SOPHIA COLLEGE
(Autonomous)

Affiliated to

University Of Mumbai

Syllabus
Program: M.Sc.
Class: M.Sc.-II
Course: MICROBIOLOGY

With effect from the academic year
2021-2022

Theory: Semester 3

Course code	Unit	Topic Headings	Credits	Total number of lectures
SMSMCB301	1	Basics of Research	4	15
	2	Sampling, data collection, interpretation and report writing.		15
	3	Scientific writing and ethics in research and publication.		15
	4	Biostatistics		15
SMSMCB302 Food Microbiology	1	Microbes in Food	4	15
	2	Use of Microbes and their products in in Food industry		15
	3	Control of Microbes in Food		15
	4	Microbiological quality of Food		15
SMSMCB303 Advances in Biotechnology-I	1	Plant and Agricultural Biotechnology	4	15
	2	Animal Biotechnology		15
	3	Nanobiotechnology		15
	4	Medical Biotechnology		15
SMSMCB304 Environmental Microbiology-I	1	Microbial Ecology	4	15
	2	Soil, Plant and Marine Microbiology		15
	3	Cultural and Physiological Methods for Studying Microorganisms in the Environment		15
	4	Immunological and Nucleic acid Methods for Studying Microorganisms in the Environment		15

Practicals: Semester 3 SMSMCBP3

Course code	Title	Credits
SMSMCBP301	Research proposal writing	2
SMSMCBP302	Food Microbiology	2
SMSMCBP303	Advances in Biotechnology-I	2
SMSMCBP304	Environmental Microbiology-I	2

Theory: Semester 4

Course code	Unit	Topic Headings	Credits	Total number of lectures
SMSMCB401	1	Advanced Microscopy techniques	4	15
	2	Spectroscopic techniques		15
	3	Chromatographic techniques		15
	4	Molecular biology techniques.		15
SMSMCB402 Pharmaceutical Microbiology	1	Main principles for pharmaceutical products	4	15
	2	Premises and personnel management		15
	3	Sterility in pharmaceutical products and other principles		15
	4	Drug discovery		15
SMSMCB403 Advances in Biotechnology-II	1	Pharmaceutical Biotechnology and Bioethics	4	15
	2	IPR and innovations, startups and Entrepreneurship		15
	3	Microbial biofuels		15
	4	Synthetic Biology		15
SMSMCB404 Environmental Microbiology-II	1	Extremophiles	4	15
	2	Impact of Microorganisms on Environment		15
	3	Environmental Monitoring and Water Pollution		15
	4	Bioremediation and Waste treatment		15

Practicals: Semester 4 SMSMCBP4

Course code	Title	Credits
SMSMCBP401	Dissertation submission and presentation	2
SMSMCBP402	Pharmaceutical Microbiology	2
SMSMCBP403	Advances in Biotechnology-II	2
SMSMCBP404	Environmental Microbiology-II	2

Semester 3

SMSMCB301-

Learning Objectives

- To learn about the process of research, types of research and research design.
- To learn about different types of sampling methods, sampling designs and variables. To learn about methods of data collection, interpretation and report writing.
- To learn about scientific writing and ethics in research and publication. To use ICT as a tool to assist in writing research proposals and research outcomes.
- To learn about the use of biostatistics software in interpretation of data.

Learning Outcomes

At the end of the course, learner will be able to:

- Design a research proposal.
- Use appropriate learn methods of sample collection, methods of carrying out the research and write a report on the same.
- Use anti plagiarism software to check if the proposal is acceptable, prepare a manuscript for presentation in a written / oral format using ICT.
- Learn use of biostatistics software so that it can be applied to the data collected for validity and interpretation.

COURSE CODE SMSMCB301	TITLE	Number Of Lectures
Unit I	**Basics of Research**	**15**
	1.1 Meaning and objectives of research, research and scientific method, research process, research methods vs methodology. Criteria of good research, Problems encountered by researchers in India.	7
	1.2 Types of research, conceptual vs empirical, applied vs fundamental, descriptive vs analytical, qualitative vs quantitative.	4
	1.3 Research designs: Features of a good research design, different research designs. Case study, cross over study,	4

	case control design, cohort study design, multifactorial design, ex post facto.	
Unit II	**Sampling, data collection, interpretation and report writing.** 2.1 Sampling and sampling design: Steps and different types of sample design. Methods of sampling: non probability, simple random, systematic, stratified, quota, cluster and area sampling, multistage and sequential sampling. Problems due to unintended sampling, ecological and statistical population in the laboratory. Variables: Nominal, ordinal, discontinuous and continuous. 2.2 Collection of data: Methods and techniques of data collection. Types of data collection: Primary and Secondary. Methods of primary data collection: Observation, Experimentation, Questionnaire, Interview, Schedules, Case pilot study etc. Methods of secondary data collection- Internal and External. 2.3 Interpretation and report writing: Techniques of interpretation and different steps involved in report writing, types of report, mechanics of writing a research report.	**15** **4** 2 6 3
Unit III	**Scientific writing and Ethics in research and publication** 3.1 Abstract, Writing of Literature review, Aim and Objectives Methodology, References/ Bibliography and Preparation of manuscript for publication of research/ review paper. Peer reviewed, UGC CARE listed, indexed journals, citation index and role of citation, impact factor of a journal. Use of open sources such as Mendeley reference manager, LaTeX as writing software, storage using Google drive/ Dropbox. Science journalism. 3.2 Use of computer in research: Computer technology, computer and researchers, software tools in the structure, design and preparation of thesis, layout, labeling of figures, legends, preparation of tables, layout, etc. Preparation of oral presentation and posters.	15 7 4

