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to explain about human microbiome and methods to study microbiomes, the link between human microbiome and diseases
- Student will be able to describe microbiome-based therapeutic approaches and their challenges, human microbiome project and various databases and software for microbiome analysis

- Student will be able to discuss the basic workflow in a typical microbiome study and analyze microbiome data
- Student will be able to describe current knowledge on the role of microbiome in various diseases

Contents:

Theory **30 hours**

Unit 1: (14 hours)

The human microbiome: Understanding microbiome, importance of microbiome research, development of the microbiome. Vertical and horizontal transfer of human microbiomes, source of the organisms in the human microbiome. Diversity in oral, gut, respiratory and skin microbiome. Microbiome-Gut-Brain Axis. Methods to study the human microbiome: DNA-based analysis of microbial communities, 16S rDNA gene amplicon sequencing and whole metagenome shotgun sequencing methods. Data pre-processing and quality control. Microbiome data analysis: clustering and OTU picking, taxonomic analysis, alpha and beta-diversity. Comparing microbial communities: phylogenetic trees, UniFrac, principal coordinate analysis, Venn diagrams, heat maps. Functional and comparative analysis: metatranscriptome, metabolome, metaproteome.

Unit 2: (10 hours)

Microbiome and its relation to health and disease: Dysbiosis, correlation of dysbiosis with disturbance in microenvironment. Dysbiosis in progression of non-communicable diseases such as cancer, Inflammatory Bowel Disease (IBD), obesity, diabetes, Alzheimer's, and incommunicable diseases such as COVID-19, tuberculosis and typhoid. Nutritional modulation of the gut microbiome. Prakriti and gut bacteria: perspective of traditional ayurveda. Microbiome and host immune system interaction. Effect of antibiotics on microbiota, oral dysbiosis and oral diseases, skin microbiome alterations and cutaneous allergic diseases.

Unit 3: (6 hours)

Microbiome-based therapeutic approaches: Maintaining and restoring a healthy microbiome. Additive, subtractive, and modulatory microbiome-based therapies. Health benefits of prebiotics and probiotics. Fecal transplant and its applications. Challenges in the field of microbiome therapeutics. Microbiome-based diagnostics.

Practicals **60 hours**

Unit 1: (20 hours)

Tools and techniques to study microbiome: Human Microbiome project. Hands-on exposure to various databases (NCBI, HOMD) and opensource software related to microbiome analysis (microbiome analyst, QIIME 2.1, galaxy).

Unit 2: (20 hours)

Research strategy and experimental design in a typical microbiome study: Sample collection, DNA extraction, library preparation and DNA sequencing through virtual lab. Data analysis. Comparison of alpha and beta diversity in given data sets. Interpretations of given heat maps.

Unit 3: (20 hours)

Student group research study projects: Current knowledge on the role of microbiome in respiratory health, the impact of the human microbiome on auto-immune diseases, the interplay of bacteria and eukaryotic microbes in the human gut: presentation of the findings and submission of research study report.

Suggested reading:

1. Recent Advances in Understanding the Structure and Function of the Human Microbiome by W. Mousa, F. Chehadeh, and S. Husband. *Frontiers In Microbiology*, *13*. doi: 10.3389/fmicb.2022.825338. 2022.

2. *Microbiome-Gut-Brain Axis* by R. Sayyed and M. Khan. Springer, Singapore. 2022.

3. Targeting the Gut Microbiota for Remediating Obesity and Related Metabolic Disorders by B. Wang et al. J Nutr. 151:1703-1716. http://doi: 10.1093/jn/nxab103. 2021.

4. The human microbiome and COVID-19: A systematic review by S. Yamamota. *PloS One* 16;6. doi:10.1371/journal.pone.0253293. 2021.

5. Metagenomics: Techniques, Applications, Challenges and Opportunities by R.S. Chopra, C. Chopra and N.R. Sharma. Springer. 2020.

6. Gut-Brain Axis: Role of Gut Microbiota on Neurological Disorders and How Probiotics/Prebiotics Beneficially Modulate Microbial and Immune Pathways to Improve Brain Functions by K. Uganya and B.S. Koo. *International journal of molecular sciences*,

21(20), 7551. 2020.