	3.3 Ethics in research and publication: Citations, acknowledgement, conflict of interest, plagiarism, plagiarism checking tools. Overview of ethics in research: Overview of legislation and regulation, ethical guidelines in animal and clinical research. IPR and patent law.	4
Unit IV	**Biostatistics**	**15**
	4.1 Basics of Biostatistics: Measure of central tendencies, mean, mode, median. Measure of dispersion, Standard deviation, Standard error of means, P value concept. Use of appropriate software for computation of statistical data.	5
	4.2 Types of hypothesis**:** Basics concepts, types of hypothesis - Null and Alternate hypothesis, levels of hypothesis and testing of hypothesis. Parametric test: Z test, t test (1 tailed and 2 tailed test) of hypothesis. Different types of ANOVA test Non parametric test.	6
	4.3 Correlation analysis & Regression analysis**:** interpolation and extrapolation, nonlinear data fitting, probit analysis etc. Software used for all of the above.	**4**
	Student activity: A hands on workshop will be organized to help students learn about the various biostatistics softwares. A talk will be organized to inform students on how to go about writing scientific articles to promote science journalism as a career choice.	**15**

SMSMCB302- Food Microbiology

Learning objectives

- To list microorganisms that are commonly associated with certain groups of foods
- To outline the process for making fermented foods & understand the benefits of using fermentation as a food processing method , also appreciate the similarities and difference among fermentations of dairy and vegetable products.
- To evaluate claims about health benefits of probiotic bacteria.
- To outline various types of traditional and advanced methods of food preservation, their objectives and their commercial applications
- To recognize the difference between methods available for microbiological analysis of food and compare the methods in terms of advantages and disadvantages.
- To discuss the importance of sanitation, good manufacturing practices (GMPs), and the HACCP system with respect to food safety and quality.

Learning outcomes

At the end of the course, learner will be able to:

- identify the sources of microorganisms, relate specific bacteria to spoilage of specific foods.
- identify important food- and waterborne parasites
- understand the positive role of viruses in pathogen control, their detrimental effect in fermentations, and their role in foodborne illness
- relate the steps of bread, cheese, idli & sauerkraut making to microbial fermentation and final characteristics.
- describe the characteristics of probiotic bacteria, possible health benefits
- understand how organic acids and inorganic food preservatives inhibit microbes and to link their ability to prevent food spoilage of certain foods,
- distinguish positive and negative aspects of chemical antimicrobials, characterize “natural” from “chemical” preservatives
- identify enzymes and how they work as preservatives, and in what foods they are useful
- understand that biological methods can be used to “naturally” enhance food safety without changing the food and appreciate the potential antimicrobial uses of the small proteins called“bacteriocins”
- Prepare food samples for determination of microbial load
- differentiate among conventional and rapid methods of detection of pathogens
- explain the basis of immunological, nucleic acid, and biochemical methods and recognize appropriate rapid method suitable for specific use
- differentiate among the various microbiological criteria
- recognize how indicator organisms are used in microbiological criteria

- understand why some sampling plans are more stringent than others and choose appropriate sampling plans as per case number.
- identify and list steps required to manage microbiological hazards in foods
- outline the basic concepts of GMPs and recognize its limitations
- Understand the process for development of a HACCP program
- identify national and international agencies involved in food safety and quality

COURSECODE SMSMCB302	**TITLE**	**Number Of Lectures**
Unit I	**Microbes in foods**	**15**
	1.1 Important microbes in food: Bacterial groups, Molds Yeast, Virus, Protozoa. Important Foodborne pathogens. 1.2 Sources of microbes in food 1.3 Importance of Stress adapted microbes in food, Sublethally injured microbes, VBNC(def), Properties and significance. 1.4 Normal microbiological quality of foods and its significance: Fish, Meat ,Raw and pasteurized milk, Egg and Egg products, Canned foods, Spices**.**	3 3 3 6
Unit II	**Use of Microbes and their products in Food industry**	**15**
	2.1 Starter cultures: Bacterial, Yeast and molds. Concentrated cultures, Problems in starter cultures and control methods. 2.2 Microbiology of fermented foods :General method of production a.Bread b.Cheese – Swiss and Blue cheese c.Fermented vegetable products – Sauerkraut d. Idli 2.3 Microbes used as Probiotics (Examples, properties and benefits) 2.4 Microbial products used in food industry: Enzymes in food processing, food waste treatment, Food grade pigments, Flavour compounds, exopolysaccharides	4 5 2 4
Unit III	**Control of Microbes in Food**	**15**

	3.1 Conventional methods a. Control by physical methods- i. Physical removal ii. Heat (Pasteurization, High heat processed foods) iii. low temperature (Chilling, Refrigeration, Freezing iv. reduced a_w, Intermediate Moisture food b. Control by chemical preservatives:organic acids and inorganic compounds (salt, nitrates, Sulphur based compounds) 3.2 Modern methods: a. Modified atmosphere,ozone b. Irradiation c. Antimicrobial preservatives of microbial, animal & plant origin d. Bacteriocins: Mode of action, delivery by nanoencapsulation 3.3 Novel emerging techniques of food preservation- Nonthermal method- HPP, PEF, PL, OMF, Ultrasound, cold plasma	4 2 4 5
Unit IV	**Microbiological quality of Food**	**15**
	4.1Detection and enumeration of microbes in food: a. Conventional Methods- i. Direct Enumeration :Microscopic Counts, count using nonselective , selective, differential chromogenic media ii. Indirect count : Dilution to extinction, MPN, Dye Reduction test b. Detection of Microbial Toxins c. Rapid and automated methods for detection of pathogens:Metabolic Fingerprinting, Immunomagnetic Separation, Reverse Passive Latex Agglutination (RPLA) Method, Immunochromatographic Lateral Flow Assay,Hybridization Method , Microarrays and Mass-Spectrometry d. Bacteriophage for Detection of Pathogen e. Biosensors for detection of microbes in food. 4.2 Indicator microorganisms : Characteristics, Coliform and enterococci.	 2 1 3 1 1 1

	4.3 Microbiological Criteria, Sampling plan, Types (2 class and 3 class)and sampling procedures 4.4 New emerging food borne pathogens of concern 4. 4.5 a.Control at source. b. Codes of GMP c. HACCP 4.6 Regulations and agencies monitoring microbiological safety of food: ICMSF, CDC, Food net, Codex Alimentarius, ISO22000, FSSAI	2 2 2

SMSMCB303-

Learning Objectives

- To introduce students to the various techniques involved in plant and animal biotechnology
- To familiarize students with the role of microbial genes in plant and animal biotechnology
- To know about the applications and risks associated with plant and animal biotechnology
- To impart knowledge of emerging areas of biotechnology such as nanotechnology
- To introduce students to both beneficial and harmful applications of biotechnology in the area of human health, with applications in medicine on one hand and bioterrorism on the other.

Learning Outcomes

At the end of the course, learner will :

- be able to correlate the principles of molecular biology methods with emphasis on the application of recombinant DNA technology to plant and animal biotechnology.
- be able to list the applications of plant and animal biotechnology
- be able to understand the risks associated with plant and animal biotechnology
- be able to understand the basic principles of nanobiotechnology and its applications.
- be able to understand both the beneficial and harmful applications of biotechnology in the area of human health

COURSECODE SMSMCB303	TITLE	Number Of Lectures
Unit I	**Plant and Agricultural Biotechnology**	**15**
	1.1 Plant Tissue Culture techniques -Callus and Suspension culture, Direct and Indirect Organogenesis, Micropropagation, Artificial seeds, Anther culture, Protoplast isolation, culture and fusion, Production of haploids, dihaploids Somaclonal variations, Germplasm conservation, Somatic hybrids, Cybrids (only Principles of the techniques).	3
	1.2 Plant Transformation Technology – Vectors used for plant transformation (Agrobacterium based vectors and viral vectors only), Molecular breeding, plant selectable markers, Reporter genes, Positive selection, Selectable marker elimination, Transgene silencing, Strategies to avoid transgene silencing	4
	1.3 Applications of transgenic plants - Production of secondary metabolites from plant cell cultures, Edible vaccines	1
	1.4 Microbial genes in crop improvement- microbial genes for insect resistance, herbicide tolerance, modified product quality, abiotic stress tolerance, resistance, hybrid seed production, Photosynthesis and nitrogen fixation	4
	1.5 Microbe – plant interactions: Plant Pathogen interaction, mutualistic interactions, mechanisms of resistance to plant viruses – protein-based resistance, RNA mediated silencing and genome editing tools	3
Unit II	**Animal Biotechnology**	**15**

	2.1 Animal Tissue Culture: Primary culture, Organ culture, Embryo Culture, Established Cell lines (self study)	5
	2.2 Creating Transgenic animals using nuclear microinjection, Alternate approaches to making transgenic animals (embryonic stem cells, nuclear transplantation, retroviral method) , Transgenic cattle, Transgenic birds, Transgenic fish, Transgenic mice, Transgenic mosquitoes	3
	2.3 Applications of transgenic animals: Recombinant protein production, knockout mice for medical research, disease control (mosquito borne) and improving livestock	5
	2.4 Location effects on expression of transgene, combating location effects on expression of transgene, targeting the transgene to a specific location, control of transgene expression, transgene regulation via steroid receptors, control by site-specific recombination using CRE or FLP	2
	2.5 Developmental and imprinting defects in cloned animals, Risk associated with DNA ingestion	
Unit III	**Nanobiotechnology**	**15**
	3.1 Nanoscale systems, nanoparticles, nanowires, thin films and multilayers, Properties of nanomaterials	3
	3.2 Visualization at the nanoscale - Scanning tunneling microscopy, Atomic force microscopy	1
	3.3 Weighing single bacteria and virus particles	1
	3.4 Synthesis of nanostructures - physical, chemical and biological, microbiological methods - Biomolecules as nanostructures, Nanoparticular carrier systems, Micro and Nanofluidics.	4
	3.5 Applications: Biosensors, drug and gene delivery systems, chip technologies, nano imaging,	

	Nanomedicine and Cancer diagnostics and treatment, detection of viruses by nanowires, nanoengineering of DNA, DNA mechanical nanodevices, Biomolecular motors, Nano barcode	6
Unit IV	**Medical Biotechnology**	**15**
	4.1 Genetic Testing of diseases and disorders, Immunogenetics; prenatal diagnosis-chorionic villus sampling, amniocentesis, Pre-implantation diagnosis., Genetic counselling.	2
	4.2 Gene therapy- general principles, vectors, gene targeting and tissue-specific expression, Antisense Technology, Aptamers, Ribozymes	2
	4.3 Novel strategies to treat cancer- Engineered Cancer – killing Viruses, using apoptosis to treat cancer	3
	4.4 Biowarfare and Bioterrorism - disease agents and purified as biowarfare agents, ribosome-inactivating proteins, agricultural biowarfare, genetic engineering of infectious agents, creation of camouflaged viruses, biosensors and detection of biowarfare agents	4
	4.5 Tissue Engineering - Fundamentals, Growth Factors & morphogens, Extracellular Matrix, Cell adhesion and migration, Inflammatory and Immune responses to tissue engineered devices, Biomaterials, applications of tissue engineering, Introduction of 3-D organ printing, organ on chip	4

SMSMCB304- Environmental Microbiology-I

Learning Objectives

- To understand theories of origin of life, chemical and cellular evolution.
- To learn basic principles of microbial ecology and interactions among microbial populations.

- To learn microbial environments and microbial diversity and interactions.
- To learn environmental sampling, collection and processing.
- To learn different methods for studying microorganisms in the environment.

Learning Outcomes

At the end of the course, learner will be able to:

- correlate origin of life and microbial evolution.
- explain basic principles of ecology and interactions among microbial populations.
- summarize physical and chemical properties of soil and microbial diversity.
- describe interactions of microorganisms with plants, mycorrhizae, nodule formation and fungal and bacterial diseases of plants.
- develop an understanding of marine microbiology and describe marine microbial biodiversity and symbiotic associations of microorganisms with marine animals.
- explain cultural, physiological, immunological and nucleic-acid based methods for studying microorganisms in the environment.