7. The Influence of the Gut Microbiome on Obesity in Adults and the Role of Probiotics, Prebiotics, and Synbiotics for Weight Loss by A. Aoun, F. Darwish and N. Hamod. Prev Nutr Food Sci., 25(2):113-123. doi: 10.3746/pnf.2020.25.2.113. 2020.
8. The gut microbiome in tuberculosis susceptibility and treatment response: guilty or not guilty? by Eribo, O. A., du Plessis, N., Ozturk, M., Guler, R., Walzl, G. and Chegou, N.N. *Cellular and molecular life sciences : CMLS*, *77*(8), 1497–1509. https://doi.org/10.1007/s00018-019-03370-4. 2020.
9. The influence of the microbiome on respiratory health by T.P. Wypych, L. Wickramasinghe and B. Marsland. *Nature Immunology*, *20* (10), 1279–1290. https://doi.org/10.1038/s41590-019-0451-9. 2019.
10. The microbiome, cancer, and cancer therapy by Helmink *et al*. *Nat Med* 25, 377–388. https://doi.org/10.1038/s41591-019-0377-7. 2019.
11. *Metagenomics* by M. Nagarajan. London: Academic Press. 2018.
12. The human skin microbiome by A.L. Byrd, Y. Belkaid, and J.A. Segre. *Nature reviews in Microbiology*, *16*(3), 143–155. https://doi.org/10.1038/nrmicro.2017.157. 2018.
13. Insights into the human oral microbiome by D. Verma, P.K. Garg and A.K. Dubey. *Archives of microbiology*, *200* (4), 525–540. https://doi.org/10.1007/s00203-018-1505-3. 2018.
14. Human Gut Microbiome: Function Matters by A. Heintz-Buschart and P. Wilmes. *Trends in microbiology*, *26*(7), 563–574. https://doi.org/10.1016/j.tim.2017.11.002. 2018.
15. *Functional Metagenomics: Tools and Applications* by T. Charles, M. Liles, A. Sessitsch, Springer. 2017.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 16:
MICROBIAL DIAGNOSIS AND PUBLIC HEALTH MANAGEMENT

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE11: MICROBIAL DIAGNOSIS AND PUBLIC HEALTH MANAGEMENT	4	2	0	2	Class XII pass with Biology/ Biotechnology/ Biochemistry	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to introduce the students to diagnostic microbiology and public health management. Students will be exposed to various methods of sampling of specimens for laboratory diagnosis.
- Student will be introduced to various automated systems and methods of pathogen identification and microbial typing. Students will develop an understanding of basic concepts of epidemiology. They will be introduced to the role of environment in human health and key aspects of disaster management.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to explain the methods of collection and transport of clinical specimens, the automated systems for pathogen identification and various methods of microbial typing.
- Student will be able to describe epidemiology, types of epidemics and pandemics, the epidemiology of infectious diseases, the reservoirs of infectious agents and modes of transmission of various diseases.

- Student will be able to explain the concept of one health, various types of zoonoses, overview of air and water pollution and its impact on human health, the key aspects of disaster management.
- Student will be able to describe the significance of various parameters determining health, the methods of blood sampling used for various animals, and demonstrate rapid diagnostic techniques.
- Student will be able to analyze epidemiological data to calculate mortality and morbidity rates, explain about epidemics through case studies.
- Student will be able to describe various disease control regulatory agencies (National and International), genome and disease surveillance.

Contents:

Theory: **30 hours**

Unit 1: (10 hours)

General principles of diagnosis and microbial typing methods: Challenges of diagnosis. General principles of specimen collection. Choice of clinical samples and methods of collection. Transportation of clinical samples. Evaluation of a diagnostic test based on specificity, sensitivity, positive predictive value, negative predictive value. Automated systems of pathogen identification: a brief outline of BACTEC, MALDI-TOF, VITEK, and their advantages and disadvantages. Microbial typing: phage typing, bacteriocin typing, serotyping, antibiogram typing, plasmid profile analysis.