COURSE CODE SMSMCB304	**TITLE Environmental Microbiology-I**	**Number Of Lectures**
Unit I	**Microbial Ecology**	**15**
	1.1 Origin of life and Microbial Evolution a.Origins of life - chemical evolution, RNA world hypothesis, cellular evolution, evolution of organelles b.Evolution of physiological diversity	**05** **01**
	1.2 Microbial Ecology – Niche, habitat, ecosystem	**06**
	1.3 Interactions among microbial populations a.Interactions within a single microbial population- i.Positive interactions, Negative interactions b.Interactions between diverse microbial populations- Neutralism, Commensalism, Synergism, Mutualism, Competition, Amensalism, Parasitism, Predation	**03**
	1.4 Succession within microbial communities a.Autotrophic-Heterotrophic succession b.Examples of successional processes (any one example) c.Homeostasis and Secondary succession	

Unit II	**Soil, Plant and Marine Microbiology**	**15**
	2.1 Soil and Plant Microbiology a. Litho-Ecosphere b.Physical and chemical properties of soils c.Soil microbial communities d.Interactions with plant roots- Rhizosphere, plant root effects on microbial population, effects of rhizosphere microbial populations on plants, Mycorrhizae-Ectomycorrhizae and Endomycorrhizae e.Nitrogen fixation in nodules- Nitrogen fixing associations between Rhizobia and legumes, Non-leguminous nitrogen fixing mutualistic relationships f.Interactions with aerial plant structures g.Microbial diseases of plants and plant pathogens-bacterial and fungal diseases of plants	**07**
	2.2 Marine Microbiology a.Planktonic environment b.Benthic habitat c.Microbial mats d.Brackish water (estuary) e.Physical, chemical and microbial characteristics of marine water f.Marine microbial populations- Bacteria, Fungi, Algae, Protozoa and Viruses (Cyanophages and other viruses) g.Horizontal gene transfer in marine microorganisms h.Symbiotic associations i. Symbioses of microalgae with animals (Types of association, Nature of dinoflagellate endosymbionts, Corals), ii. Symbioses of chemoautotrophic prokaryotes with animals (Chemoautotrophic endosymbionts in hydrothermal vent animals, Episymbiotic bacteria on vent animals, Chemoautotrophic endosymbionts in non-vent animals, Phylogeny and acquisition of symbiotic bacteria) iii. Light organ symbioses in fish and invertebrates (Flashlight fishes and anglerfishes, Sepiolids-bobtail squids), iv. Microbial symbionts of sponges v. Symbiosis and mixotrophy in protists vi. Metabolic consortia and mutualism between prokaryotes	**08**

Unit III	**Cultural and Physiological Methods for Studying Microorganisms in the Environment**	**15**
	3.1 Environmental sample collection and processing a.Soils and Sediment- Sampling strategies and methods for surface soils, Sampling strategies and methods for the subsurface, Sample processing and storage b.Water- Sampling strategies and methods for water, processing water samples for virus analysis, processing water samples for detection of bacteria and protozoan parasites	**02**
	3.2 Cultural Methods a.Cultural methods for isolation & enumeration of bacteria i.Enumeration and Isolation techniques ii.Plating methods iii.Most probable number technique b.Culture media for bacteria i.General media used for culturing bacteria ii.New approaches to enhanced cultivation of soil bacteria c.Cultural methods for fungi d.Cultural methods for Algae and Cyanobacteria e.Cell culture based detection methods for viruses	**03**
	3.3 Physiological Methods a.Measuring microbial activity in pure culture b.Carbon Respiration i. Measurement of respiratory gases CO_2 and O_2 in laboratory and field studies ii. The application of respiration measurements in environmental microbiology iii. Tracer studies to determine heterotrophic potential iv. Anaerobic respiration as an indicator of microbial activity c.Incorporation of radiolabeled tracers into cellular macromolecules i. Incorporation of thymidine into DNA ii. Incorporation of leucine into protein d.Adenylate energy charge e.Enzyme assays- Dehydrogenase assay f.Stable isotope probing g..Functional genomics and proteomics based approaches	**10**

Unit IV	Immunological and Nucleic acid Methods for Studying Microorganisms in the Environment	15
	4.1 Immunological methods a. Immunoassays. i. Fluorescent immunolabeling ii. Immunomagnetic separation assays iii. Immunoaffinity chromatographic assays iv. Immunocytochemical assays	**04**
	4.2 Nucleic acid based methods of analysis a. Extraction of nucleic acids from environmental samples b. Gene probes and probing- Fluorescent in situ hybridization (FISH) c. PCR Fingerprinting d. Metagenomics (Pyrosequencing, Shotgun cloning) e. Metatranscriptomics f. Metaproteomics g. Restriction fragment length polymorphism analysis i. RFLP analysis of whole genomes ii. RFLP analysis of PCR sequences iii. Fluorescent fragment length polymorphism techniques iv. Pulsed field gel electrophoresis v. Advantages and disadvantages of RFLP and PFGE analyses h. Denaturing/temperature gradient gel electrophoresis i. Theory, concept, advantages and disadvantages of DGGE and TGGE i. Reporter genes i. Theory and concept ii. Specific reporter gene systems iii. Advantages and disadvantages of reporter genes	**11**

Practicals- Semester 3 SMSMCBP3

SMSMCBP301

Sr	Name of the experiment
1	Research proposal writing. Hypothesis, Literature survey.
2	Plan of work and methodology.
3	Using anti plagiarism software to check the validity of the proposal.
4	Research proposal preparation using ICT tools and presentation using poster and defense.

SMSMCBP302

Sr.No	Name of the experiment
1	Microbiological study of fermented foods (Idli batter), Yoghurt
2	Microbiological load in carrot and apple juice, salad, mayonnaise.
3	Quality Assessment and Analysis of food :Milk (Raw, Packed)
4	Detection of pathogens in frozen fish/poultry/meat
5	Report to be written in journal on Novel detection methods for food borne pathogens/ toxins.

SMSMCBP303

Sr. No	Name of the experiment
1	Laboratory design of Animal tissue culture laboratory (Visit or Video)
2	Laboratory design of Plant tissue culture laboratory (Visit or Video)
3	Preparation of Nanosilver By Wet reduction Method (Chemical), using Neem Extract & Bacteria (Biological)
4	Characterisation of Nanosilver by UV spectrometry and microscopic methods
5	Antimicrobial effect of Ionic silver and Nanosilver prepared by above methods
6	Study of Nanosilver coated Gauze/textiles for antimicrobial effect on different bacteria
7	Artificial Intelligence in Biotechnology: Student seminars

SMSMCBP304

Sr. No	Name of the experiment
1	A detailed report to be written on Bacterial and Archaeal diversity containing important characteristics, examples and pictures of different groups of a. Bacteria- The Deinococci and Nonproteobacteria, Proteobacteria (Alpha, Beta, Gamma, Delta and Epsilon), Low G+C and High G+C Gram Positive bacteria b. Archaebacteria **Student activity**- Students to watch videos of Archaebacteria, Proteobacteria and Nonproteobacteria on YouTube.
2	Soil analysis- a. To determine the organic matter content of soil b. To determine the chloride content of soil.
3	Isolation of indole acetic acid (IAA) producing bacteria from rhizospheric soil and its effect on plant growth.
4	Study of algae, Purple sulphur and Green sulphur bacteria.
5	**Student activity-** Reading a review article on *Roseobacter* bacteria in marine environments followed by discussion. (Reference no 9)
6	Soil respiration method.
7	Dehydrogenase assay-Tetrazolium reduction test.
8	A report to be written in the journal on Viable but non culturable bacteria (VBNC)- Mechanism, methods for detection, resuscitation .

References – Semester 3

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Semester 4

SMSMCB401-

Learning Objectives

- To learn about the advanced microscopic techniques and their applications in various fields including Nanobiotechnology.

- To learn basic and advanced spectroscopic techniques in judging purity and properties of an analyte.
- To learn about chromatography techniques for separation and analysis of compounds.
- To learn about molecular biology techniques like PCR, FISH etc

Learning Outcomes

At the end of the course, learner will be able to:

- To explain the size, shape and structure of a particle/ organelle/ microorganism using microscopic methods.
- To use spectroscopic techniques to judge the purity of a compound and its properties viz light absorption.
- To use an appropriate chromatographic technique for separation of a molecules of interest.
- To use an appropriate method for amplification of DNA/ detection of RNA to help in genetic analysis of a sample.

COURSECODE SMSMCB401	**TITLE**	**Number Of Lectures**
Unit I	**Advanced Microscopy techniques:** Principle, working and applications of i. SEM and TEM. ii. Scanning Probe Microscopes - Scanning Tunneling microscope (STM), Atomic force microscope (AFM), Magnetic force microscope (MFM), Scanning near field microscope (SNOM). iii. Confocal microscopy. iv.Fluorescence microscopy, high resolution fluorescence microscopy, fluorescence recovery after photobleaching and Forster resonance energy transfer.	**15** 3 6 2 4
Unit II	**Spectroscopic and Centrifugation techniques** Principle, working and applications of i. Atomic absorption spectroscopy. ii. Nuclear magnetic resonance iii. Mass spectroscopy: ESI-MS and MALDI - MS	**15** 2 2 3

	iv. FTIR. v. Preparative ultracentrifugation vi. Analytical ultracentrifugation	2 2 2 2
Unit III	**Chromatography and Electrophoresis techniques** Principle, working and applications of i.Gas chromatography ii.High performance liquid chromatography iii. Supercritical fluid chromatography iv. High performance thin layer chromatography. vi. Isoelectric focussing. v. 2D electrophoresis vi. Immunoelectrophoresis vii. Capillary electrophoresis	 2 2 2 2 1 2 2 2
Unit IV	**Molecular biology techniques** i.Methods of extraction of DNA/RNA ii. Variation / Modification of Basic PCR techniques: Hot start, Multiplex, Broad range, Nested, Real time, Quantitative and Arbitrary PCR. iii. Hybridization array technologies: application of microarrays in Microbiology, Microarray platform technologies(oligonucleotide microarrays and cDNA microarrays) iv. FISH with other techniques (confocal laser scanning microscopy, microautoradiography, flow cytometry, immunofluorescence, microsensors, nucleic, peptides etc)	**15** 1 3 5 6
	Student activity: A visit will be organized to an institute in order to study the use of advanced techniques in research. Students will be encouraged to present the use of an advanced technique published in a research	

	paper for detection, separation and identification of compounds.	

SMSMCB402- Pharmaceutical Microbiology

Learning objectives

- To learn the basic principles of Quality assurance, Quality Control and GMP in the pharmaceutical industry.
- To understand the design and structure of pharmaceutical premises.
- To learn the principles of personnel hygiene and health in the pharmaceutical industry.
- To learn the concept of GCLP.
- To understand the importance of sterility in the pharmaceutical industry and methods of sterilization used.
- To learn the Quality assurance in manufacture of sterile products and sterility testing.
- To understand the importance of HACCP.
- To introduce the concept of cosmetics microbiology and learn antimicrobial preservation efficacy and microbial content testing.

Learning outcomes

At the end of the course, learner will be able to:

- explain the relationship between Quality assurance, Quality Control and GMP.
- explain the design, layout and structure of pharmaceutical premises.
- explain the principles of personnel hygiene and health in the pharmaceutical industry.
- explain the importance of GCLP.
- list the pharmaceutical products that need to be sterile.
- describe and differentiate between the methods of sterilization used in the pharmaceutical industry.
- explain the Quality assurance in manufacture of sterile products.
- explain sterility testing and its importance and apply these skills in testing the sterility of a pharmaceutical product.
- recognize the importance of HACCP in the pharmaceutical industry.
- explain antimicrobial preservation efficacy and microbial content testing of cosmetics.