Unit 2: (12 hours)

Basic concepts of epidemiology: Definitions: health, epidemiology, prevalence, birth rate, morbidity, mortality, sero-prevalence, genome surveillance, R^o value, quarantine, endemic, epidemics and types (common source, propagated/progressive, mixed), pandemic, travel notice, public health guidelines. Uses of epidemiology. Infectious disease epidemiology. Modes of transmission of disease and its dynamics, human reservoirs, animal reservoirs, carriers. Investigation of an epidemic. Role of immunization in public health. Clinical trials: randomized control trials (multiple treatment arms, factorial design, cluster design), nonrandomized trials.

Unit 3: (8 hours)

Environment and Health: The concept of one health. Definition, history and socio-economic impact of zoonotic diseases. Classification of zoonoses with examples (based on transmission cycle: orthozoonoses, cyclozoonoses, metazoonoses, saprozoonoses;

based on reservoir hosts: anthrapozoonoses, zooanthroponoses, amphixenoses). Air pollution and its effects. Water pollution and its effect. Disaster management: key aspects.

Practicals: **60 hours**

Unit 1: (30 hours)

Health indicators, blood sampling methods and diagnostic methods: Student individual project: preparation of a short report on indicators of health. Guidelines and collection sites for sampling of blood from humans, cattle, sheep and goat. **Student group study project:** preparation of a flow chart for detection of microbial pathogens for two diseases prevalent in India. Principles and working of rapid antibody detection test using COVID-19 as example. Principles and working of antigen and antibody detection kits for HIV. Principle and working of slide agglutination test for typhoid. Principles and working of quantitative real time PCR test for COVID-19 through virtual lab.

Unit 2: (15 hours)

Epidemiological Data Analysis: Student group research study: Case studies of a common source epidemic (Cholera outbreak, London, 1854) and progressive epidemic (SARS 2002, MERS 2012, and COVID-19). **Student group research project**: Measurement of disease: determination of morbidity and mortality rates/ratios. Generation of epidemiological protocols and reports.

Unit 3: (15 hours)

Case Studies through student group research projects: INSACOG: role in SARS- CoV-2 genome surveillance, Role of WHO and National Centre for Disease Control in disease management, AMR stewardship and National Action Plan, CDC –EOC levels (www.cdc.gov).

Suggested Reading:

1. Park's Textbook of Preventive and Social Medicine by K. Park. 26th edition. Banarsidas Bhanot Publishers, India. 2021.

2. Brock Biology of Microorganisms by M.T. Madigan, K.S. Bender, D.H. Buckley, W.M.Sattley and D.A. Stahl. 16th edition. Pearson Education, USA. 2021.

3. Microbiology: A Laboratory Manual by J. Cappuccino and C.T. Welsh. 12th edition. Pearson Education, USA. 2020.

4. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGrawHill Higher Education, USA. 2019.

5. National Centre for Disease Control: Anti-Microbial Resistance and COVID National Action plan: https://ncdc.gov.in/index1.php?lang=1&level=2&sublinkid=389&lid=347

6. Microbiology: An Introduction by G.J. Tortora, B.R. Funke,and C.L. Case. 13th edition. Pearson, USA. 2018.

7. Textbook of Microbiology by R. Ananthanarayan and C.K.J. Paniker. 10th edition.Universities Press, India. 2017.

8. Veterinary Microbiology by D. Scott McVey, Melissa Kennedy and M.M. Chengappa. 3rd edition. Wiley – Blackwell, USA. 2013.

9. An Introduction to Public Health and Epidemiology by S. Carr, N. Unwin and T. Pless-Mulloli. 2nd edition. Open University Press, UK. 2007.

10. Handbook of Good Dairy Husbandry Practices. National Dairy Development Board (NDDB). https://www.nddb.coop/sites/default/files/handbook_of_good_dairy_husbandry_practices_low.pdf

11. Mackie and McCartney Practical Medical Microbiology by J. Collee, A. Fraser, B. Marmion and A. Simmons. 14th edition. Elsevier. 1996.