COURSE CODE SMSMCB 402	**TITLE Pharmaceutical Microbiology**	**Number Of Lectures**
Unit I	**Main principles for pharmaceutical products**	**15**
	1.1 Quality management in the drug industry - Quality assurance, Good manufacturing practices	**11**

	for pharmaceutical products (GMP), Sanitation and hygiene, Qualification and validation, Complaints , Product recalls, Contract production and analysis, Self-inspection and quality audits, Personnel, Training, Personal hygiene, Premises, Equipment, Materials, Documentation, Good practices in production, Good practices in quality control **1.2 GMP and regulations** - Good manufacturing practice- EU good manufacturing practice, FDA and CFRs, Key aspects of GMP compliance, Ten rules of GMP, Risk management, The role and development of pharmacopoeias, Importance of inspections in the life cycle of medicines, Role of the company regulatory affairs department, CDSCO guidelines	**04**
Unit II	**Premises and personnel management**	**15**
	2.1 Premises and contamination control - Requirements for a pharmaceutical production facility, contamination types and sources, control **2.2 Premises :** location, design, structure, layout, services and cleaning. **2.3 Personnel management** **2.4 Training** **2.5 Personnel: Hygiene and health**	**03** **04** **02** **03** **03**
Unit III	**Sterility in pharmaceutical products and other principles**	**15**
	3.1 Quality control and GCLP **3.2 Sterile products** - Pharmaceutical products which need to be sterile, methods of sterilization- steam	**03**

	sterilization, SIP, dry heat, radiation sterilization, ,gas sterilization and filter sterilization **3.3 Assurance of quality in the manufacture of sterile products** - Clean rooms, sterile products manufacturing area or suite, changing rooms, Air supply, The sterile manufacturing area-construction, materials and finishes, Personnel, In-process control of sterilization processes, Examination for particulate contamination, Sterility testing, Leaks and leak testing, Pyrogen/endotoxin testing, Parametric release **3.4 Non-sterile manufacture and packaging** - Solid dose manufacture (tablets and capsules), Liquids, creams and ointments, packaging **3.5 HACCP** **3.6 Cosmetics**- Definition, Introduction to cosmetics microbiology, Antimicrobial preservation efficacy and microbial content testing	**05** **01** **01** **02**
Unit IV	**Drug designing**	**15**
	4.1 Modern Methods of Drug Discovery:important terms 4.2Natural products for lead identification 4.3 Drug Discovery Tools, Combinatorial Chemistry 4.4 High throughput screening technology 4.5 Rational Drug Designing , The role of protein 3D structures in the drug discovery process, Proteomics, Bioinformatics, In silico Modelling, Molecular Modeling, Structure Prediction 4.6 Concept of Pharmacokinetics and Pharmacodynamics Clinical studies	

SMSMCB403- Advances in Biotechnology

Learning Objectives

- To familiarize students with the various categories of biotechnological products used in the area of human health care.
- To make students aware of bioethical issues associated with the applications of biotechnology in areas of plant, animal and human health
- To provide fundamental knowledge of concepts related to entrepreneurship and funding resources
- To educate students about basic concepts IPR regarding biotechnology inventions and research and the requirements for filing of patents
- Students will learn about the fundamental concepts associated with manipulating biomolecules and their applications

Learning Outcomes

At the end of the course, learner will be able to:

- to describe the applications of biotherapeutics in human health care.
- able to analyse ethical issues associated with biotechnology and recognize risks associated with inadequately researched biotechnology
- identify rewards associated with biotechnology in the from of IPRs
- recognise the basic requirements of entrepreneurial ventures and the associated opportunities
- will be able to understand the fundamental processes involved in manipulating functional biomolecules
- will appreciate the role of biotechnology in solving the future economical and environmental issues related to fuels via biofuel

COURSE CODE SMSMCB403	TITLE	Number Of Lectures
Unit I	**Pharmaceutical Biotechnology and bioethics**	**15**
	1.1 Therapeutics a. Proteins therapeutics – Cytokines, Interferons, hormones (Insulin, Human Growth Hormone) Recombinant blood products, Enzymes, monoclonal and recombinant antibodies b. Nucleic acids -antisense RNA, Ribozymes, Chimeric RNA- DNA molecules, Aptamers, Interfering RNAs c. Vaccines- Subunit, vaccines, peptide vaccines, DNA vaccines, attenuated vaccines vector vaccines d. Chimeric antigen receptor T cells in cancer therapy 1.2 Bioethics a. Principles of ethics, Perceptions of ethical biotechnology, Bioethical concerns - genetically modified organisms, Gene Therapy, Organ Replacement, Antibiotics and Antiviral Agents, b. Bioethics and Interference with the Natural World - Bioethical issues related to Transgenic Crops, Transgenic Animals, Animal Cloning, Genetic Screening in Pregnancy and Abortion, Stem Cell Research, Human Cloning, Eugenics, Selective Breeding, Transgenic Humans and Designer Children	4 2 2 1 3 3
Unit II	**Biotechnology and IPR and innovations, startups and Entrepreneurship**	**15**

	2.1. Intellectual Property Rights (IPR) and Protection (IPP), Rationale of Patent in Research and Scientific Innovations, Biotechnological Patents	2
	2.2 Requirements for Patentability- Patentable subject matter, Novelty, Invention in Biotechnological Research, Industrial Applicability	2
	2.3 Patent Specifications and Basic Component of License Agreement in IP System, Categories of Biotechnological Patents	2
	2.4 Introduction to entrepreneurship - entrepreneurial opportunity, entrepreneurial planning, commercialization process and strategy, financial management, human resource management, marketing and partnering strategies, collaboration and negotiation skills	5
	2.5 Funding of entrepreneurship ventures	2
	2.6 Schemes of DBT and the Department of Industrial Policy and Promotion	1
	2.7 Government initiatives for startups	1
Unit III	**Microbial biofuels**	**15**

	3.1 Types of energy sources - primary and secondary energy sources, biomass and Biomass conversion processes, generations of biofuels and production technologies, advantages of biofuels 3.2 Bioprospecting of Microorganisms for Biofuel Production 3.3 Biofuels from algal biomass- algae strain selection, cultivation, harvesting, oil extraction, Integrated algal biofuel production and wastewater treatment, Photosynthetic Production of Ethanol Using Genetically Engineered Cyanobacteria 3.4 Bioelectricity- Microbial Fuel Cells- Principle, design, substrates and applications	5 2 7 1
Unit IV	**Synthetic biology**	**15**
	4.1 Manipulation of genes a Chemical synthesis of oligonucleotides using Phosphoramidite method, Applications of synthesized oligonucleotides, gene assembly, genome synthesis b. Directed Mutagenesis: Oligonucleotide directed mutagenesis with M13 and plasmid DNA, PCR amplified oligonucleotide directed mutagenesis, Random mutagenesis with degenerate oligonucleotide primer and nucleotide analogues, Error-prone PCR 4.2 Manipulation of Gene Expression a. In Prokaryotes- Use of strong and regulatable promoters, Fusion proteins, unidirectional tandem gene arrays, DNA integration into host chromosome b. Heterologous protein production in eukaryotes: S*accharomyces cerevisiae*, *Pichia pastoris*, Baculovirus-Insect cell, mammalian cell	2 2 2 3

	4.3 Protein Engineering - Post translational modifications and improving Improving protein stability, using non natural amino acids, DNA Shuffling, Combinatorial Protein Libraries, Biomaterials Design, Engineered Binding Proteins	4
	4.4 Applications of synthetic biology	2

SMSMCB404- Environmental Microbiology-II

Learning Objectives:

- To learn extremophiles, their diversity and survival strategies in extreme habitats.
- To learn applications of extremophilic microorganisms in Biotechnology, various industries, and biofuel research.
- To understand the role of microorganisms in sulfur and iron cycle.
- To understand consequences of biogeochemical cycles- biocorrosion, concrete corrosion, acid mine drainage.
- To learn the significance and mechanism of biofilm formation in nature and methods to control the same.
- To learn the process of environmental monitoring and role of microorganisms in the same.
- To understand the process of eutrophication of aquatic systems, methods for detection of fecal pollution of water and oil spills.
- To understand the methods of bioremediation for treatment of waste containing chemicals, metals, gases and oil.
- To understand the methods of managing solid waste such as kitchen waste, plastics and e-waste.

Learning Outcomes:

At the end of the course, learner will be able to:

- describe various extreme habitats on the planet and life thriving in such habitats.
- explain the molecular adaptations in extremophilic microorganisms for survival.
- recognize the importance of extremophilic microorganisms and their enzymes and other products.
- describe the role of microorganisms in sulfur and iron cycle.
- explain the consequences of biogeochemical cycles and role of microorganisms in processes such as biocorrosion, acid mine drainage and bioleaching.
- explain the mechanism of biofilm formation and methods to control the same.
- explain the various processes to monitor environmental pollution.

- describe eutrophication and oil spill as serious problems in aquatic systems, methods for detection of fecal contamination of water and microbial source tracking.
- explain various methods of bioremediation and use of microorganisms in treatment of waste.
- explain the importance and methods of solid waste management.

COURSE CODE SMSMCB404	**TITLE** **Environmental Microbiology-II**	**Number Of Lectures**
Unit I	**Extremophiles**	**15**
	Extreme environments and Extremophiles a. Introduction, extremophiles and polyextremophiles b. Extreme environments i. Hydrothermal systems ii. Polar environments iii. Acid environments iv. Hypersaline and alkaline environments v. Deep-subsurface environments vi. Extraterrestrial environment c. Molecular adaptations and survival strategies in Thermophiles, Psychrophiles, Halophiles, Alkaliphiles, Acidophiles, Piezophiles, Xerotolerant and Radiation resistant organisms d. Sampling from extreme environments and enrichment culturing methods for isolation of extremophiles e. Culturing of extremophiles in fermenters f. Applications of extremophiles i. Applications of extremozymes in industry and biotechnology ii. Extremophiles in biofuel synthesis. iii. Carotenoids iv. Biopolymers v. Compatible solutes	

	vi. Medical applications	
Unit II	**Impact of Microorganisms on Environment**	**15**
	2.1 Biogeochemical cycling a.Sulfur cycle b.Iron cycle **2.2 Consequences of Biogeochemical cycles** a.Microbially influenced corrosion (Biocorrosion) i. Metal corrosion ii. Microbially induced concrete corrosion b.Acid mine drainage and metal recovery, Uranium leaching **2.3 Biofilms** a. The biofilm formation process: attachment, maturation and dispersion to planktonic mode of growth. b. Communication in biofilms: Quorum sensing & other chemical signalling molecules c. Biofilm-related diseases: Cystic fibrosis, Dental plaque, Wounds, Urinary infection, Prosthetic joint infection, Cardiac valve infection. d. Biofilm resistance to antibiotics & host immune system: Limited antibiotic penetration, Horizontal gene transfer, Reduced growth rate, Persister cells, Efflux pumps, EPS matrix protection e. Beneficial biofilms: Application of biofilms in wastewater treatment and microbial leaching of ores. f. Biofouling: health risks and financial losses in the medical, marine and industrial fields. **g.** Biofilm eradication :Methods and commonly used biocides such as surfactants, enzymes, triclosan, chlorhexidine, quaternary ammonium compounds**.** **2.4 Climate change and Combating Greenhouse effect using microbes**	**03** **03** **08** **01**
Unit III	**Environmental Monitoring and Water Pollution**	**15**
	3.1 Environmental monitoring	**05**

	a. Definition of pollution b. Sampling- Land sampling, water sampling and air sampling c. Physical, Chemical and Biological analysis d. Determination of biodegradable organic material e. Monitoring pollution f. Bioindicators g. Biomarkers- Biochemical and genetic indicators h. Toxicity testing using biological material- toxicity testing using plants and algae, Luminescent organisms, Ames test, molecular biology biomarkers i. Biosensors **3.2 Pollution of Aquatic Systems** a. Nature of pollution i. The concept of the self-purification of water as basis for the understanding of pollution ii. Kinds of pollutants iii. Pollution by eutrophication- Algal blooms iv. Biological Indicators of Pollution by Eutrophication b. Pollution of Water with Reference to Human Health i. Microbiological examination of water for fecal contamination- Principle of Indicator organisms, Procedure for the determination of fecal contamination, Methods used in the enumeration of indicator organisms in water, Standard water analysis, Total Maximum Daily Loads and Microbial source tracking in water pollution, Microbial source tracking, Methodologies employed in MST- Molecular, biochemical and chemical methods, Choice of the MST method to use c. Pollution by petroleum in oceans and seas i. Oil spills- Behavior of Oil in an Oil Spill	**10**
Unit IV	**Bioremediation and Waste treatment**	**15**
	4.1 Bioremediation	**12**

	a. Introduction, Synthetic compounds, petrochemical compounds, Inorganic wastes b. Bioremediation strategies- Indigenous microorganisms, stimulation of indigenous microbial growth, Bioaugmentation, use of genetically manipulated organisms, Planned release of genetically engineered microorganisms in the environment and concerns regarding the same. c. Bioremediation techniques in situ- Bioremediation on land, land farming, Bioventing, Biosparging, stimulation d. Bioremediation techniques ex-situ- Composting, biopile process, use of bioreactors, novel technologies e. Bioremediation of metals- Biosorption, extracellular precipitation f. Bioremediation of gases g. Bioremediation of textile dyes/effluent- types of textile dyes, bioremediation methods, role of bacteria, fungi, yeasts, molds, microbial consortia and biofilms, mechanisms behind bioremediation of textile dyes- (biosorption, biodegradation, mineralization, bioaccumulation), factors affecting degradation, immobilization of bacterial cells, Optimization procedures- Response surface methodology, Environmental concerns- effects on humans and water bodies h. Bioremediation of oil spills **4.2 Solid waste management** a. Solid waste management by reduction, collection, recycling and incineration b. Treatment/degradation of kitchen waste, composting, vermicomposting, waste-to-energy technique, landfilling c. Treatment of slaughterhouse/abattoir waste d. Case studies of implementation of ideas- Entrepreneurs e. Management of biomedical waste, plastic and e-waste	**03**

Practicals- Semester 4 SMSMCBP4

SMSMCBP401

Sr. No	Name of the experiment
1	Experimental work as per plan of work and methodology
2	Interpretation, discussion and conclusion of research work.
3	Preparation of manuscript- dissertation using ICT
4	Preparation of poster, its presentation and defense.

SMSMCBP402

Sr. No	Name of the experiment
1	**Student activity-** a. Critically read Standard Operating Procedures (SOPs) from Quality in the Manufacture of Medicines and other healthcare products , John Sharp and b. Write a SOP on your own on any basic microbiological/analytical process like steam sterilization, UV spectrophotometric analysis etc.
2	A detailed report to be written on Validation in the Pharmaceutical industry.
3	Sterility testing of a pharmaceutical product and reporting (as per Pharmacopoeia).
4	A detailed report to be written on Endotoxin and pyrogen testing in pharmaceutical products.
5	Determination of Microbial load in cosmetic product.
6	Efficacy testing of preservatives.

SMSMCBP403

Sr. No	Name of the experiment
1	Assignments on IPR-Case studies on different patents granted
2	Report on International Bioethics survey on specific concerned issues
3	1 page description of student's business idea
4	Lipid staining of microalgae - Nile red / Sudan black B staining
5	Extraction of lipids from microalgae
6	Visit to Pharmaceutical industry

7	Case study- the successful Entrepreneur
8	AI and Biotechnology- student seminars

SMSMCBP404

Sr. No	Name of the experiment
1	Enrichment and isolation of thermophiles from soil/ mangrove soil/ compost/ any environment. To determine whether the isolated bacteria are obligate thermo Detection of amylase, lipase, cellulase and xylanase enzymes.
2	Enrichment and isolation of halophiles from sea/ mangrove soil. Detection of amy lipase, cellulase and xylanase enzymes.
3	Isolation and characterization of alkaliphiles from soil/ mangrove soil.
4	Visualization and study of biofilms using crystal violet assay.
5	Detection and monitoring of water pollution in rivers and lakes of Mumbai (any one river and lake from the following- Mithi river, Oshiwara river, Poisar river, Dahisar river, Tulsi lake, Vihar lake)- a. Estimation of Chromium b. Determination of pH, BOD and COD c. Detection of human fecal pollution (*E.coli and fecal Streptococci*) d. Determination of Antibiotic resistance in *E.coli* isolates
6	**Student activity-** Detection of coliforms and *E.coli* from packaged/bottled drinking water as per BIS standards.
7	A report to be written on carbon credit.
8	Visit to Maharashtra Pollution Control Board, Central/Regional laboratory **OR** Common Effluent Treatment Plant, Kopar Khairane, Navi Mumbai to learn treatment of domestic and industrial waste and sludge treatment. A report to be written on this in the journal.
9	A detailed report to be written on hazardous waste management. (Minimum 5 references to be included. **Reference no 28** is compulsory.)

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Modality of assessment

A. Theory- Internal assessment 40% marks **40**

Sr. No	Evaluation type	Marks
1.	Test a. Choose the correct alternative- 05 marks - (any five out of eight) b. Answer in one or two sentences- 05 marks - (any five out of eight) c. Diagrammatically explain/Describe/Justify/Explain/ Differentiate between/HWY- 10 marks – (any two out of three)	20
2.	Power Point Presentation on any of the topics from the syllabus / Report writing / Assignment / Essay writing / Notes preparation / Making a Review article	15
3.	Attendance	05

B. Theory- External examination – 60% marks **60**

Semester end examination (SEE)

- The duration of the examination will be 2.5 hours.
- The question paper will have 5 questions each of 12 marks.
- On each unit, there will be one question (subjective) and the fifth one will be based on all four units (objective).
- All questions will be compulsory with internal choice within the questions.
- Question 5 will be subdivided into sub questions a, b and c.

Practical Examination: -

- There will be no internal examination for practicals.
- External (semester end practical examination): 50 Marks per paper/section